

# RESEARCH COLLABORATION

2011 and 2012



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# Research Collaboration

2011 and 2012

A joint publication highlighting the  
research partnerships between the CSIR and  
University of the Western Cape,  
University of Cape Town,  
Stellenbosch University



# Foreword



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CSIR's partnerships with the University of the Western Cape (UWC), University of Cape Town (UCT) and Stellenbosch University (SU) seek to conduct research that improves the quality of the lives of the people of South Africa by responding to the country's development priorities, which include improving health, supporting sustainable resource management, and strengthening skills. Through these partnerships, we contribute to national development objectives according to our specific mandates. Each one of our institutions has strategically selected areas of priority through which we contribute to addressing the country's development challenges.

We recognise that each of our institutions has complementary capabilities, infrastructure and facilities which can be pooled together to improve the impact of our individual responses.

We achieve excellence by creating an enabling environment that promotes outstanding scholarship and research. We continue to look for additional opportunities to work together.





## Overview



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One of the ways to contribute to the economic growth and development of South Africa is to have institutions working together in partnerships. Such partnerships exist between the CSIR, the University of the Western Cape (UWC), University of Cape Town (UCT) and Stellenbosch University (SU).

To realise economic growth and development, South Africa – like any nation – requires investment in human capital development (HCD). Through the respective memoranda of understanding (MoU) signed

by the CSIR and these three institutions, human capital is developed through joint research, teaching and supervision of students and the exchange of staff. Scholarships for full-time postgraduate training in areas relevant to the MoU are awarded through programmes to which UWC, UCT, SU and the CSIR contribute equal funding. The CSIR supports its staff to train at these and other tertiary education institutions in the country, and also supports students at universities who work on CSIR projects as part of their postgraduate training.

Collaborative research projects were jointly undertaken and resources were shared. These led to the production of a significant number of research outputs, including journal articles and conference papers.

To increase teaching and research capacity, the universities have awarded honorary appointments to several CSIR researchers as extraordinary professors, lecturers and supervisors, while the CSIR has appointed university staff to its research advisory panels. The numbers below show the contribution of the collaboration:

## RESEARCH

|                                                                                   |                                                            | 2011 | 2012 |
|-----------------------------------------------------------------------------------|------------------------------------------------------------|------|------|
|  | Collaborative research projects implemented                | 36   | 38   |
|  | Researchers collaborating on joint projects                | 102  | 109  |
|  | Joint outputs resulting from supervised and joint research | 94   | 58   |

## HUMAN CAPITAL DEVELOPMENT

|                                                                                     |                                                                                | 2011 | 2012 |
|-------------------------------------------------------------------------------------|--------------------------------------------------------------------------------|------|------|
|    | CSIR researchers lecturing/supervising students                                | 68   | 65   |
|   | Students supported by the joint scholarship programmes                         | 16   | 20   |
|  | CSIR staff studying at the institutions                                        | 71   | 69   |
|  | Scholarship students and CSIR staff who graduated                              | 26   | 6    |
|  | CSIR staff appointed extraordinary professorships/honorary research associates | 9    | 10   |
|  | University researchers serving on CSIR research advisory panels                | 7    | 7    |

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# CSIR and University of the Western Cape Partnership



# Introduction

UWC is committed to excellence in teaching, learning and research; nurturing the cultural diversity of South Africa; and responding in critical and creative ways to the needs of a society in transition.

This section of the report gives an overview of some of the research highlights and achievements resulting from the collaboration between the CSIR and UWC during 2011 and 2012. The collaboration was mainly in the following areas, as identified in the memorandum of understanding between the two institutions:

- Materials science and manufacturing with a focus on metals and metal processing.
- Biosciences with a focus on pharmaceuticals and synthetic biology.
- Nanotechnology with a focus on modelling of nanomaterials.
- Environment management with a focus on water quality.
- Human capital development including staff exchange, joint bursaries and student supervision.

|                                                                  | 2011 | 2012 |
|------------------------------------------------------------------|------|------|
| Collaborative research projects implemented                      | 7    | 8    |
| Researchers at both institutions collaborating on joint projects | 19   | 21   |
| Joint outputs resulting from supervised and joint research       | 10   | 10   |
| CSIR researchers lecturing/supervising students                  | 7    | 7    |
| Students supported by the CSIR/UWC scholarship programme         | 8    | 5    |
| CSIR staff studying                                              | 3    | 4    |
| Scholarship students and CSIR staff who graduated                | 7    | 0    |
| CSIR researchers who hold extraordinary professorships           | 1    | 2    |
| UWC researchers serving on CSIR research advisory panels         | 1    | 1    |

# Highlights and Achievements

## NATURAL ENVIRONMENT

### Investigation of the fate and transport of selected micro-organisms in two simulated aquifer conditions in the laboratory and in the field

*Dr Martella du Preez, Marna van der Merwe, Wouter le Roux, CSIR • Jaco Nel, UWC • Dr Gideon Steyl, UFS*

#### Background

The detailed behaviour of micro-organisms in groundwater is not well understood. This is due to the complex biophysical and biochemical processes that affect the fate and transport of micro-organisms that enter groundwater. Besides movement of groundwater, there are many biological and hydrogeological processes such as natural die-off, formation of bio-films, adsorption and desorption, and the chemical and physical conditions that influence the spatial and temporal spread of organisms in aquifers.

#### Response

This project investigated the fate and transport of microbes in the groundwater of a South African sandy and fractured rock aquifer. Models were formulated to provide better insight and knowledge on the complexity of the processes that govern microbes in groundwater. Data to support the modelling was generated by field tests conducted in a sandy aquifer and fractured rock aquifer at UWC, and the Institute of Ground water Studies at the University of Free State borehole fields, respectively.

#### Progress

The field studies at UWC showed that the sand aquifer was capable of removing

viruses and bacteria completely over a two meter distance (the distance between the borehole where viruses and bacteria were injected, and a second borehole, where water samples were checked for breakthrough of the microbes).

The fractured rock aquifer study indicated that bacteria move at the same speed as a salt tracer. This phenomenon is known and is caused by the relatively “clean” flow path of the groundwater in the fracture. What is meant by “clean” flow path is that there are fewer sand particles and physical retaining of the bacteria and therefore movement with the flow speed of the groundwater.

The most important lesson learnt through the development of simulation models (based on published data) and through adapting currently used models (using a combination of the data generated during the project and published data) is that the complexity of the interactions of the combined biological factors of living organisms, and that of hydrogeology, cannot be captured using a single model. Importantly one cannot develop a general model applicable to all aquifers. The reason is that underground conditions, groundwater chemical and physical condition, and behaviour of the microorganisms are different for each



borehole. This implies that a new model based on new data will have to be developed for each locality.

A major constraint experienced was the inadequate data generated. This hampered the modelling. It is also very important that supervision of students is thorough, sustained and undertaken by experienced experts in the field.

#### Outputs

Students trained – 2 (1 UWC, 1 UFS)

## Electrochemical sensor for environmental applications

Dr Vernon Somerset, CSIR • Prof Emmanuel Iwuoha, UWC

### Background

The project involved the design, development and synthesis of new electrochemical sensor materials and chemical compounds with nanoscopic and controlled surface structure, and chemical activity towards metal ions associated with platinum group metals (PGMs), such as lead, nickel, platinum, rhodium and palladium. The intention was to monitor and apply the research results in specific water management areas of South Africa, where heavy metal pollution from precious metal refineries has been identified. Knowledge of the life cycle of heavy metal pollutants, and their impact on water resources and ecosystems could be used to improve the quality of life of people in affected areas.

### Response

Stripping voltammetry has been very useful in the analysis of heavy and other metal ions, due to its excellent detection limits, and its sensitivity in the presence of different metals or interfering ions. Recent assessments of aquatic samples have shown increased levels of PGMs in aquatic ecosystems, caused by automobile exhaust emissions and mining activities.

The development of an analytical sensor for the detection and characterisation of PGMs was investigated, since there is an on-going need to find new sensing materials with suitable recognition elements that can respond selectively and reversibly to specific metal ions in environmental samples.



### Progress

The research revealed the successful application of another mercury-free sensor electrode for the determination of PGMs in environmental samples. The work entails the use of a glassy carbon electrode modified with a bismuth film for the determination of platinum ( $Pt^{2+}$ ), palladium ( $Pd^{2+}$ ) or rhodium ( $Rh^{2+}$ ) by means of adsorptive cathodic stripping voltammetry. Optimised experimental conditions included composition of the supporting electrolyte, complexing agent concentration, deposition potential, deposition time, and instrumental voltammetry parameters for  $Pt^{2+}$ ,  $Pd^{2+}$  and

$Rh^{2+}$  determination. Adsorptive differential pulse stripping voltammetric measurements for PGMs were performed in the presence of dimethylglyoxime (DMG) as the complexing agent. The glassy carbon bismuth film electrode (GC/BiFE) employed in this study exhibits good and reproducible sensor characteristics. Application of GC/BiFE sensor exhibited well-defined peaks and highly linear behaviour for the stripping analysis of the PGMs in the concentration range between 0 and 3.5  $\mu g/L$ .

It is envisaged that research undertaken in this project will contribute to the further development of the CSIR's capacity in trace metal pollution assessment. The study has also created opportunities for postgraduate students and young researchers, to develop capacity and expertise to implement the technology that has been created. The analytical, design and sensor manufacturing skills developed in this project are scarce in South Africa.

It is expected that sound data on the development and construction of sensors, and the use of ion exchange and chemical precipitation techniques for heavy metal ion speciation and determination in freshwater resources will be produced.

### Outputs

Students trained – 2



# Industrial brine minimisation: development and application of functionalised fibres for brine treatment

Dr Ravi Vadapalli, CSIR • Prof Leslie Petrik, UWC

## Background

Reverse Osmosis (RO) is a widely-accepted membrane technology for mine and waste water treatment in South Africa. While RO has enabled the recovery of waste water for potable use, the associated brine treatment and disposal is creating a long-term limitation to water reuse as well as a financial constraint for many applications. For example, the Emalahleni water reclamation RO system is estimated to produce about 200 m<sup>3</sup> of brine per day from processing 10 million litres of acid mine drainage (AMD).

There are plans to construct at least two more RO systems in the area with similar capacity. This would result in more problems of brine storage and a growing need for sustainable and cost-effective technologies for treating brine and recovering water, either for safe disposal or for domestic and industrial applications. Given the CSIR's experience in developing waste water treatment technologies, and UWC's expertise in developing novel materials for waste water treatment, the two institutions have embarked on a research project that deals with the development and application of nanoscale novel materials for brine treatment.

## Response

Advances in nanoscale science and engineering suggest that many of the current problems involving water quality could be resolved using different nanomaterials

applied as nanosorbents, nanocatalysts, bioactive nanoparticles, nanostructured catalytic membranes or nanoparticle-enhanced filtration. Utilisation of specific nanoparticles, either embedded in membranes or in other structural media that can effectively, inexpensively and rapidly make unusable water potable, is being explored to address water-related challenges. Previous research where functionalised nanoscale fibres have been applied to remove specific contaminants in wastewater has shown encouraging results.

The capability on brine treatment at the CSIR, and the expertise at UWC on the application of functionalised fibres in such waste streams, motivate for the establishment of a long-term collaborative research project. In particular, the project seeks to specifically develop and apply functionalised fibres in removing targeted problematic contaminants from sodium sulphate-rich brines.

## Progress

Several workshops and meetings were held at UWC and the CSIR with potential collaborators, to establish networks and identify funding for the proposed research programme. This project will help, not only to further strengthen the collaboration between the CSIR and UWC, but will provide an opportunity to build relationships between the CSIR and European universities.



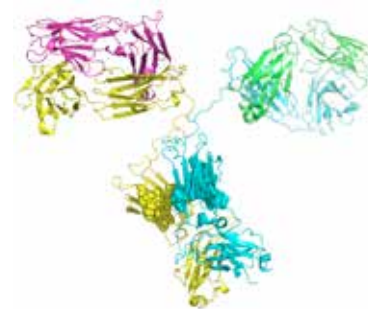
## Outputs

Students trained – 2

## BIOSCIENCES

### Structural characterisation of a rabies prophylactic antibody expressed in tobacco

Dr Tsepo Tsekoa, CSIR • Prof Trevor Sewell, UWC/UCT • Prof Wolf-Dieter Schubert, UWC



#### Background

Antibodies continue to be the most promising drug class in the biopharmaceutical industry. To date, the United States Food and Drug Administration has approved more than 20 monoclonal antibodies for use, with several others in clinical trials. Monoclonal antibodies currently in the market are indicated for various conditions including the treatment of microbial infections, autoimmune diseases and cancer. In the next decade, growth of this class of biologics is expected to outpace that of the broader pharmaceutical market, and will be the major driver for the biotech industry.

Through the Greenpharm™ initiative, the CSIR has demonstrated its capacity to produce pharmaceutical antibodies, and lead their development towards commercialisation. In one of the current projects, two humanised chimeric anti-rabies antibodies have been successfully expressed in tobacco and purified in quantities that are potentially suitable for commercialisation. The CSIR is therefore poised to play a significant role in the development of the therapeutic monoclonal antibody industry in South Africa, in particular where plants are used as vehicles for expression.

#### Response

These antibodies, branded Rabivir™, will be used in a cocktail to replace the current

rabies post-exposure prophylactic HRIG (Human rabies immune globulin) product. This first generation product is produced by concentration of antibodies from the blood of hyper immunised individuals. It is thus a relatively crude biopharmaceutical that poses supply and infection risk to the market.

Monoclonal antibodies are high molecular weight proteins with highly complex secondary and tertiary structures that are subject to various post-translational modifications. One of the requirements for regulatory approval of monoclonal antibodies produced by Greenpharm™ is their comprehensive structural and biochemical characterisation. In addition to use in fulfilling regulatory requirements, complete characterisation of antibody products will be important for a fundamental understanding of their structure and function. This will aid the development of next-generation derivatives of these products such as antibody fragments, which have properties that render them more attractive to the market. For example, the various antibody fragments demonstrate properties more akin to small molecule drugs, including the possibility of oral administration and decreased dosage requirements.

This characterisation work requires sophisticated techniques that include glycan profiling, mass spectrometry, liquid chromatography, circular dichroism spectrometry, and where accessible,

higher resolution structural studies using techniques such as x-ray crystallography. In this way, a complete picture of the product can be described. Due to the wide variety of high-end equipment required; this type of research benefits greatly from collaborative work.

The project will contribute to biochemical and structural characterisation aspects of the larger Greenpharm Rabivir project which will be conducted by CSIR in partnership with UCT and UWC.

UWC will provide access to equipment and expertise in X-ray crystallography of biological macromolecules. This project will ultimately provide atomic resolution data that may support regulatory compliance of current antibody products, as well as inform future development of next generation fragment products.

The results of the study will also form a sound foundation for future collaborative work with UCT, UWC and the Joint UCT/UWC Structural Biology Initiative, that seeks to utilise structural biology approaches to identify, characterise and validate enzymes, biopharmaceuticals and drug targets. Experimental observation of macromolecular structures will benefit biopharmaceutical and drug target discovery efforts at the CSIR.



# Human Capital Development

## CONTEXT OF THE COLLABORATION

Pinda Sifunda, CSIR • Prof Lorna Holtman, UWC

UWC and the CSIR support human capital development through several mechanisms. The joint UWC/CSIR scholarship programme supported eight students in 2011 and five in 2012.

In the same period, 6 CSIR staff members – 1 Honours, 2 Master's and 3 PhD – were supported by the CSIR to study for higher qualifications at UWC in disciplines including physics, chemistry and medical biosciences.

Some of the staff were supervised by UWC and CSIR researchers and worked on CSIR projects as part of their graduate programmes. Seven staff members and scholarship students completed their studies

in the two years. Two CSIR staff members have been awarded honorary appointments by UWC. A selection of some of the student research and experiences follows.



**Mduduzi Radebe** is studying for an MSc (Chemistry) with specific interest in the synthesis, characterisation of novel iminopyridyl complexes for carbon-carbon coupling reactions. "My project entails developing new nitrogen-donor catalysts, namely iminopyridyl compounds (comprising pyridyl ring and an aliphatic imine) coordinated to a late transitional metal. The iminopyridyl compounds are designed as an alternative to phosphine compounds which are air-sensitive, moisture sensitive and very expensive. The rationale for the (research) preparation and investigation is the need for cheap and stable phosphine-free catalysts. The metals of interest are palladium and nickel. These complexes are obtained by synthesising ligands from commercially-available aldehydes and primary amines. Upon purification the ligands are characterised using infrared spectroscopy,  $^1\text{H}$ ,  $^{13}\text{C}$  nuclear magnetic resonance (NMR) spectroscopy, elemental analysis, and mass spectroscopy.

"The ligands are then reacted with metal precursors  $\text{PdCl}_2(\text{cod})$  and  $\text{NiBr}_2(\text{DME})$  to form new complexes (catalysts) that are subjected to the above-mentioned analytical techniques. The last part of the project was to evaluate the catalytic activity of the complexes for carbon-carbon coupling reactions. The evaluation was investigated by varying the substrates to obtain high yield and conversion of the new carbon-carbon bond. Since the complexes contain elements such as sulphur, nitrogen and carbon they can further be used in biological investigation for anti-cancer and anti-tumour testing.

"My aim is to pursue a PhD degree and Postdoctoral degree thereafter, and I am hoping that CSIR will continue to be my financial sponsor, especially if there is a studentship position available. My research focus will be to incorporate synthetical methods with nanotechnology."

**Unathi Sidwaba** is studying for BSc (Hons) in Chemistry with specific interest in electrochemical lab-on-chip biosensor for therapeutic monitoring of anti-tuberculosis drugs. "Tuberculosis is still a major health problem in South Africa and other developing countries. The high TB incidence is associated with improper dosage and development of resistance to the treatment drugs which is due to non-compliance with the therapy. Drug toxicity due to overdose also has a great impact on the high TB rates and deaths. Due to polymorphism of enzymes responsible for the clearance of these drugs in the body, patients can develop drug resistance and toxicity (e.g. liver damage) and therefore non-compliance with the therapy. In this study, an electrochemical lab-on-a-chip biosensor for the determination of the biotransformation of anti-TB drugs will be developed. The aim is to provide medical practitioners with an easy-to-use point of care system (biosensor) for determining proper dosages to avoid toxicity and non-compliance with the therapy.

"The biosensor will be applied to detect isoniazi, pyrazinamide, rifampin and ethambutol, (which are tuberculosis treatment drugs), in urine and plasma. The study is line with the South African National TB Control programs on monitoring responses to treatment."

**Asanda Vincent Busa** is studying for an MSc (Chemistry) with specific interest in oxidative cleavage of long chain alkenes using dendritic rhenium and ruthenium catalysts. "The proposed work was to develop dendritic complexes of ruthenium/rhenium which could be employed in oxidative cleavage/Epoxidation reactions. The dendritic complex would be based on dendrimeric diimine ligands. Several examples of these types of ligands have been prepared in our research group and will thus be employed.

"In an attempt to increase the steric bulk around the active site we also prepared dendrimeric quinolinyl-imine ligands and employ these for the formation of multinuclear ruthenium/rhenium complex.

"Alkene oxidation profoundly impacts the development of synthetic organic chemistry. Oxidation reactions constitute core technologies for the synthesis of chemical intermediates in the production of both high-tonnage commodities and high-value fine chemicals, such as agrochemical and pharmaceutical precursors. Ruthenium and rhenium compounds constitute a versatile class of catalysts for important synthetic transformations in organic chemistry, biochemistry, sensors etc. Upon completing my MSc degree I would like to continue with my PhD studies"

## SUPERVISED RESEARCH

### Application of MAGIC code to compute TEC over the Southern Africa region using Global Navigation Satellite System networks

Valentino van de Heyde, UWC • Supervisors: Dr Daniel Moeketsi, CSIR • Robert Lindsay, Channon Price, UWC

#### Background

The development of a regional ionospheric Total Electron Content (TEC) model helps in understanding the behaviour of ionospheric parameters and its coupling to global space weather activities. In the past decades, the International Global Navigation Satellite Systems Service (IGNSS) network of dual frequency data receivers has been used to develop models of ionospheric TEC. These models were mainly developed in the northern hemisphere where there is a dense network of ground based global positioning System (GPS) receivers. Such modelling only started recently in Africa.

#### Response

The objective of the research is to construct and expand the MAGIC code to characterise ionospheric parameters over Southern Africa. The work will be of interest to local and international researchers and will contribute to the regional space weather initiative in South Africa by improving understanding of the coupling between the solar activity and ionospheric process over the Africa.

#### Progress

The project on the construction and expansion of the MAGIC code over southern Africa has been completed. For the first time, data from more than 40 local Tignet GPS stations has been used to compute TEC maps over South Africa. Figure 1 depicts geographical locations of Tignet GPS and South African ionosondes stations used. Figure 2 is an example of a TEC map of South Africa produced by the MAGIC code. More TEC maps have been simulated for geomagnetically quiet and perturbed conditions. Statistical analysis of these conditions has been completed.

#### Future Work

Future work will involve the validation of model results using other techniques such as ionosonde measurements particularly for Global Navigation Satellite Systems (GNSS) co-located sites, the International Reference Ionosphere model, satellite observations, etc. The MAGIC code will also be expanded to get wider coverage once a suitable number of GPS stations have been installed in Africa.



Figure 1: Distribution of GPS and Ionosonde networks, where the yellow circle represents the ionosonde stations and the blue squares the GPS networks across South Africa.

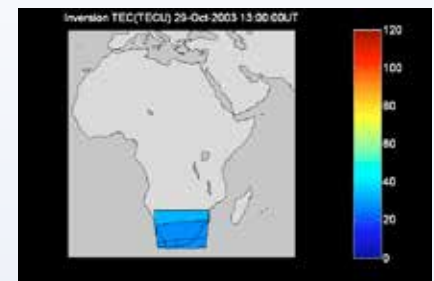


Figure 2: Inversion TEC map over South Africa on the 29 October 2003 at 13:00:00 UT.

## Development of High Performance Composite $\text{LiFePO}_4$ Cathode Material for Lithium Ion Batteries

Chinwe Ikpo, UWC • Supervisors: Dr Kenneth Ozoemena, CSIR • Prof Emmanuel Iwuoha, UWC

### Background

The exponential growth in portable electronics as well as increasing environmental concerns has attracted worldwide research and development for efficient and sustainable energy storage devices. The unique properties of lithium ion batteries, such as high energy density, high efficiency and long life, have made them the power sources of choice for consumer electronics, electric and hybrid electric vehicles, and renewable energy plants. Much research effort is centred around the development of the cathode because the performance and costs of lithium-ion batteries are mainly limited by the properties of the cathode materials in use. The electrochemical performance of the cathode is measured in terms of charge-discharge capacity, cyclability, rate capability and coulombic efficiency. These parameters are closely related to the reversibility, kinetics and efficiency of lithium ion intercalation/de-intercalation in the active material.

The predominant cathode material used in lithium ion batteries is  $\text{LiCoO}_2$ . It was utilised in the world's first commercial lithium-ion battery introduced by Sony in 1991. However, it has the disadvantages of being unsafe, toxic, and costly. It also suffers from stability problems and can, as a result of this, undergo performance degradation when overcharged. This limits its practical capacity ( $<140 \text{ mAh/g}$ ) and rates. A search for alternative materials with better characteristics became imperative and led to the discovery of  $\text{LiFePO}_4$ . Orthorhombic  $\text{LiFePO}_4$  of the olivine structure has a flat discharge potential at about 3.4 V and a capacity of 170 mAh/g. Its delithiation during charging gives  $\text{FePO}_4$  in which the  $\text{Fe}^{2+}$  ions are oxidized to  $\text{Fe}^{3+}$  leaving the 3D olivine framework intact. This structural stability imparts a good cycle life to  $\text{LiFePO}_4$  cells. In addition to its attractive features, it is based on iron, an element that is abundant, inexpensive and environment-friendly. Its major drawback as a cathode material is that of having low electronic conductivity and lithium-ion diffusivity, which affects its overall electrochemical performance and applications.

### Response

The main objective of this research therefore is to develop novel  $\text{LiFePO}_4$  composite cathode systems with enhanced electrochemical properties that will fit the characteristics required in modern lithium ion batteries. To that end, composite cathodes based on lithium iron phosphate, derivatised carbon nanotubes and polyaniline nanomaterials were developed.

The charge/discharge, impedimetric and voltammetric properties of the composite and pristine cathodes were studied using lithium ion rechargeable coin cells of the 2032 configuration. The results showed that the novel composite cathode exhibited excellent cyclability after twenty cycles, with capacity retention of 99.72% and coulombic efficiency of 90%, while the pristine cathode gave capacity retention of 89.61% and coulombic efficiency of 80.36%. The research results have been sent out for publication in peer-reviewed journals.

# Detailed Indicators of Collaboration

## Collaborative research projects implemented

| CSIR researchers                                      | UWC researchers                                                                    | Name of project                                                                                                             | 2011 | 2012 | Research area                      |
|-------------------------------------------------------|------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------|------|------|------------------------------------|
| Dr Dean Brady; Dr Friitha Hennessey; Dr Daniel Visser | Prof Donald Cowan                                                                  | Plantbio Biofuels platform: LEAF                                                                                            | •    | •    | Energy                             |
| Dr Michelle Audouin;<br>Dr Keith Kennedy              | Prof Yongxin Xu; Prof Jaqui Goldin; Prof Thokozani Kanyerere; Prof Eberhard Braune | Using IWRM best practices to develop appropriate capacity and training for the benefit of sub-Saharan Africa water security |      | •    | Natural environment                |
| Martella du Preez; Wouter Le Roux; Marna vd Merwe     | Jaco Nel                                                                           | Fate and transport of microbes in groundwater                                                                               | •    | •    |                                    |
| Dr Ravi Vadapalli                                     | Prof Leslie Petrik                                                                 | Industrial Brine Minimisation: Development and Application of functionalised fibres for Brine Treatment                     | •    | •    |                                    |
| Dr Vernon Somerset                                    | Prof Emmanuel Iwuoha                                                               | Electrochemical Sensor for Environmental Applications                                                                       | •    | •    |                                    |
| Dr Dean Brady                                         | Prof Donald Cowan                                                                  | Industrial biologics (lignocellulose degradation enzymes)                                                                   |      | •    | Biosciences                        |
| Dr Tsepo Tsekoa                                       | Prof Trevor Sewell;<br>Prof Wolf-Dieter Schubert                                   | Structural Characterisation of a Rabies prophylactic antibody expressed in Tobacco                                          | •    | •    |                                    |
| Dr Dawie van Vuuren                                   | Prof Vladimir Linkov                                                               | Electrolyser                                                                                                                | •    | •    | Material science and manufacturing |
| Dr Gerald Malgas;<br>Dr Thembela Hillie               | Prof Dirk Knoesen;<br>Prof Emmanuel Iwuoha;<br>Dr Christopher Arendse              | Solar cells and photovoltaic                                                                                                | •    |      | Nanotechnology                     |



## Joint outputs resulting from supervised and joint research

| Authors                                                                             | Title of paper                                                                                                                                              | Publication                                                                                                                                              |
|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Peer-reviewed journal articles</b>                                               |                                                                                                                                                             |                                                                                                                                                          |
| Sanyika TW; Stafford W; Cowan DA                                                    | The soil and plant determinants of community structures of the dominant actinobacteria in Marion Island terrestrial habitats, Sub-Antarctica                | Polar Biology, Vol. 35(8), Pages: 1129-1141<br>Aug 2012                                                                                                  |
| Vadapalli VRK; Gitari MW; Petrik LF; Etchebers O; Ellendt A                         | Integrated acid mine drainage management using fly ash                                                                                                      | Journal of Environmental Science and Health, Part A: Toxic/Hazardous Substance and Environmental Engineering, Vol. 47(1), Pages: 60-69<br>Jan 2012       |
| Mwakikunga BW; Maaza M; Hillie KT; Arendse CJ; Malwela T; Sideras-Haddad E          | From phonon confinement to phonon splitting in flat single nanostructures: a case of VO <sub>2</sub> @V <sub>2</sub> O <sub>5</sub> core-shell nano-ribbons | Vibrational Spectroscopy, Vol. 61, Pages: 105-111<br>Jul 2012                                                                                            |
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| Sone BT; Sithole J; Bucher R; Mlondo SN; Ramontja J; Sinha Ray S; Iwuoha E; Maaza M | Synthesis and structural characterisation of tungsten trioxide nanoplatelet-containing thin films prepared by aqueous chemical growth                       | Thin Solid Films, Pages: 164-170<br>2012                                                                                                                 |
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| Somerset V; Klink M; Petrik L; Iwuoha E                                                                           | Neutralisation of acid mine drainage with fly ash in South Africa                                                                                       | Mine Drainage and Related Problems, Pages: 211-226 Mar 2011                                                                                 |

## CSIR researchers lecturing/supervising students

| Name of researcher  | Research area as defined in MoU | Type of collaboration             | 2011 | 2012 |
|---------------------|---------------------------------|-----------------------------------|------|------|
| Dr Anwar Vahed      | ICT                             | External examination, supervision | •    |      |
| Dr Daniel Moeketsi  | ICT                             | Supervision, lecturing            | •    | •    |
| Dr Kenneth Ozoemena | Material science                | Lecturing                         | •    | •    |
| Dr Ravi Vadapalli   | Environmental management        | Supervision                       | •    | •    |
| Dr Nebo Jovanovic   | Environmental management        | Supervision                       |      | •    |
| Dr Bonex Mwakikunga | Material science                | Supervision                       |      | •    |
| Dr Gerald Malgas    | Material science                | Supervision                       | •    | •    |
| Dr Vernon Somerset  | Environment management          | Supervision                       | •    | •    |
| Derek Hohls         | ICT                             | Supervision                       | •    |      |

## Students supported by the CSIR/UWC scholarship programme

| Name of student  | Degree programme                        | UWC supervisor        | 2011 | 2012 |
|------------------|-----------------------------------------|-----------------------|------|------|
| Michael Berry    | PhD (Bioinformatics)                    | Dr Junaid Gamieldeen  |      | •    |
| Garvin Allard    | BSc Honours (Chemical Science)          | Dr Martin Opoyi Onani |      | •    |
| Asanda Busa      | MSc (Chemistry)                         | Dr Martin Opoyi Onani | •    | •    |
| Mduduzi Radebe   | MSc (Chemistry)                         | Dr Martin Opoyi Onani | •    | •    |
| Wade Harker      | MSc (Geography & Environmental Studies) | Michael Dyssel        | •    | •    |
| Usisipho Feleni  | BSc Honours (Chemistry)*                | Prof Emmanuel Iwuoha  | •    |      |
| Unathi Sidwaba   | BSc Honours (Environmental Studies)*    | Prof Emmanuel Iwuoha  | •    |      |
| Dean Booysen     | MSc (Biotechnology)*                    | Prof Donald Cowan     | •    |      |
| Hlamulo Makelane | PhD (Chemistry)*                        | Prof Emmanuel Iwuoha  | •    |      |
| Exo Nxusani      | BSc Honours (Chemistry)*                | Prof Emmanuel Iwuoha  | •    |      |

## CSIR Staff studying

| Name of CSIR staff     | CSIR supervisor     | UWC supervisor           | Degree programme          | 2011 | 2012 |
|------------------------|---------------------|--------------------------|---------------------------|------|------|
| Sibongiseni Thabethe   | Dr Bonex Mwakikunga | Prof Christopher Arendse | MSc (Physics)             |      | •    |
| Bongani Thabethe       | Dr Gerald Malgas    | Prof Christopher Arendse | MSc (Physics)             |      | •    |
| Chavon Walters         | Dr Vernon Somerset  | Prof Edmond Pool         | PhD (Medical Biosciences) |      | •    |
| Charlton van der Horst | Dr Vernon Somerset  | Prof Emmanuel Iwuoha     | PhD (Chemistry)           | •    | •    |
| Lestinah Mthombeni*    | Derek Hohls         | Prof Peter Witbooi       | BSc Honours (Mathematics) | •    |      |
| David Motaung*         | Dr Gerald Malgas    | Prof Christopher Arendse | PhD (Physics)             | •    |      |

\* = Graduated

## CSIR researchers holding extraordinary professorships

| Name of researcher  | Area of expertise        | 2011 | 2012 |
|---------------------|--------------------------|------|------|
| Dr Kenneth Ozoemena | Chemistry                | •    | •    |
| Dr Nebo Jovanovic   | Environmental Management |      | •    |

## UWC researchers serving on CSIR advisory panel

| Name of researcher | Area of expertise | 2011 | 2012 |
|--------------------|-------------------|------|------|
| Prof Dirk Knoesen  | Nanoscience       | •    | •    |



# CSIR and University of Cape Town Partnership





# Introduction

This section of the report gives an overview of some of the research highlights and achievements resulting from the collaboration between the CSIR and UCT during 2011 and 2012. The collaboration was mainly in the areas identified in the memorandum of understanding between the two institutions:

- Materials science and manufacturing, with focus on photonics and laser manufacturing, bio-materials and laser materials processing.
- Natural resources and the environment, with focus on climate change, sustainability studies, marine studies, coastal engineering, energy and mining technology.
- Information and communications technology, with focus on scientific computing, human language technologies, and ICT for development.
- Biosciences and health, with focus on human cell biology, including gene regulation and immune function; recombinant proteins and inhibitors; biomedical engineering, including artificial liver programme, ocular implants, and delivery systems; synthetic organic and medicinal chemistry, including drug design; photodynamic therapy/imaging, including development and use of porphyrin-related compound; and the determination of macromolecular structure by electron microscopy and x-ray crystallography.
- Defence, peace, safety and security with focus on radar, explosive event and impact and intelligent agent software systems.
- Human capital development in the areas listed above, including joint appointments, staff exchanges, studentships and co-supervision of students in compliance with the internal requirements of the respective institutions, where applicable.

|                                                                  | 2011 | 2012 |
|------------------------------------------------------------------|------|------|
| Collaborative research projects implemented                      | 16   | 17   |
| Researchers at both institutions collaborating on joint projects | 60   | 52   |
| Joint outputs resulting from supervised and joint research       | 42   | 24   |
| CSIR researchers lecturing/supervising students                  | 36   | 28   |
| Students supported by the CSIR/UCT scholarship programme         | 8    | 12   |
| CSIR staff studying                                              | 42   | 38   |
| Scholarship students and CSIR staff who graduated                | 11   | 5    |
| CSIR researchers appointed as honorary research associates       | 3    | 4    |
| UCT researchers serving on CSIR research advisory panels         | 4    | 4    |

# Highlights and Achievements

## NATURAL ENVIRONMENT

### South African risk and vulnerability atlas

Dr Emma Archer van Garderen, CSIR • Prof Bruce Hewitson, UCT



#### Background

Climatic and other environmental changes are set to impact many sectors of South African society. Decision-makers in these sectors urgently require information on the impact and risk of global environmental change.

#### Response and progress

The South African Risk and Vulnerability Atlas (SARVA), an atlas of risk and vulnerability in the context of global environmental change, was published in 2011. The Atlas provides decision-makers with information on the impact and risk associated with global change in southern Africa. It provides easily-understandable global change sensitivity and vulnerability information at regional, national, provincial and municipal levels. It also helps support

national initiatives such as the National Disaster Management Framework.

The Atlas provides an electronic geographical information system (GIS), and South African researchers from various disciplines continuously update the content with new research. The Atlas captures data related to aspects such as groundwater, surface water, forestry, biodiversity, agriculture, demography, economics and social issues.

The SARVA project is funded by the Department of Science and Technology and is managed by the CSIR. Key content and technological inputs are provided by South African institutions and research groups, including the University of Cape Town, the University of KwaZulu-Natal, the University of the Witwatersrand, South African

National Biodiversity Institute, Global Earth Observation System of Systems, Kulima, and the South African Environmental Observation Network, who co-host the platform for the electronic spatial portal.

A dedicated outreach and capacity-building team is undertaking a programme of orientation and capacity-building on SARVA. The programme is assessed by the extent to which it is used by key stakeholders, namely local and provincial government, and the private sector. A clear monitoring and evaluation framework has been designed for SARVA in this regard. Workshops and orientation sessions have been held since 2010.

#### Outputs

Technology demonstrator – 1  
Book – 1

## Collaborative research on the ecology and management of invasive alien plants

Dr Brian van Wilgen, CSIR • Prof John Hoffmann, Prof Cliff Moran, UCT • Prof Dave Richardson, SU



### Background

The invasion of ecosystems by alien species is an increasingly important aspect of global change. The on-going and increasing human redistribution of species into new environments to support agriculture, forestry, horticulture and recreation supplies a continuous pool of species from which invasive aliens are recruited. The problem is growing in severity and geographic extent as global trade and travel accelerate. As human-mediated disturbance changes the world's climate and biogeochemical cycling,

ecosystems also become more susceptible to invasion by alien species. As a result, all human communities and natural ecosystems are under siege from a growing number of destructive invasive alien species that erode natural capital, compromise ecosystem stability, and threaten economic productivity.

Invasive alien species already cause damage estimated at billions of dollars worldwide. The situation is of major concern in South Africa, especially with regard to invasive alien plants. Invasive plants affect almost 10 million hectares (over 8%) of

the country, and have negative impacts on ecosystem services and agricultural practices. Perhaps best known in South Africa are the impacts that invading tree species have on scarce water resources. However, there are many others. They include the exacerbation of problems with wildfires; the reduction of the grazing potential of the land by replacing palatable plants with unpalatable or poisonous plants; the reduction of biodiversity and the potential extinction of many endemic species; and the degradation of water bodies by invading aquatic weeds.



Dealing with this problem requires a sound understanding of the ecology of invasive species, and the identification of effective methods to control them. It also requires a detailed understanding of the impacts of invasive alien species, so that the economic consequences of invasions can be assessed. This is especially important and challenging, where alien species simultaneously provide benefits, but cause unintended problems. Finally, it is necessary to use this understanding to formulate effective policies to address the problems.

### Response

Through the Department of Science and Technology/National Research Foundation Centre of Excellence for Invasion Biology which is hosted by SU, researchers from SU, UCT and the CSIR have collaborated in studying a variety of aspects relating to the ecology and management of invasive alien

plants over the past five years. All three collaborating partners also work closely with the Working for Water programme, which manages alien plant control.

### Progress

The work has led to the quantification of current and potential future impacts of invasive alien plants in South Africa, in both biophysical and economic terms. The latest assessments indicate that impacts on water resources, grazing and other biodiversity-related ecosystem services are substantial. Robust criteria for the prioritisation of control operations have also been developed, to ensure that the limited funds available for control are directed to areas where they will achieve the greatest benefit. The team works closely with implementing agents, and the results of the work are currently informing control operations across the country. These include control projects managed by

Working for Water, South African National Parks, conservation departments in all nine provinces, and the South African National Defence Force.

The impacts of invasive alien plants are substantial, and improving the management of the problem can lead to equally substantial benefits. The work has shown that although an estimated R6.5 billion is lost every year due to invading alien plants, this would have amounted to an estimated additional R41.7 billion had no control been carried out.

### Outputs

Peer-reviewed journal articles – 9  
Book chapters – 2  
Students trained – 2



# BIOSCIENCES

## ReSyn™: Next-generation microsphere technology platform

Dr Justin Jordan, CSIR • Prof Jonathan Blackburn, Prof Edward Rybicki, Prof Trevor Sewell, UCT • Prof Donald Cowan, UWC

### Background

The CSIR has developed and patented a novel microsphere technology platform, called ReSyn™, that offers significant advantages over current commercial technologies. The novelty of the ReSyn™ technology is the use of polyethyleneimine (PEI) as the core polymer material and controlled degree of cross-linking, resulting in a loosely-linked matrix. This allows biological molecules to penetrate the entire volume of the microsphere, in contrast to the current solid and porous microsphere technologies that are limited to surface-based interaction, or allow limited penetration of biological molecules. Coupled with the high functional group density afforded by the use of PEI, this provides an unparalleled binding capacity for biological molecules. ReSyn™ microspheres are further readily engineered to provide several functionalities and superior performance features, such as exceptional purity, recovery, sensitivity, ease of use and efficiency.

The research team has successfully translated these features into market-ready products. Commercialisation of these products is planned through the creation of a start-up company, ReSyn™ Biosciences. The demonstrated competitive advantages of the ReSyn™ technology, and the potential applications, provide an opportunity to make a significant contribution to South Africa's emerging bio-economy.

### Response

The work relating to the microsphere technology platform includes the development and evaluation of microsphere research reagents and the development of next-generation diagnostic technologies.

In the development of research reagents, the UCT and UWC researchers have identified a number of opportunities where ReSyn™ technologies and products can enable and improve the efficiencies of current research and development (R&D) workflows, leading to increased R&D efficiency, and enhanced outputs or outcomes. In many instances, the ReSyn™ technology and products are able to provide R&D solutions that are not possible with current technologies.

For example, the availability of suitable biomarkers is a key limitation in the development of new, accurate and sensitive diagnostic devices. UCT has implemented a programme to identify a suite of tuberculosis (TB) biomarkers that may subsequently be used for the development of rapid and accurate TB diagnostic tests.

Biomarker discovery is a complex process that relies heavily on the accuracy of the data generated using analytical mass spectrometry. The complexity is compounded by data interpretation using bio-informatic tools. Research reagents and sample preparation techniques are critical

in sample quality for mass spectrometry analysis, and are required to reduce the complexity of data analysis by providing high purity samples.





### Progress

Several process steps where the ReSyn™ technology can assist in improving R&D efficiency and data quality have been identified. The development of reagents with highly-desirable features not only results in improved efficiencies in biomarker discovery, but can potentially lead to the identification of biomarkers not possible with current commercially-available alternatives. The MagReSyn™ Trypsin product has been developed for increased speed of protein digestion (accomplishing reduction from the current 24 hours to 1 hour without loss of data integrity), and to perform in extremely harsh conditions (8 M urea). No existing commercial products are capable of offering this.

The team has identified several other partners with key issues or potential

opportunities for improved bio-separation, where the technology platform may be used to alleviate problems and bottlenecks. These include microspheres for bio-therapeutic protein purification (UCT), and enzyme discovery and purification applications (UWC). The tailoring of R&D tools, in partnership with UCT and UWC, allows for direct translation of the superior features of the microsphere technology to address relevant R&D outcomes.

The CSIR and UCT are translating the superior features of the microsphere technology platform for detection agents aimed at alleviating the limitations in sensitivity and specificity of current diagnostic technologies. Together with other partners they are also developing next-generation diagnostic technologies that utilise the unique advantages of this

technology platform, with a focus on the development of improved sensitivity for point-of-care application. The development of next-generation diagnostic detection agents and devices is aimed at reducing the limitations of current technologies.

### Outputs

Students trained – 3



# Development of nanomedicine-based drug delivery systems for malaria treatment

Dr Hulda Swai, CSIR • Prof Peter Smith, UCT

## Background

Malaria is one of the world's most devastating diseases and a leading cause of sickness and death in the developing world. About 3.3 billion people, close to half of the world's population, are at risk of contracting malaria. The most vulnerable groups include young children and pregnant women, as well as nonimmune travelers and immigrants. In sub-Saharan Africa where more than 90% of morbidity and deaths occur, a child dies of malaria every 12 seconds.

Currently, there is no effective vaccine against malaria. The increase in parasite resistance to existing drugs, as well as poor bio-availability have led to therapeutic failures. Therefore, there is a need to protect and increase the available anti-malarials by using new innovative modalities such as drug delivery systems. This is aimed at enhancing their effectiveness, solubility and bioavailability, and achieve a reduction in the administered dose without reducing their efficacy. The application of nanotechnology should enhance the efficacy of the therapeutic agents.

## Response

Samples for the preliminary investigation, using the UCT *in vitro* facility are being tested. The envisaged results are:

- Finding drug delivery systems for the optimal use of new and current drugs used in the treatment of malaria.

- Carrying out *in vitro* Absorption, Distribution, Metabolism, Excretion and Toxicity (ADMET) and pharmacokinetic/pharmacodynamic (PK/PD) studies towards the validation of *in vitro* and *in vivo* models for the safe and effective use of medicines against malaria.
- Defining a commercial niche for such findings which can be jointly exploited by UCT and the CSIR.

- Research capacity-strengthening of the CSIR and UCT, in the science and technology of drug delivery, ADMET and PK/PD studies.
- Joint publications and application for funds.

The current approach will strengthen the platform in South Africa for drug encapsulation and delivery of new and existing therapeutic agents and actives for malaria, and other poverty-related diseases in Africa. This will enhance human capital development through the various training and research opportunities, and also enable South Africa to effectively prevent future spread of resistant malaria in the country. It could lead to improvement in the bio-availability of existing therapies and thus decrease the dose administered. Finding an effective solution to malaria will reduce the disease risk of concomitant infection in HIV-infected patients.



# MATERIALS SCIENCE AND MANUFACTURING

## Titanium Centre of Competence

Dr Willie du Preez, CSIR • Prof Rob Knutsen, UCT • Prof Dimitri Dimitrov, SU

### Background

The Titanium Centre of Competence (TiCoC) was established in 2009. The South African government, the research and development community, and leading aerospace companies, such as Airbus and Boeing recognise the importance of titanium to the aerospace industry and the role that the TiCoC can play in developing it. The revival of a South African space industry has also highlighted the need for titanium for applications such as the building of satellites.

### Response

The TiCoC has responded to the needs of government and industry by developing and implementing several technology blocks, as illustrated in Figure 1.

The development of four technology blocks – primary metal production, powder consolidation, high speed additive manufacturing and investment casting – is led by the CSIR, working in collaboration with other organisations, such as Mintek, SU and UCT. Mill products technology will receive particular attention and investment in the next three years. Given the time schedule for the commercialisation of the primary metal production technology, a market for locally-produced titanium powder will be required in about five years. The country should aim to establish competence

**Titanium Centre of Competence:**  
Developing and commercialising technology building blocks for the South African titanium industry

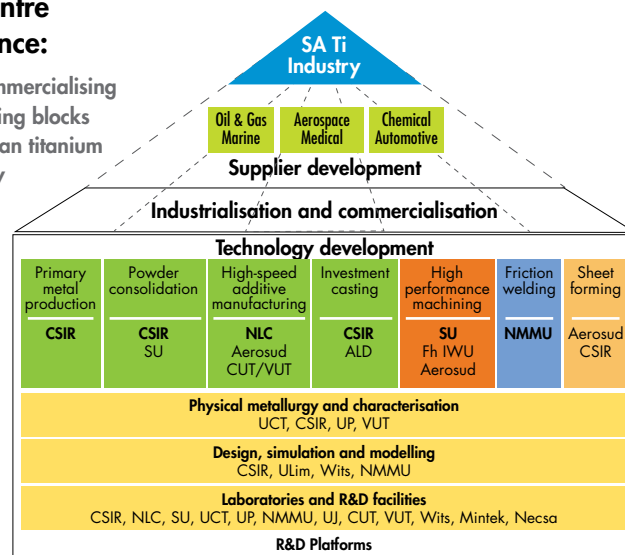


Figure 1: The Titanium Centre of Competence operational framework.

to convert such powder into mill products (large basic shapes, such as sheet, bar or tube) by that time.

SU has been leading work on machining of titanium in collaboration with local partners, such as UCT, and University of Johannesburg, as well as the Fraunhofer Institute. The first phase of this work was completed in 2012. A competence base in titanium machining has been established in South Africa, and the work has demonstrated a substantial potential

reduction in machining times. Opportunities for further collaboration with German institutions are being explored. Additive manufacturing of titanium has grown in prominence, with the CSIR National Laser Centre providing the lead, especially in the development of high speed laser additive manufacturing (HSAM).

The Central University of Technology has established competence in additive manufacturing of titanium implants for orthopaedic and orthodontic purposes,



through collaboration with the local and international orthopaedic industries and medical practitioners. A globally-leading South African medical company, Southern Implants, has confirmed its interest in using some of the technologies in the production of medical and dental implants using titanium. One of these technologies is metal injection moulding (MIM) of titanium dental implants.

On the joining of titanium, Nelson Mandela Metropolitan University, in collaboration with other South African and international

research groups, has been the key contributor, specifically on friction stir welding of titanium. The research consortium has demonstrated its ability to apply friction stir welding to titanium, and will continue to deepen its understanding and extend the technology to linear friction welding for medical and aerospace applications.

Regarding the underpinning R&D platforms, UCT is leading in the physical metallurgy of titanium. Simulation and modelling activities include *ab initio* modelling, and

finite element-based modelling and analysis of metal conversion processes and products, (led by the CSIR). Simulation and modelling is becoming much more prominent as the TiCoC is moving towards industrialisation and commercialisation of technologies for which engineering design, analysis and modelling are crucial.

### Progress

Through the support of the Department of Science and Technology for the Light Metals Development Network and the TiCoC, the CSIR and the other consortium members have upgraded their R&D facilities and have also established new facilities, eg in powder metallurgy.

The TiCoC initiative has a large human capacity development component, in collaboration with tertiary education institutions. The industrialisation and commercialisation of the technologies that are being developed is being done with the support of the Technology Innovation Agency, and the industry support initiatives of the Department of Trade and Industry, as well as local private sector companies.

### Outputs

Students trained – 4  
Peer-reviewed conference papers – 2  
Peer-reviewed journal articles – 5

## Electrochemical fabrication of membrane electrode assembly for fuel cell application

*Dr Mmalewane Modibedi, Dr Mkhulu Mathe, Dr Kenneth Ozoemena, CSIR • Prof Jack Fletcher, UCT*

### Background

Alternative energy resources are needed to alleviate the energy crisis. Fuel cells, such as proton exchange membrane fuel cells (PEMFCs), have the potential to solve part of the problem. The cost of PEMFCs depends primarily on the costs of platinum (Pt) and the membrane. The development of a new fabrication technique for membrane-electrode assembly (MEA), which will increase the Pt utilisation, is one of the major issues in fuel cell research.

### Response

The main purpose of the research was to explore the feasibility of using the automated sequential electrochemical deposition method. This involved the application of multilayer growth mechanisms in the form of Electrochemical Atomic Layer Deposition, for the fabrication of catalytic active nanostructured layers, or nanofilms, directly onto electrode materials at ambient conditions for applications in energy devices. The research could reduce the costs of PEMFCs electrodes and hence



accelerate the commercialisation of fuel cells, accompanied by employment creation.

Working with the UCT Chemical Engineering department was important for establishing the link between the chemistry and engineering aspects of fuel cells. The Computational Fluid Dynamics (CFD) study was also launched at UCT as an undergraduate research project. Although the process of CFD proved useful and pertinent to the research objective, the project has not yet delivered a design proposal for the desired electrochemical cell. Funding has been secured from the National Research Foundation-Thuthuka (2011) to continue this project. A presentation based on the proposed technique was made at the CSIR-US Air Force workshop in 2011. This proposed technique is further applied in the fabrication of electrode materials for alkaline alcohol fuel cells using Pd as the catalytic active metal.

### Outputs

Students trained – 3

# Human Capital Development

## CONTEXT OF THE COLLABORATION

Pinda Sifunda, CSIR • Linda Vranas, UCT

UCT and the CSIR support human capital development through several mechanisms. The joint UCT/CSIR scholarship programme supported 14 students in 2011 and 2012 – 5 PhD, 7 Master's, and 2 Honours.

In the same period, 52 CSIR staff members – 1 Honours, 28 Master's, 23 doctoral candidates – were supported by the CSIR to study for higher qualifications at UCT in disciplines including electrical engineering, biochemistry, health science, and oceanography. Some of the staff were supervised by UCT and CSIR researchers and worked on CSIR projects as part of their graduate programmes. Sixteen CSIR staff members completed their studies in the two years.

A large number of CSIR staff members are lecturing and supervising students at UCT and some have been awarded honorary appointments by the university. This includes four honorary research associates, as well as 46 lecturers and supervisors. A selection of some of the student research and experiences follows.

**Bianca Amos-Brown** is studying for a PhD in Medical Biochemistry in the field of tuberculosis diagnostics. "Our aim is to develop a platform for an affordable point-of-care diagnostic test that overcomes the shortfalls of current diagnostics. I am developing capture molecules for one of the target biomarkers that will be used in the final assay. This research is important for the fight against tuberculosis, as diagnosis is key to reducing the time that a patient is infectious, and to administering the correct treatment. This type of assay could be used for the detection of biomarkers in other diseases in the future."

**Jessica Kavonic** is studying for an MSc in Environmental Management. Climate change is expected to have impacts on coastal zones. South African coastal communities could be particularly vulnerable to the predicted impacts of sea level rise and the potential change in the frequency and intensity of coastal storms. One of the key adaptive measures used to reduce this vulnerability is the determination and establishment of coastal development setback lines. The research investigates the potential socio-economic implications of the establishment of coastal setback lines for the Kogelberg Coast in the Western Cape. The implementation of coastal setbacks has multiple social and economic implications for coastal property owners, especially with respect to property rights and the associated loss of property value.

Using a preliminary cost-benefit analysis, the cost of alternate coastal protection measures is considered to determine the potential use and favourability of coastal setbacks. The study will offer guidance and assist the management of the South African coastline, particularly in the context of climate change.



## SUPERVISED RESEARCH

### Using an airborne hyperspectral and LiDAR integrated sensor approach to spectrally discriminate and map savanna bush encroaching species in the greater Kruger National Park region

Laven Naidoo, CSIR • Supervisor: Dr Moses Cho, Dr Renaud Mathieu, CSIR • Dr Frank Eckardt, UCT

#### Background

Bush encroachment is an environmental phenomenon which affects arid and semi-arid savanna rangelands across the world. Bush encroachment has numerous negative and positive impacts on these savanna ecosystems depending on the land use practices and associated rangeland management regimes. In an attempt to understand bush encroachment further, mapping of encroaching species, rather than traditional quantitative woodiness analyses, provided a greater understanding of savanna ecosystem dynamics for management. The introduction of the Carnegie Airborne Observatory (CAO) integrated hyperspectral and Light Detection And Ranging (LiDAR) sensor technology have provided simultaneous spectral and structural information to mitigate the challenges associated with tree species level mapping in savanna environments.

This study spectrally decomposed and describe the regional patterning of key bush encroaching species in the Greater Kruger National Park savanna ecosystem of Mpumalanga. The objective was to investigate the spectral and structural characteristics of the patterning of savanna tree species, particularly bush encroaching species, over regionally varying topography, geology and different management practices. The project

specifically intended to provide accurate mapping of the spatial distribution of economically viable trees, which are a key source of food production and fuel wood for the local populace and communities (e.g. the Marula tree); help ecologists and managers to monitor problematic alien invasive species and bush encroaching species which have detrimental impacts on the local populace and biodiversity (e.g. the Sickle bush); and help improve the natural quality of the heavily impacted and sensitive environments.

#### Response

In an attempt to investigate the intra and inter-species spectral separability of savanna tree species in general, it was found that the bulk of the species' discriminatory potential in the entire transformed spectrum was concentrated in the primary and secondary plant chemical spectral wavelengths where chlorophylls -a and -b, carotenoids and xanthophylls were most expressive. Despite this, Spectral Similarity Measurement (SSM) results illustrated that the bush encroaching species in this study yielded fairly low spectral discriminatory values as their spectral properties were considered to be fairly similar to surrounding species. This would make species separation and subsequent mapping very challenging.

A novel decision tree multiple endmember SAM classification approach was thus



proposed, in an attempt to overcome the lack of spectral separability between bush encroaching and other savanna tree species, and tested against a traditional multiple endmember Spectral Angle Mapper (SAM). The final 2 end node decision tree design derived from minimum tree height thresholding, together with the use of spectrally significant bands, yielded the highest overall classification accuracy of 62.2% which surpassed the traditional approach (56.7%). As an end product of this study, individual bush encroaching species distribution maps were produced from the final decision tree design.

#### Outputs

Conference papers – 2

## Preparation of a self-contained NADH co-factor recycling particle system

Busisiwe Twala, CSIR • Supervisors: Dr Justin Jordaan, CSIR • Prof Trevor Sewell, UCT

### Background

The use of enzymes for applications in the textile, food and feed, chemical and biomedical industries is well established. This is due to their superior efficiency, high specificity, and comparatively clean technology (reduced by-products). The applications of enzymes are limited by their relative instability at high temperatures and in highly acidic or alkaline conditions, short-half-lives, and further environmental parameters including their use in organic solvents. Furthermore, enzymes in the class of oxidoreductases require the use of expensive co-factors in stoichiometric amounts for their enzymatic activity. These co-factors are not readily recoverable from biocatalytic systems; all of which negatively impacts on process viability and increases costs, hampering the enzymes applicability.

Various methods, which involve the immobilisation of the enzymes and subsequent recycling of the co-factors, have been developed to alleviate these disadvantages. Immobilisation provides a platform for improving the chemical and physical stability of the enzymes. Since glucose dehydrogenase (GDH) and NADH oxidase (NOD) are widely-used industrial co-factor recycling enzymes for NAD(P)H and NAD<sup>+</sup> respectively, characterisation of their immobilisation is of interest.

### Response

The work focused on using the proprietary particle technology, termed ReSyn™ for the construction of a self-contained enzymatic co-factor recycling system. The immobilised enzymes displayed improved thermal and pH stability compared to the non-immobilised native enzyme. The system was shown to be capable of recycling NADH/NAD<sup>+</sup> and it could be recovered and re-used efficiently. The adoption of such a system may be used to greatly reduce the quantity of co-factor required and allow the recycling and re-use of the enzymes in certain biocatalytic applications, thus reducing process costs and simplifying downstream processing.



### Outputs

Peer-reviewed journal article – 1

# Detailed Indicators of Collaboration

## Collaborative research projects implemented

| CSIR researchers                                  | UCT researchers                                 | Name of project                                                                              | 2011 | 2012 | Research area        |
|---------------------------------------------------|-------------------------------------------------|----------------------------------------------------------------------------------------------|------|------|----------------------|
| Peta de Jager;<br>Thabang Molefi;<br>Jan Opperman | Mladen Poluta                                   | TB and HIV infection prevention and control                                                  | •    | •    | Health               |
| Dr Hulda Swai                                     | Prof Peter Smith                                | Development of nanomedicine-based drug delivery systems for malaria treatment                | •    | •    |                      |
| Raj Laloo                                         | Dr Vernon Coyne                                 | Industrial Biologics (Abalone probiotics)                                                    |      | •    | Biosciences          |
| Dr Dashnie Naidoo                                 | Prof Nonhlanhla Khumalo                         | Cosmeceuticals                                                                               |      | •    |                      |
| Dr Justin Jordaan                                 | Prof Jonathan Blackburn                         | Hypersensitive detection agents                                                              | •    | •    |                      |
| Dr Dusty Gardiner;<br>Dr Justin Jordaan           | Prof Jonathan Blackburn;<br>Prof Edward Rybicki | Next generation microsphere products                                                         | •    | •    | Defence and security |
| Asheer Bachoo;<br>Jason de Villiers               | Prof Fred Nicolls                               | Image Processing: Active texture segmentation (Research Visit to CSIR)                       | •    | •    |                      |
| Thanyani Pandelai                                 | Prof Fred Nicolls                               | Passive optical ranging                                                                      | •    | •    |                      |
| Dr Bennie Boughton                                | Prof Bob Tait;<br>Prof Daya Reddy               | BALLAST: Evaluation of objective functions for the optimisation of non-axisymmetric endwalls | •    | •    |                      |
| Dr Glen Snedden                                   | Prof Bob Tait;<br>Prof Daya Reddy               | BALLAST: Material properties of directly manufactured titanium                               | •    | •    | ICT                  |
| Dr Bennie Boughton                                | Dr Arnaud Malan                                 | High performance computing                                                                   |      | •    |                      |

| CSIR researchers                                                                                                                                                                                                                                                  | UCT researchers                                                                                                                                                                        | Name of project                                                                                                                     | 2011 | 2012 | Research area          |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------|------|------|------------------------|
| Kristy Facer                                                                                                                                                                                                                                                      | Ralph Hamann                                                                                                                                                                           | Business Risk & Resilience                                                                                                          |      | •    | Natural environment    |
| Dr Julia Mambo;<br>Dr Emma Archer van Garderen; Dr Bob Scholes; Willem Landman; Francois Engelbrecht; Alize le Roux; Elsona van Huysteen; Dr Belinda Reyers; Dr Luthando Dziba; Pierre de Wet; Daleen Lotter; Claire Davis; Tirusha Thambiran; Thamsanqa Mzinyane | Prof Bruce Hewitson; Dr Chris Jack; Dr Chris Lennard; Dr Babatunde Abiodun; Dr Mark Tadross; Dr Mathieu Roault; Dr Francois Dufois; Prof John Field; Gina Ziervogel; Prof Timm Hoffman | Risk & Vulnerability Atlas                                                                                                          | •    | •    |                        |
| Dr Nicolas Fauchereau                                                                                                                                                                                                                                             | Prof Chris Reason                                                                                                                                                                      | Trends in the Southern Annular Mode: what impact on Southern Ocean air-sea fluxes?                                                  | •    |      |                        |
| Dr Brian van Wilgen                                                                                                                                                                                                                                               | Prof John Hoffmann; Prof Cliff Moran                                                                                                                                                   | Ecology and management of invasive alien plants                                                                                     | •    |      |                        |
| Dr Emma Archer van Garderen                                                                                                                                                                                                                                       | Dr Gina Ziervogel                                                                                                                                                                      | Supporting climate change adaptation in a rural Western Cape Province municipality                                                  |      | •    |                        |
| Dr Manfred Scriba                                                                                                                                                                                                                                                 | Prof Margit Härting                                                                                                                                                                    | Nanostructured Silicon Intermediate Layers for Energy Solutions in Photovoltaics and Energy Storage                                 | •    | •    | Nanotechnology         |
| Aletta Karsten                                                                                                                                                                                                                                                    | Dr Lester Davids                                                                                                                                                                       | An investigation into the photodynamic treatment of skin cancers using laser light activation of second generation photosensitizers | •    |      | Lasers                 |
| Dr Mmalewane Modibedi; Dr Mkhulu Mathe; Dr Kenneth Ozoemena                                                                                                                                                                                                       | Prof Jack Fletcher                                                                                                                                                                     | Electrochemical fabrication of membrane electrode assembly for fuel cell application                                                | •    | •    | Energy                 |
| Kiri Nicolaides                                                                                                                                                                                                                                                   | Dr Andrew Wilkinson                                                                                                                                                                    | Sonar Signal Processing/Ledger Programme                                                                                            | •    |      | Advanced manufacturing |
| Dr Willie du Preez                                                                                                                                                                                                                                                | Prof Rob Knutsen                                                                                                                                                                       | Titanium Centre of Competence (Physical Metallurgy of Titanium)                                                                     | •    | •    |                        |

## Joint outputs resulting from supervised and joint research

| Authors                                                                                                 | Title of paper                                                                                                                                                             | Publication                                                                                                  |
|---------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------|
| <b>Peer-reviewed journal articles</b>                                                                   |                                                                                                                                                                            |                                                                                                              |
| Mufhandu HT; Gray ES; Madiga MC; Tumba N; Alexandre KB; Khoza T; Wibmer CK; Moore PL; Morris L; Khati M | UCLA1, a synthetic derivative of a gp120 RNA aptamer, inhibits entry of human immunodeficiency virus type 1 subtype C                                                      | Journal of Virology, Vol. 86(9), Pages: 4989-4999<br>May 2012                                                |
| Rybicki EP; Chikwamba R; Koch M; Rhodes JI; Groenewald J-H                                              | Plant-made therapeutics: an emerging platform in South Africa                                                                                                              | Biotechnology Advances, Vol.30(2), Pages: 449-459<br>Mar-Apr 2012                                            |
| Matthews MW; Bernard S; Robertson L                                                                     | An algorithm for detecting trophic status (chlorophyll-a), cyanobacterial-dominance, surface scums and floating vegetation in inland and coastal waters                    | Remote Sensing of Environment, Vol. 124, Pages: 637-652<br>Sep 2012                                          |
| Wischiers-Theophilus H; Bidwell NJ; Blake E                                                             | Altering participation through interactions and reflections in design                                                                                                      | CoDesign: International Journal of CoCreation in Design and the Arts, Vol 8(2-3), Pages: 163-182<br>Jun 2012 |
| Oxtoby OF; Malan AG                                                                                     | A matrix-free, implicit, incompressible fractional-step algorithm for fluid-structure interaction applications                                                             | Journal of Computational Physics Vol. 231(16), Pages: 5389-5405<br>Jun 2012                                  |
| Dewar G; Reimer PJ; Sealy J; Woodborne S                                                                | Late-Holocene marine radiocarbon reservoir correction (Delta-R) for the west coast of South Africa                                                                         | The Holocene, Vol. 22(12), Pages: 1481-1489<br>Dec 2012                                                      |
| Buitenwerf R; Bond WJ; Stevens N; Trollope WSW                                                          | Increased tree densities in South African savannas: >50 years of data suggests CO <sub>2</sub> as driver                                                                   | Global Change Biology, Vol. 18(2), Pages: 675-684<br>Feb 2012                                                |
| Krug M; Tournadre J                                                                                     | Satellite observations of an annual cycle in the Agulhas Current                                                                                                           | Geophysical Research Letters Vol. 39, Issue 15<br>Aug 2012                                                   |
| Wright CY; Norval M; Summers B; Davids L; Coetzee G; Oriowo MO                                          | The impact of solar ultraviolet radiation on human health in Sub-Saharan Africa                                                                                            | South African Journal of Science, Vol. 108(11/12), 6pp<br>Oct 2012                                           |
| Twala BV; Sewell BT; Jordaan J                                                                          | Immobilisation and characterisation of biocatalytic co-factor recycling enzymes, glucose dehydrogenase and NADH oxidase, on aldehyde functional ReSyn polymer microspheres | Enzyme and Microbial Technology, Vol. 50(6-7), Pages: 331-336<br>May 2012                                    |



| Authors                                                                                                                 | Title of paper                                                                                                                                                                 | Publication                                                              |
|-------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------|
| O'Farrell PJ; Anderson PML; Le Maitre DC; Holmes PM                                                                     | Insights and opportunities offered by a rapid ecosystem service assessment in promoting a conservation agenda in an urban biodiversity hotspot                                 | Ecology and Society, Vol. 17(3), 2012                                    |
| Winschiers-Theophilus H; Bidwell NJ; Blake E                                                                            | Community consensus: Design beyond participation                                                                                                                               | Design Issues, Vol. 28(3), Pages: 89-100 Jul 2012                        |
| Mariotti V; Bopp L; Tagliabue A; Kageyama M; Swingedouw D                                                               | Marine productivity response to Heinrich events: a model-data comparison                                                                                                       | Climate of the Past, Vol. 8(5), Pages: 1581-1598 Oct 2012                |
| Zawaira A; Pooran A; Barichievsky S; Chopera D                                                                          | A discussion of molecular biology methods for protein engineering                                                                                                              | Molecular Biotechnology, Vol. 51(1), Pages: 67-102 May 2012              |
| Fouche G; Nieuwenhuizen N; Maharaj V; Van Rooyen S; Harding N; Nthambeleni R; Jayakumar J; Kirstein F; Emedi B; Meoni P | Investigation of <i>in vitro</i> and <i>in vivo</i> anti-asthmatic properties of <i>Siphonochilus aethiopicus</i>                                                              | Journal of Ethnopharmacology, Vol. 133(2), Pages: 843-849 Jan 2011       |
| Nel JL; Turak E; Linke S; Brown C                                                                                       | Integration of environmental flow assessment and freshwater conservation planning: a new era in catchment management                                                           | Marine and Freshwater Research, Vol. 62(3), Pages: 290-299 Mar 2011      |
| Shackleton CM; Scholes BJ; Vogel C; Wynberg R; Abrahamse T; Shackleton SE; Ellery F; Gambiza J                          | The next decade of environmental science in South Africa: a horizon scan                                                                                                       | South African Geographical Journal, Vol. 93(1), Pages: 1-14 Jun 2011     |
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| Naidoo D; Maharaj V; Crouch NR; Ngwane A                                                                                | New labdane-type diterpenoids from <i>Leonotis leonurus</i> support circumscription of <i>Lamiaceae</i> s.l.                                                                   | Biochemical Systematics and Ecology, Vol. 39(3), Pages: 216-219 Jun 2011 |
| Zawaira A; Yen Ching L; Coulson L; Blackburn J; Chun Wei Y                                                              | An expanded, unified substrate recognition site map for mammalian cytochrome P450s: Analysis of molecular interactions between 15 mammalian CYP450 isoforms and 868 substrates | Current Drug Metabolism, Vol. 12, Pages: 684-700 Jul 2011                |

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| Monteiro PMS; Dewitte B; Scranton MI; Paulmier A; Van der Plas AK                                                                                           | The role of open ocean boundary forcing on seasonal to decadal-scale variability and long-term change of natural shelf hypoxia                                                                                               | Environmental Research Letters, Vol. 6(2), 18pp<br>May 2011                              |
| Van Wilgen BW; Dyer C; Hoffmann JH; Ivey P; Le Maitre DC; Moore JL; Richardson DM; Rouget M; Wannenburgh A; Wilson RU                                       | National-scale strategic approaches for managing introduced plants: insights from Australian acacias in South Africa                                                                                                         | Diversity and Distributions, Vol. 17(5), Pages: 1060-1075<br>Sep 2011                    |
| Hoffmann JH; Moran VC; Van Wilgen BW                                                                                                                        | Prospects for the biological control of invasive <i>Pinus</i> species (Pinaceae) in South Africa                                                                                                                             | African Entomology, Vol. 19(2), Pages: 393-401<br>Sep 2011                               |
| Ratnam J; Bond WJ; Fensham RJ; Hoffmann WA; Archibald S; Lehmann CER; Anderson MT; Higgins SI; Sankaran M                                                   | When is a 'forest' a savanna, and why does it matter?                                                                                                                                                                        | Global Ecology and Biogeography, Vol. 20(5), Pages: 653-660<br>Sep 2011                  |
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| Amigun B; Von Blotnitz H                                                                                                                                    | Operating cost analysis of an annexed ethanol distillery in a rural, landlocked African country                                                                                                                              | Environmental Progress & Sustainable Energy, Vol. 30(3), Pages: 500-515<br>Oct 2011      |
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| Joubert WR; Thomalla SJ; Waldron HN; Lucas MI; Boye M; Le Moigne FAC; Planchon F; Speich S                                                                  | Nitrogen uptake by phytoplankton in the Atlantic sector of the Southern Ocean during late austral summer                                                                                                                     | Biogeosciences, Vol. 8, Pages: 2947-2959<br>2011                                         |
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| <b>Conference papers reviewed</b>                                      |                                                                                                                   |                                                                                                                                                                                                      |
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|-----------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Conference papers reviewed</b>                                           |                                                                                                                                                           |                                                                                                                                                                                           |
| Bogaers AEJ; Kok S; Reddy BD; Fran T                                        | Inverse parameter identification for a branching 1D arterial network                                                                                      | 3rd International Conference on Engineering Optimization (EngOpt 2012), Rio de Janeiro, Brazil, 1-5 July 2012, 10pp<br>Jul 2012                                                           |
| Bogaers AEJ; De Villiers AM; Kok S; Ubbink O; Franz T; Reddy BD; Du Toit CG | Towards the development of a fully coupled arterial-venous 1D model: suitability of using a 1D finite volume method with staggered spatial discretization | 10th World Congress on Computational Mechanics (WCCM 2012), Sao Paulo, Brazil, 8-13 July 2012, 16 pp<br>Jul 2012                                                                          |
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| Bergh J; Snedden G; Meyer C                                                 | Optimisation of non-axisymmetric end wall contours for the rotor of a low speed, 1 1/2 stage research turbine with unshrouded blades                      | ASME Turbo Expo 2012, Copenhagen, Denmark, 11-15 June 2012, 13pp<br>Jun 2012                                                                                                              |
| James S; Verrinder RA; Sabatta D; Shahdi A                                  | Localisation and mapping in GPS-denied environments using RFID tags                                                                                       | ROBMECH 2012: 5th Robotics and Mechatronics Conference of South Africa, Pretoria, 26-27 November 2012, 4pp<br>Sep 2012                                                                    |
| Makondo N; Claassens J; Tlale N; Braae M                                    | Geometric technique for the kinematic modelling of a 5 DOF redundant manipulator                                                                          | ROBMECH 2012: 5th Robotics and Mechatronics Conference of South Africa, Pretoria, 26-27 November 2012, 7pp<br>Nov 2012                                                                    |
| Golding D; Tittgemeyer M; Anwender A; Douglas T                             | A comparison of methods for the registration of tractographic fibre images                                                                                | Proceedings of the Twenty-Second Annual Symposium of the Pattern Recognition Association of South Africa (PRASA), Vanderbijlpark, South Africa, Pages: 51-59<br>November 2011<br>Nov 2011 |

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| Bachoo AK; De Villiers JP; Nicolls F; Le Roux PJ                                                                               | Quantitative analysis of the improvement in high zoom maritime tracking due to real-time image enhancement | Proceedings of SPIE – The International Society for Optical Engineering. Acquisition, Tracking, Pointing, and Laser Systems Technologies XXV. Vol. 9052 art. no. 80520C. Orlando, USA, 25 - 27 April 2011, Pages: 13pp<br>Apr 2011 |
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| Heyns JA; Harms TM; Malan AG                                                                                                   | Free-Surface modelling technology for compressible and violent flows                                       | 20th AIAA Computational Fluid Dynamics Conference, Honolulu, Hawaii, 27-30 June 2011, Pages: 16pp<br>Jun 2011                                                                                                                      |
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| Bidwell NJ; Lalmas M; Marsden G; Dlutu B; Ntlangano S; Manjingolo A; Tucker WD; Jones M; Robinson S; Vartiainen E; Klampanos I | Please call ME.N.U4EVER: Designing for 'callback' in rural Africa                                          | 10th International Workshop on Internationalisation of Products and Systems (IWIPS 2011), Kuching, Malaysia, 11-14 July 2011, 21pp<br>Jul 2011                                                                                     |
| De Villiers JP; Cronje J; Nicolls FC                                                                                           | Improved neural network modelling of inverse lens distortion                                               | Proceedings of SPIE – The International Society for Optical Engineering. Visual Information Processing XX, Orlando, Florida, USA, 26-28 April 2011, Pages: 9pp<br>Apr 2011                                                         |

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|----------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
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| Dube C; Tsoeu M; Tapson J                          | A model of the humanoid body for self-collision detection based on elliptical capsules                                            | 2011 IEEE International conference on Robotics and Biomimetics (IEEE-ROBIO 2011), art. no. 618657, Pages: 2397-2402. Phuket, Thailand, 7-11 December 2011, Dec 2011                                                 |
| De Villiers J; Wilson F; Nicolls F                 | The effects of lens distortion calibration patterns on the accuracy of monocular 3D measurements                                  | 22nd Annual International Symposium of the Pattern Recognition Association of South Africa (PRASA), Vanderbijlpark, South Africa, 22-25 November 2011, 6pp Nov 2011                                                 |
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| Sentongo VN; Ferguson KL; Dlodlo ME                | Real-time performance evaluation of media pipeline plug-in architectures                                                          | Southern Africa Telecommunication Networks and Applications Conference (SATNAC 2011), East London, South Africa, 4-7 September 2011, 6pp Sep 2011                                                                   |
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| Authors                                                          | Title of paper                                                                                                                                                                 | Publication                                                                                                                               |
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| Lubobya, C.S., Dlodlo, M.E., De Jager, G., Ferguson, K.L.        | SIMD implementation of integer DCT and Hadamard transforms in H.264/AVC encoder                                                                                                | 2011, IEEE AFRICON Conference, Victoria Falls, Zambia, 13 -15 Sept 2011 art. no. 6071998                                                  |
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| Koduri, N.R., Dlodlo, M.E., De Jager, G., Ferguson, K.L.         | Fast implementation of block motion estimation algorithms in video encoders                                                                                                    | Proceedings - 1st International Conference on Data Compression, Communication, and Processing, CCP 2011, art. no. 6061009. Pages: 103-107 |

## CSIR researchers lecturing/supervising students

| Name of researcher          | Research area as defined in MoU | Type of collaboration | 2011 | 2012 |
|-----------------------------|---------------------------------|-----------------------|------|------|
| Chris Elphinstone           | Built environment*              | Supervision           | •    |      |
| Dr Igle Gledhill            | Defence and security            | Supervision           | •    |      |
| Isaac Osunmakinde           | ICT                             | Lecturing             | •    |      |
| Dr Anwar Vahed              | ICT                             | External examination  | •    |      |
| Dr Bruce Becker             | ICT                             | Supervision           | •    |      |
| Dr Frans van den Bergh      | ICT                             | Supervision           | •    | •    |
| Dr Keith Ferguson           | ICT                             | Supervision           | •    | •    |
| Dr Tommie Meyer             | ICT                             | Supervision           | •    |      |
| Chris Burger                | ICT                             | Supervision           | •    |      |
| Dr Pedro Monteiro           | Natural environment             | Supervision           | •    | •    |
| Dr Stephan Woodborne        | Natural environment             | Supervision           | •    |      |
| Dr Esbeth van Dyk           | Built environment*              | Supervision           | •    | •    |
| Gerbrand Mans               | Built environment               | Supervision           |      | •    |
| Dr Bob Scholes              | Natural environment             | Supervision           |      | •    |
| Dr Stewart Bernard          | Natural environment             | Supervision           |      | •    |
| Dr Sandy Thomalla           | Natural environment             | Supervision           |      | •    |
| Dr Wesley Roberts           | Natural environment             | Supervision           |      | •    |
| Dr Emma Archer van Garderen | Natural environment             | Supervision           | •    |      |
| Dr Musa Mhlanga             | Biosciences                     | Supervision           |      | •    |
| Ali Shahdi                  | Modelling and digital science*  | Supervision           |      | •    |
| Deon Sabatta                | Modelling and digital science*  | Supervision           |      | •    |
| Willie Nel                  | Defence and security            | Supervision           |      | •    |
| Dr Colin Wright             | ICT                             | Supervision           |      | •    |
| Dr Raj Laloo                | Biosciences                     | Supervision           | •    | •    |
| Dr Justin Jordaan           | Biosciences                     | Supervision           | •    | •    |
| Jacques Etienne Cilliers    | Defence and security            | Supervision           | •    | •    |
| Dr Lionel Gresh             | Biosciences                     | Supervision           | •    | •    |
| Dr Makobetsa Khati          | Biosciences                     | Supervision           | •    | •    |
| Dr Vinesh Maharaj           | Biosciences                     | Supervision           | •    | •    |



| Name of researcher      | Research area as defined in MoU | Type of collaboration | 2011 | 2012 |
|-------------------------|---------------------------------|-----------------------|------|------|
| Dr Dean Brady           | Biosciences                     | Supervision           | •    |      |
| Dr Dalu Mancama         | Biosciences                     | Supervision           | •    | •    |
| Dr Stoyan Stoychev      | Biosciences                     | Supervision           | •    | •    |
| Dr Rachel Chikwamba     | Biosciences                     | Supervision           | •    | •    |
| Dr Jeff Chen            | ICT                             | Supervision           | •    |      |
| Etienne Bernard         | ICT                             | Supervision           | •    |      |
| Dr Quentin Williams     | ICT                             | Supervision           | •    | •    |
| Dr Nkgatho Tlale        | Modelling and digital science*  | Supervision           | •    | •    |
| Dr Schalk Kok           | Modelling and digital science*  | Supervision           | •    | •    |
| Jonathan Claassens      | Modelling and digital science*  | Supervision           | •    |      |
| Natasha Govender        | Modelling and digital science*  | Supervision           | •    |      |
| Onno Ubbink             | Modelling and digital science*  | Supervision           | •    |      |
| Dr Allan Wilson-Langman | ICT                             | Supervision           | •    |      |
| Dr Moses Cho            | Natural environment             | Supervision           | •    |      |
| Dr Renaud Mathieu       | Natural environment             | Supervision           | •    |      |
| Dr Phil Loveday         | Materials Science               | Supervision           | •    | •    |
| Dr Nicolas Fauchereau   | Natural environment             | Supervision           | •    | •    |

\*= Not in MoU

## Students supported by the CSIR/UCT scholarship programme

| Name of student      | Degree programme                                                | UCT supervisor          | 2011 | 2012 |
|----------------------|-----------------------------------------------------------------|-------------------------|------|------|
| Adila Cassim*        | BSoc Sci (Honours)<br>(Environmental and Geographical Sciences) | Dr Horman Chitonge      |      | •    |
| Lebohang Melato      | BSc (Honours)<br>(Ocean & Atmosphere Science)                   | Dr Isabel Ansorge       |      | •    |
| Jessica Kavonic      | MSc (Environmental Management)                                  | Dr Jane Turpie          |      | •    |
| Elizabeth Lain       | PhD (Oceanography)                                              | Dr Chris Reason         |      | •    |
| Sarah-Anne Nicholson | PhD (Oceanography)                                              | Dr Jennifer Veitch      |      | •    |
| Mfundo Vesi          | MEng (Civil Engineering)                                        | Prof Pilate Moyo        |      | •    |
| Bianca Amos-Brown    | MSc (Medical Biochemistry)                                      | Prof Jonathan Blackburn | •    | •    |
| Shaun Garnett        | MSc (Medical Biochemistry)                                      | Prof Jonathan Blackburn | •    | •    |
| Mine Cheri Zantow    | MSc (Biomedical Engineering)                                    | Prof Tania Douglas      | •    | •    |
| Mark Matthews        | PhD (Oceanography)                                              | Prof Frank Shillington  | •    | •    |
| Hapiloe Maranyane    | PhD (Medical Biochemistry)                                      | Prof Virna Leaner       | •    | •    |
| Stefan Milandri      | PhD (Environmental Management)                                  | Dr Kevin Winter         | •    | •    |
| Emily Musil*         | MEng (Chemical Engineering)                                     | Prof Alison Lewis       | •    |      |
| Rofhiwa Seletani     | MSc (Biomedical Engineering)                                    | Dr Lester John          | •    |      |

\* = graduated

## CSIR staff studying

| Name of CSIR staff  | CSIR supervisor                       | UCT supervisor                                      | Degree programme                | 2011 | 2012 |
|---------------------|---------------------------------------|-----------------------------------------------------|---------------------------------|------|------|
| Millicent Mokgalaka | Gerbrand Mans                         | Prof Julian Smit                                    | MSc (Geomatics)                 |      | •    |
| Alecia Nickless     | Dr Bob Scholes                        | Dr Peter Rayner; Dr Birgit Erni; Prof Les Underhill | PhD (Applied Science)           | •    | •    |
| Emma Bone           | Dr Stewart Barnard; Dr Sandy Thomalla | Dr Howard Waldron                                   | PhD (Oceanography) <sup>#</sup> |      | •    |
| Claire Davis        | Dr Wesley Roberts                     | Prof Timm Hoffman                                   | MSc (Botany)                    | •    | •    |
| Jacques van Tonder  | None                                  | None                                                | MBA                             |      | •    |
| Lambert de Wet      | None                                  | None                                                | MBA                             |      | •    |
| Loretta Magagula    | Dr Musa Mhlanga                       | Prof Frank Brombacher                               | MSc (Cell Biology)              |      | •    |
| Sisa James          | Ali Shahdi; Deon Sabatta              | Robyn Verrinder                                     | MSc (Electrical Engineering)    |      | •    |

| Name of CSIR staff          | CSIR supervisor                        | UCT supervisor          | Degree programme               | 2011 | 2012 |
|-----------------------------|----------------------------------------|-------------------------|--------------------------------|------|------|
| Sulayman Salie              | Willie Nel                             | Dr Amit Mishra          | MEng (Electrical Engineering)  |      | •    |
| Jane Hewitson               | Dr Colin Wright                        | Prof Michael Inggs      | PhD (Electrical Engineering)   | •    | •    |
| Dheepak Maharaj             | Dr Raj Laloo                           | Prof Sue Harrison       | PhD (Chemical Engineering)     | •    | •    |
| Andrish Reddy               | Dr Justin Jordaan                      | Dr Deon Bezuidenhout    | PhD (Biomaterials)             | •    | •    |
| Jason de Villiers           | None                                   | Dr Fred Nicolls         | PhD (Electrical Engineering)   | •    | •    |
| Asheer Bachoo               | None                                   | Dr Fred Nicolls         | PhD (Engineering)              | •    | •    |
| Vanessa Jansen van Rensburg | None                                   | Prof Michael Inggs      | MEng (Electrical Engineering)  | •    | •    |
| Richard van Schalkwyk       | None                                   | Prof Michael Inggs      | MEng (Electronic & Electrical) | •    | •    |
| Richard Focke               | None                                   | Prof Michael Inggs      | MSc (Electrical Engineering)   | •    | •    |
| Pieter Goosen               | None                                   | Prof Tom Ryan           | MBA*                           | •    |      |
| Jurgen Strydom              | Jacques Etienne Cilliers               | Prof Michael Inggs      | MSc (Radar Engineering)*       | •    | •    |
| Dan Golding                 | Onno Ubbink                            | Prof Tania Douglas      | MSc (Biomedical Engineering)*  | •    |      |
| Daleen Lotter               | Dr Emma Archer van Garderen            | Dr Mark Tadross         | PhD (Geography)                | •    | •    |
| Dr Marjolaine Rouault       | None                                   | Prof Frank Shillington  | PhD (Physical Oceanography)*   | •    |      |
| Charlotte Maserumule        | Dr Lionel Gresh                        | Prof Keertan Dheda      | MSc (Health Science)           | •    | •    |
| Grace London                | Dr Makobetsa Khati                     | Prof Bongani Mayosi     | PhD (Medical Science)          | •    | •    |
| Pamisha Pillay              | Dr Vinesh Maharaj                      | Prof Kelly Chibale      | PhD (Organic Chemistry)*       | •    |      |
| Prenitha Sewnarain          | Dr Vinesh Maharaj                      | Prof Pete Smith         | PhD (Pharmaceutical Chemistry) | •    | •    |
| Joni Frederick              | Dr Dean Brady                          | Prof Trevor Sewell      | PhD (Biochemistry)#            | •    |      |
| Sindisiwe Buthelezi         | Dr Dalu Mancama;<br>Dr Stoyan Stoychev | Prof Jonathan Blackburn | MSc (Biochemistry)             | •    | •    |
| Therese Stark               | Dr Rachel Chikwamba                    | Prof Edward Rybicki     | PhD (Molecular Biology)        | •    | •    |
| David Macleod               | Dr Jeff Chen                           | Prof Michael Inggs      | MSc (Electrical Engineering)*  | •    |      |
| Jama Ndwe                   | Dr Etienne Bernard                     | Prof Mqhele Dlodlo      | PhD (Electrical Engineering)   | •    |      |

\* = graduated

# = left CSIR/no longer studying

| Name of CSIR staff  | CSIR supervisor                         | UCT supervisor                            | Degree programme                                    | 2011 | 2012 |
|---------------------|-----------------------------------------|-------------------------------------------|-----------------------------------------------------|------|------|
| Samuel Ogunleye     | Dr Quentin Williams                     | Prof Jean-Paul van Belle                  | PhD (Information Systems)                           | •    | •    |
| Boroto Hwabamungu   | Dr Quentin Williams                     | Prof Irwin Brown;<br>Prof Wallace Chigona | PhD (Information System)                            | •    | •    |
| Peter Muvhali       | None                                    | Dr Richard Knight                         | MSc (Town and Regional Planning) <sup>#</sup>       | •    | •    |
| Fezile Khumalo      | Dr Justin Jordaan                       | Prof Jonathan Blackburn                   | PhD (Medical Biochemistry)                          | •    | •    |
| Ndivhuwo Makondo    | Dr Nkgatho Tlale                        | Prof Martin Braae                         | MSc (Electrical Engineering)                        | •    | •    |
| Cebile Ntombela     | None                                    | Prof Loretta Feris                        | MPhil (Environmental Law)                           | •    | •    |
| Alfred Bogaers      | Dr Schalk Kok                           | Prof Daya Reddy                           | PhD (Cardiovascular Modelling)                      | •    | •    |
| Narine van den Berg | Dr Makobetsa Khati                      | Prof Bongani Mayosi                       | MSc (Medicine) <sup>*</sup>                         | •    | •    |
| Henriëtte Hobbs     | Dr Justin Jordaan                       | Prof Jonathan Blackburn                   | PhD (Medical Biochemistry)                          | •    | •    |
| Umur Kathree        | Willie Nel                              | Prof Michael Inggs                        | MEng (Electrical Engineering)                       |      | •    |
| Nomkwezane Kobo     | Dr Pedro Monteiro                       | Dr Steven Herbette; Prof Chris Reason     | MSc (Climate and Ocean Dynamics)                    | •    |      |
| Terence Ratshidaho  | Jonathan Claassens;<br>Natasha Govender | Prof Jules Raymond Tapamo                 | BSc (Honours) (Mechanical Engineering) <sup>*</sup> | •    |      |
| Nodumo Zulu         | Dr Raj laloo                            | Prof Vernon Coyne                         | MSc (Electrical Engineering) <sup>*</sup>           | •    |      |
| Nicholas Thorne     | Dr Allan Wilson-Langman                 | Prof Michael Inggs                        | MSc (Electrical Engineering) <sup>*</sup>           | •    |      |
| Laven Naidoo        | Dr Moses Cho; Dr Renaud Mathieu         | Dr Frank Eckardt                          | MSc (Environmental Geography) <sup>*</sup>          | •    |      |
| Jenny Holloway      | Dr Chris Elphinstone                    | Prof Linda Haines; Dr Kerry Leask         | MSc (Mathematical Statistics) <sup>*</sup>          | •    |      |
| Jerolen Naidoo      | Dr Musa Mhlanga                         | Prof Frank Brombacher                     | PhD (Immunology)                                    |      | •    |
| Kiri Nicolaides     | Dr Phil Loveday                         | Prof Andrew Wilkinson                     | MSc (Engineering)                                   | •    | •    |
| Sticks Mabakane     | None                                    | Prof Michelle Kuttel                      | PhD (Computer Science)                              |      | •    |
| Busisiwe Twala      | Dr Justin Jordaan                       | Prof Trevor Sewell                        | MSc (Molecular and Cell Biology) <sup>*</sup>       | •    |      |
| Marc Pienaar        | None                                    | Dr Fred Nicolls                           | PhD (Electrical Engineering)                        | •    | •    |

\* = graduated

# = left CSIR/no longer studying



## CSIR researchers appointed as honorary research associates

| Name of researcher    | Area of expertise | 2011 | 2012 |
|-----------------------|-------------------|------|------|
| Dr Nicolas Fauchereau | Climate change    | •    | •    |
| Dr Stewart Bernard    | Earth observation | •    | •    |
| Dr Marjolaine Rouault | Earth observation |      | •    |
| Dr Makobetsa Khati    | Drug discovery    | •    | •    |

## UCT professors serving on CSIR Advisory Panel

| Name of researcher      | Area of expertise         | 2011 | 2012 |
|-------------------------|---------------------------|------|------|
| Prof Robert Knutsen     | Metallurgical engineering | •    | •    |
| Prof Daya Reddy         | Materials science         | •    | •    |
| Prof Jonathan Blackburn | Applied chemical biology  | •    | •    |
| Prof Sue Harrison       | Biochemical engineering   | •    | •    |



# CSIR and Stellenbosch University Partnership



# Introduction

SU and the CSIR have for many years collaborated through research projects, human capital development (HCD), as well as the use of facilities. The university's five research themes which, together with teaching and community outreach activities constitute the HOPE project, respond to national and international issues, and resonate well with the CSIR's research impact areas.

This section of the report gives an overview of some of the research highlights and achievements resulting from the collaboration between the CSIR and SU during 2011 and 2012. The collaboration was mainly in the following areas that are identified in the memorandum of understanding between the two institutions:

- ICT: e-course development; wireless mesh; human language technologies; sign language machine translation; sensor web and distributed sensing; ICT for unmanned aerial vehicles; knowledge technologies; high-performance computing; mobile technologies; and the 'Internet of Things'.
- Natural resources and environment: sustainability studies; invasion biology; resource economics; sustainable, renewable energy; environmental assessment and management; and groundwater and environmental microbiology.
- Laser technology: short-pulse lasers; modern optics; laser development; and laser-based applications.
- Built environment: planning; rural infrastructure; logistics; and supply-chain management.
- Materials science and manufacturing: titanium research; polymer science; nanoscience; adipose-derived stem cells for use in gastroesophageal reflux disease treatment; finite element modelling; micro-electro mechanical systems; and electro-optics.
- Biosciences: molecular biomaterials.
- Human capital development: joint appointments, staff exchange, studentships, and co-supervision of students.

|                                                                  | 2011 | 2012 |
|------------------------------------------------------------------|------|------|
| Collaborative research projects implemented                      | 12   | 11   |
| Researchers at both institutions collaborating on joint projects | 28   | 36   |
| Joint outputs resulting from supervised and joint research       | 42   | 24   |
| CSIR researchers lecturing/supervising students                  | 31   | 36   |
| Students supported by the SU/CSIR scholarship programme          | 0    | 3    |
| CSIR staff studying                                              | 26   | 27   |
| Scholarship students and CSIR staff who graduated                | 8    | 1    |
| CSIR researchers holding extraordinary professorships            | 5    | 4    |
| SU researchers serving on CSIR research advisory panels          | 2    | 2    |

# Highlights and Achievements

## BIOSCIENCES

### Uptake of anti-TB nanoparticles in *M.tb* infected bone marrow derived mouse macrophage cells

Dr Hulda Swai, CSIR • Prof Paul Van Helden, SU

#### Background

Innovative technologies can meet the challenge of addressing the limitations of current therapies for poverty-related diseases such as tuberculosis (TB), malaria, chagas disease, and human immunodeficiency virus (HIV). Nanomedicine has the potential to improve bio-availability; reduce toxic side effects; shorten treatment durations; reduce drug-drug interactions; and prevent drug resistance.

The CSIR has already made substantial progress in developing an anti-TB nanodrug delivery product. The drug efficiency of CSIR nanodrug delivery products would be greatly enhanced if they could be targeted at the cells of interest and to the sites of infection. After *in vivo* preliminary data showed promising results for the anti-TB nanodrug delivery product, this project will focus on characterising these synthesised nanoparticles with or without potential targeting ligands in the biological environment.

Nanoencapsulation of drugs for delivery provides an opportunity to incorporate targeting strategies to further enhance drug efficiency and limit systemic toxic side-effects on the patient. By functionalising the surface of the particles with a targeting ligand, higher bio-availability is generated at the site of infection and therefore the dose and



side effects of the drug may be minimised. This demands an intricate knowledge of the cellular and molecular aspects of the disease,

as well as how the potential drug nanocarrier behaves near or at the site of infection.

## Response

The objective of this study is to investigate the molecular and cellular mechanisms of drug delivery systems in representative cells, including delivery systems containing ligands such as hydrophobic molecules, for the optimal use of new and current drugs used in the treatment of TB.

Instead of new therapeutic compounds, the research group focuses on improved uptake and delivery of existing drugs, and drugs in the clinical trial phases, by exploring the practical feasibility of encapsulating them into nanoparticles. The new and innovative technology developed could be taken up by the health industry to improve the treatment of poverty-related diseases that are especially pronounced in Africa, and to shorten the treatment duration time.

In order to investigate the potential targeting ligands and nanocarriers for anti-TB drugs, a suitable representation of human-like macrophages is needed. Initial experiments have already been conducted in non-animal models, such as immortalised cell lines namely: THP-1 and U937 monocyte-macrophage-like cell lines, with promising results. However, these cells have limitations because they do not truly represent the human macrophage cells. The work in immortalised cell lines delivers good initial results, but a

more suitable model is needed for testing before *in vivo* studies can be conducted. A more suitable cell type is necessary to represent TB infection. Compared to immortalised cell lines, bone marrow derived macrophages from mice display a closer resemblance and nature to human macrophage cells, making them more suitable for the intracellular studies.

*In vitro* experiments with bone marrow-derived mouse macrophage cells will be conducted with the different anti-TB drug nanoparticles. Preliminary data indicated an enhanced phagocytic uptake of nanoparticles when the particles contained the two different targeting agents that are currently under investigation. The nanoparticle-containing phagosomes were processed into phagolysosomes in which the nanoparticles were slowly degraded (still present but smaller 5 days after uptake). These promising data prompted the development of the research project as indicated below.

These cells will be infected with *M.tb* H37Rv in a P3 facility at Stellenbosch University. Nanoparticle uptake in infected and non-infected cells will be compared, and time studies will also be conducted to determine the behaviour of the nanoparticles in these cells.

The fate of the mycobacteria, as well as the state of the cells will also be investigated with this technique. Additionally, primary macrophage cell lines could be converted to foamy macrophages, (a specific state of macrophage cells in which persistent mycobacteria reside) where the behaviour of the nanoparticles could be studied. This could provide an indication on how the particles will address the persistent stage of the disease.

## Outputs

Students trained – 1



## DEFENCE AND SECURITY

### BALLAST: Gas Turbine Technology

Dr Glen Snedden, CSIR • Dr Johan van der Spuy, SU

#### Background

Flutter is one of the most severe failure modes encountered in design of modern turbo machinery and therefore, potentially impacts aircraft safety. Although 90% of the potential High Cycle Fatigue (HCF) problems are discovered during development testing, identifying the few remaining problems accounts for nearly 30% of the total development cost and are responsible for over 25% of all engine distress events. Every new development programme for jet engines has about 2.5 serious HCF problems. Flutter events impose large cost and programme delays since they are encountered late in development when engines are tested at full power or in flight conditions.

Reducing the rotor blade airfoil chords, for a given flow path, not only reduces the weight and cost of the rotor blade itself, but also has a large impact in the disk (through a reduction of the pull load) and the casing (through a reduction of the containment requirements). Furthermore, a reduction of the rotor blade chords increases the number of rotor blades of the wheel; the blade passing frequency increases, and the perceived noise decreases since its emission takes place at higher frequencies. Unfortunately, the reduction on the blade natural frequencies, due to its larger flexibility, induces flutter problems that require more sophisticated and accurate tools.



No detailed measurements of vibrating blades subjected to flutter in a three-dimensional multi blade-row flow environment have yet been reported in Europe, or elsewhere. If no development is carried out on the experimental side, the current gap between sophisticated, but un-calibrated, results from numerical models and experimental verification data is expected to grow significantly during the next decade, which will not advance the

design methodologies in the way that would be expected.

The exploitation of these outcomes is expected to enhance knowledge of turbo-machinery aeromechanics in the participating companies; reduce the gas turbine time-to-market by 10%, and development costs by 15%; reduce the aero engine maintenance cost by 3%; and reduce the airline CO<sub>2</sub> emissions by

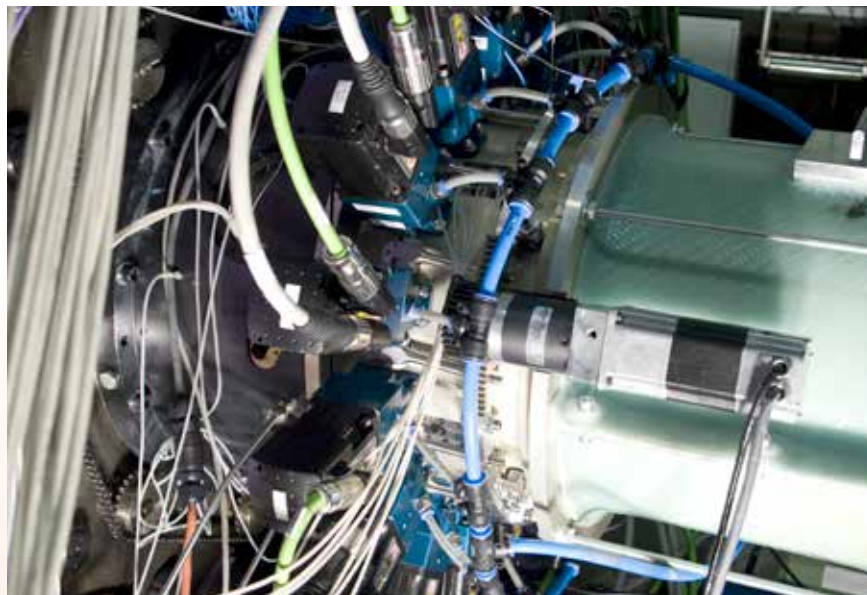


2 million tonnes per year through a decrease of 2% in fuel burn.

Because of the synergy with land-based gas turbines, significant reductions will also be achieved in emissions from electricity generation. In addition the project is expected to contribute to aircraft safety, and improve teaching material and courses in turbo-machinery aeromechanics at the participating universities.

### Response

The CSIR and Stellenbosch University will work with Volvo Aero and Darmstadt University to develop a novel flutter excitation system for the transonic compressor at Darmstadt University. This effort utilised the CSIR's expertise in developing flutter excitation equipment for aircraft, combined with turbo-machinery knowledge at the CSIR and Stellenbosch University, as well as the compressor test rig at Stellenbosch, to provide a packaged solution for the Darmstadt transonic compressor test rig.



### Outputs

Students trained – 1

## MATERIALS SCIENCE AND MANUFACTURING

### Evaluation of biodegradable materials for environmentally friendly packaging solutions (Greenpac)

Dr Rajesh Anandjiwala, CSIR • Prof Dimitri Dimitrov, Prof Mbavhi Mabogo, Prof Malcom Dodd, SU • Dr Martin Taylor, ExperiCo  
Prof Bohua Sun, CPUT

#### Background

Globally there is an increase in consumerism, which is leading to high levels of packaging waste and greenhouse gases. In response to consumer pressure, major retailers are increasingly looking for solutions to this problem. A consortium of the CSIR, Cape Peninsula University of Technology (CPUT), Institute of Advanced Tooling (IAT) and Post Harvest Innovation Programme (PHI), both at SU, and ExperiCo is implementing a project called GREENPAC to establish the introduction of compostable biodegradable materials as a means of providing environmentally friendly packaging for the South African fruit industry. GREENPAC focuses on external and internal packaging aspects. With external packaging, the primary focus is on natural fibre reinforced polylactic acid composite materials development, for use in the manufacture of returnable and one-way bio-plastic crates, to enable the replacement of non-compostable conventional plastics. The ultimate aim of GREENPAC is to enable the development of packaging solutions, which will enable the transition from plastics made from petroleum-based resources, to those made from renewable resources, thereby reducing the carbon footprint and long-term landfill residues.



#### Response

Good progress has been made by the CSIR in the preparation of natural fibre reinforced poly lactic acid (PLA). Innovative research (using vegetable oils as plasticizer in PLA) was conducted with good effects. This improved the maximum stress and the elongation at break, and also decreased water uptake of the composite. Preparation of neat bioplastics and biocomposites by injection moulding has also been completed, but is to be continued using the addition of vegetable oil. Future studies will also concentrate on extrusion of

PLA with flax fibre in the presence of additives using a twin screw extruder, and research on the mechanical, thermal, morphological and water uptake properties of the composites. Initial experiments with PLAs have shown that they have poor elasticity and as a result the material is somewhat more brittle. This brittleness needs improvement to ensure desired performance when fruit packaging crates for load bearing applications are moulded. 200kg of PLA are being extruded with macadamia nutshell powder in presence of 8 wt. % of plasticizer.

Within the project, the IAT is responsible for product design and analysis of the crates, project management, inclusive of complicated machining, and the sampling phase of the project. Prior to these activities it was necessary to conduct a product specification study. The investigative study included all the requirements (eg. packaging classification, product standardisation, stacking, legislative directives, etc.) and the critical issues to be addressed before the design phase can commence.

The initial disposable one-way crate designs are complete (three designs in total), and are currently undergoing cooling and structural analysis at CPUT. From these results, further model development, and detailing will be conducted at an optimised flow configuration. The mould development and manufacturing will follow.

The literature reviews on bioplastics and modified atmosphere storage have been done by ExperiCo. In addition, flexible films were tested across a range of fruit types. Overall, the initial results suggest that thin (17 micron) flexible film is unsuitable for use on fruit because it is not sufficiently strong. In the case of loose packed table grapes, 25 micron biodegradable film gave reasonable modification of the atmosphere in the pack, but a higher level of modification is desired. With punnet packed table grapes the PLA biodegradable top-film performed well, and consequently, gave good control of decay.

With apples and pears, it is likely that 25 micron biodegradable film liner bags which are tied on closure, can be used to replace non-biodegradable polyethylene (PE) film liners which are currently folded on closure. The biodegradable film gave

improved retention of skin colour and flesh firmness on apples; and with pears, it effectively reduced moisture loss and shrivel. In the case of plums, it was evident that different cultivars react differently to a particular flexible film type. It is likely that the gas modification properties of the biodegradable films tested will need to be reduced on certain cultivars, possibly by using laser perforation. Carbon dioxide, oxygen and water vapour permeation tests are underway, and further work on moulding crates and conducting field trials is in progress.

The impact of the project is based on the successful moulding of disposable

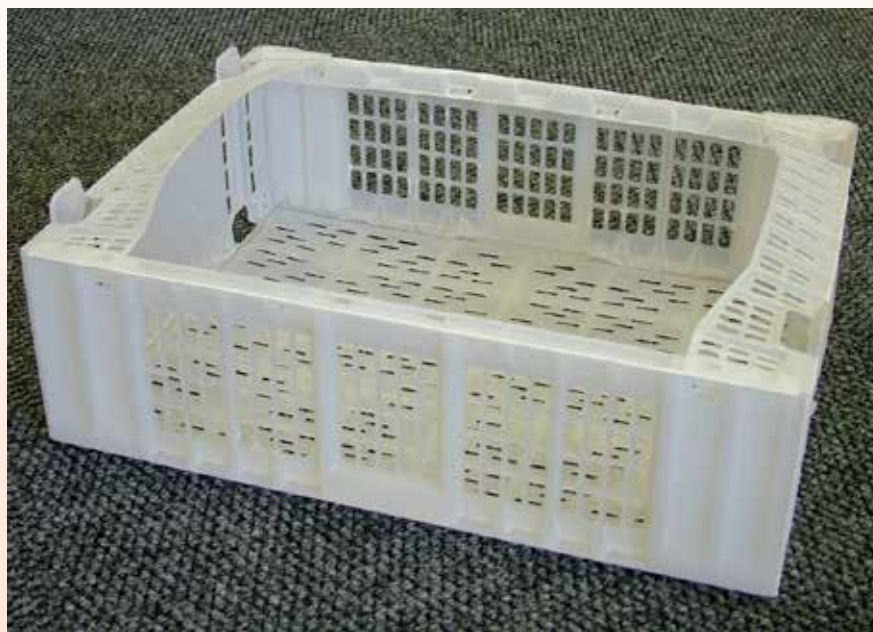
and returnable crates. Until now, the development of a PLA based material, and initial trials for moulding crates has not been successful. Further work in fine tuning material, as well as conducting proper moulding trials in the development environment will be necessary.

## Outputs

Peer-reviewed journal articles – 2

Conference papers – 1

Students trained – 4



## High performance computing methods applied to finite element modelling of propagating elastic waves in rails

Dr Craig Long, CSIR • Prof Albert Groenwold, SU

### Background

Rail infrastructure worldwide is ageing, resulting in the need for railway operators to employ inspection and monitoring systems to ensure the integrity of the network. The Institute for Maritime Technology (IMT) and CSIR have developed such a system for Transnet. The system makes use of guided wave ultrasound to detect breaks in railway lines, and has been installed on Transnet's coal line to Richards Bay and the Orex line between Sishen and Saldanha.

Over the past several years, numerical modelling techniques have been developed by the CSIR to assist in the design of transducers for the system, and to simulate how the generated waves propagate along the rail. These capabilities have resulted in the development of an improved transducer which is currently being commercialised. The aim of the project is to further extend these modelling capabilities in order to study the complex interaction between propagating elastic waves, and imperfections in continuous welded train rails. The system challenge will be to reliably distinguish between real defects in rails, such as cracks, and other reflectors such as welds which do not represent damage. The numerical models developed to address this system challenge are computationally demanding, and will benefit from High Performance Computing (HPC) techniques and algorithms being developed at Stellenbosch University. The aim of this research is therefore to investigate methods to increase the efficiency and speed



of the numerical analysis by exploiting HPC techniques.

### Response

The research will effectively combine the unique skills of the two research groups, with an on-going doctoral study on this topic. Although this research is still at an early stage, specific research questions have been identified and will form the basis of collaboration over the coming three years. The research will specifically focus on:

- The development of analysis and mathematical optimisation procedures to study the scattering of propagating elastic waves as a result of discontinuities in waveguides.
- The application of HPC techniques and algorithms to this analysis, with a focus on Graphics Processing Unit implementations.

### Progress

Progress on these initiatives was presented at an elastic wave propagation workshop. The focus of the workshop was mainly on



the computation, measurement and analysis of (elastic) wave propagation. The knowledge gained during this research should make impact through extension of the offerings of the current ultrasonic broken rail detection system developed by IMT and the CSIR. This system makes economic impact by helping Transnet to avoid expensive derailments of freight trains, and has attracted considerable international attention. Tests have been performed with the system at the Transport Technology Center in Colorado, in the United States; on a test section in Kingston, Canada; on the subway in New York; in Hong Kong; as well as two recent test sections in Japan. Ideally, the knowledge generated during the course of this study could, in future, result in a system which will not only detect complete rail breaks, but identify and characterise damage type, location and severity before a break occurs. This information would facilitate an informed decision-making process by rail operators on safety and maintenance issues.

### Outputs

Students trained – 1  
Peer-reviewed conference paper – 1



# NATURAL ENVIRONMENT

## Spatial decision support system to aid environmental management in the military

Suja Joseph-Malherbe, CSIR • Supervisors: Marius van Wyk, CSIR • Prof Adriaan van Niekerk, Prof Hannes van der Merwe, SU  
Lt. Col. Jan Marx, SANDF

### Background

The South African military has, on numerous occasions, expressed its need for geographic information systems (GIS). Although the South African National Defence Force (SANDF) utilises a variety of GIS tools, its full requirements have not yet been met. A particularly important area still requiring attention is environmental management of areas where military training and exercises are performed. The CSIR and SU are collaborating to develop a web-based spatial decision support system (SDSS) to ensure that the area used for military training exercises is managed in an environmentally responsible manner, in line with military integrated environmental management guidelines.

### Response

The Military Training Area at Langebaan on the west coast, Western Cape, hosts various military training activities. The facility includes one of only 15 island ecosystems in South Africa. In order to ensure that the area is managed sustainably, sound environmental management principles are required. This includes developing a management plan that takes into account both the conservation requirements of the area, as well as the military training activities.

A doctoral dissertation (*in preparation*) identifies environmental challenges and puts forward recommendations on how to minimise

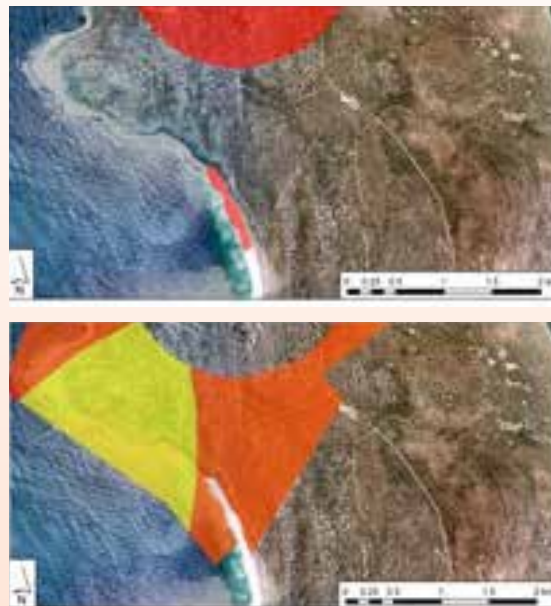
the impact of military training exercises on the environment. A web-based SDSS turns this linguistic rule set into a practical tool.

The first phase of the project included numerous workshops to convert the linguistic rule set to a logical rule set.

The logical rule set has been developed for all training activities. The geographical rule set has been manually applied in ArcGIS using standard spatial queries and analysis tools (i.e. a land unit database).

The result is a set of maps indicating where certain training activities can be carried out under a given planning priority framework (operational versus environmental).

The application of the logical rule set on a geographical area is shown in Figure 1. The red areas in Figure 1(a) indicate no-go areas for pyrotechnics activities and Figure 1(b) shows the most suitable areas for this specific activity.



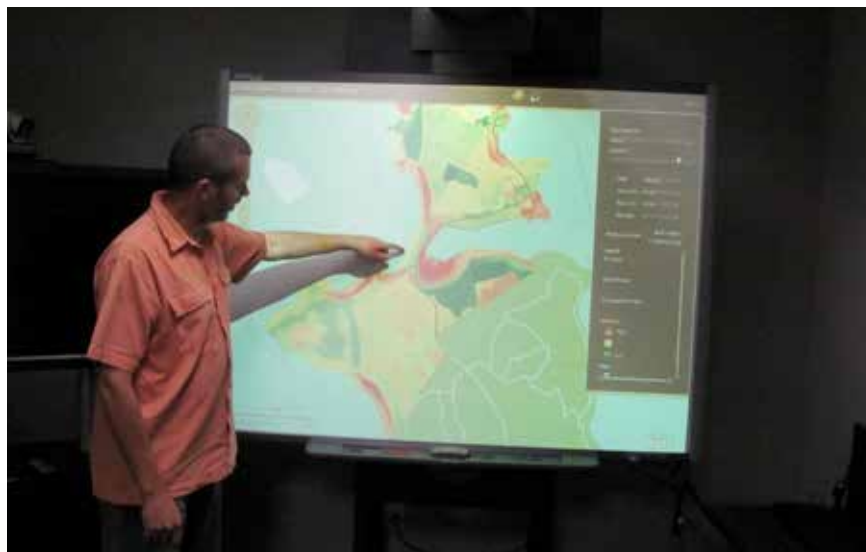
A

Figure 1: (a) No-go areas for pyrotechnic activities (b) Suitability (Importance) factor for pyrotechnic activities

B

The spatial decision support system will be developed on a web-based GIS (ArcGIS Server) platform that produces dynamic maps which can be accessed via the World Wide Web. The system will be able to identify the most suitable area, as well as alternative areas for the different types of training exercises. It is envisaged that if this system is utilised at a military training area during planning and executing of training exercises, the impact on the environment could be minimised. It is envisaged that the system may also be adapted for application to all SANDF military training areas.

The project should assist the SANDF to minimise the negative impact on the environment when performing training exercises.



## Outputs

Prototype – 1



Figure 2: Vegetation on granite soils



# Human Capital Development

## CONTEXT OF THE COLLABORATION

Pinda Sifunda, CSIR • Chantal Swartz, SU

SU and the CSIR support human capital development through several mechanisms. The joint scholarship programme, supported the first group of students in 2012 – 1 PhD and 2 Master's students.

In 2011 and 2012, 48 CSIR staff members were supported by the CSIR to study for Master's and doctoral degrees at SU, in disciplines including electrical engineering, chemical engineering, conservation ecology, and laser physics.

Some of the staff were supervised by SU and CSIR researchers and worked on CSIR projects as part of their graduate programmes. Nine staff members and scholarship students completed their studies during the year.

A large number of CSIR staff members are lecturing and supervising students at SU and some have been awarded honorary appointments by the university. This includes six extraordinary professorships, as well as 44 lecturers and supervisors. A selection of some of the student research and experiences follows.

**Siyanda Nazo** is studying for an MSc Engineering with specific interest in hybridisation in computational electromagnetics. "I have received funding for my trips to the university and support from my supervisor within the CSIR. I would have liked to spend more time at the university in order to interact with other students who are working on similar research topics.

*I would recommend that students be allowed more time at the university in order to interact with the academic supervisor in order to better manage the relationships between the CSIR and the university. This would also be beneficial to the students' progress because the student would also interact with other students working on similar topics. I would like to work before I pursue another degree"*

**Marinel Janse van Rensburg** is studying for an MSc in BioMathematics focusing on dynamic models for invasion processes. "I have grown up in a family of nature lovers and environmentally conscious individuals. This early awareness has contributed to my academic field of interest.

*I am developing dynamic models to simulate invasive species' range expansions (with the European Starling Sturnus Vulgaris as a case study). The Starling has a tremendous impact on the economy, spreads diseases and competes aggressively with native birds for nest cavities. Since its introduction to South Africa in 1897, the Starling's range has expanded across the country and into Namibia.*

*I have gathered all data, completed an introductory course in ArcGIS to assist with mapping techniques and attended a workshop on ecological niche modeling where we studied methods for developing species' potential distributions. These techniques were then integrated to develop a complex Individual Based Model. I am currently optimising and evaluating this model, and also designing one model for studying the Starling's genetic dynamics during the invasion process.*

*I have presented my work at the South African Mathematical Society's Annual Congress (2012) and at SU's Centre for Invasion Biology's Annual Research Meeting where I received an award for best MSc poster. I am determined to optimise modeling techniques to help understand the problems posed by invasive species, the associated risks, and the possible solutions".*

## SUPERVISED RESEARCH

### Vacuum ultra violet spectroscopy of forbidden carbon monoxide transitions

Charles Rigby, SU • Supervisors: Dr Christine Steenkamp, Prof Erich Rohwer, SU

#### Background

Vacuum ultra violet (VUV) spectroscopy has been an active research area at Stellenbosch University for the past decade. A few papers have been published investigating the weak spectral lines of rare isotopomers and forbidden transitions of CO. The spectroscopic data, in particular accurate wavelength values, which will be and have previously been acquired, is relevant to astrophysics. Previous work done in this laboratory has already been used in the interpretation of astrophysical observations of CO in the interstellar medium. The relevance of CO in astrophysics stems from its abundance in interstellar clouds and from its well-observable spectra in the VUV, infra-red and millimetre-wave regions. The data is used in determining the CO column densities between the observer and the interstellar object in question. The weak lines are of specific importance since the stronger lines become saturated and thus cannot be used in determination of the column density. The weaker lines on the other hand are not saturated and thus useful for accurate determination of CO concentration.

For proper interpretation of the ultraviolet absorption spectra of interstellar CO isotopomers, accurate rest wavelengths from rotationally resolved laboratory spectra



are needed. Much work has been done mapping the intersystem transitions of CO and showing that laboratory measured wavelengths are not available for a large number of these forbidden transitions.

The objective of this project will be the detection of the forbidden transitions of CO for which experimentally measured wavelengths are not yet available.

The search for these observable lines of singlet-triplet transitions will be extended to wavelength ranges that were not investigated during previous work and subsequently to weaker lines. Recently, new laser equipment has been acquired which will allow higher output energies of laser light, and thus it is expected that even weaker spectral lines may be detected with the new system than was possible in the past.

The CO molecules will be cooled in a supersonic jet. This has the advantage of a higher spectral resolution than would normally be possible with room temperature samples. The high spectral resolution is due to the cold molecules having minimal Doppler broadening and the narrow bandwidth of laser, with the bandwidth being the limiting factor at the supersonic jet temperatures. There is also a high sensitivity for the lines originating from low rotational levels due to low temperature (and thus higher population of these levels) and low background signal in spectra.

### Response

A tuneable narrow-bandwidth pulsed Nd:YAG laser is used to pump two dye laser systems. The two visible laser beams from the dye lasers are focussed into the crossed heat pipe with magnesium

vapour as the active medium. VUV light is generated in the magnesium vapour medium and exits the heat pipe via a window into the sample chamber. Natural CO gas is used as sample. The sample is cooled with the aid of a seeded supersonic jet allowed to expand into vacuum (to  $\sim 2$  K). The VUV light interacts with the sample in the supersonic jet to produce fluorescence. Photomultiplier tubes are used to detect the fluorescence and transmitted VUV light. The VUV wavelength will be scanned over the wavelength regime in search of known and unknown spectral lines.

### Progress

The current activity is the upgrade of the VUV source. The project benefitted from the installation of a new Nd:YAG pump laser and a new Sirah dye laser during 2011; both lasers provided through the CSIR

National Laser Centre Rental Pool Project. This makes the dye laser peak power that is available up to 30 times larger than that available in the past. By January 2012 both the new Sirah dye laser and the second, older, Lambda Physik dye laser were fully operational, producing wavelength tuneable laser beams. In the meantime a completely new computer control and data acquisition system running on a custom Labview programme has been developed.

Currently the optical setup for aligning the two dye laser beams is being redesigned and rebuilt, using prisms that can withstand the higher peak powers instead of mirrors. Delivering the laser beams with good spatial and temporal overlap and with sufficiently pure circular polarisation is critical, and requires detailed analysis of the setup and careful alignment.

## Magneto optical trapping of rubidium 87

Huzifa Elnour, SU • Supervisors: Dr Christine Steenkamp, Prof Erich Rohwer, SU

### Background

Magneto optical trapping of neutral rubidium atoms finds application in state-of-the-art optical frequency standards for industry, and in basic research involving ultracold atoms and molecules. External cavity diode laser technology is relevant for practical spectroscopy applications due to their relatively low cost, compactness and ease of operation. Both spectroscopy using external cavity diode lasers, and magneto optical trapping are state-of-the-art techniques globally, but underutilised in research in South Africa. This project is contributing to the local expertise and human capacity in these fields, and prepares the way for future research on application of ultracold atoms and molecules.

Magneto optical trapping is the technique of producing trapped atoms at very low temperature in a vacuum, by using low intensity laser beams and a magnetic field gradient. Due to momentum exchange between the scattered photons from the laser beams and the atoms, radiation pressure force on the atoms will be created. By using the Doppler effect, this force can be dependent on the atom's velocity, and then it can be used to decelerate atoms, thus cooling them. Simultaneously, by using the

magnetic field gradient and the Zeeman effect, the radiation force is employed to trap the atoms at the zero magnetic field position.

The aim of this project is to study the principles of laser cooling of the neutral atoms, and to develop an experimental setup for magneto optical trapping. Thereafter, the effect of the trapping parameters on the number of the trapped atoms will be investigated experimentally, and compared to the results in the literature. The project focusses on trapping and cooling of the rubidium 87 atoms.

### Response

For the two laser beam sources, the research team uses external cavity diode lasers provided by the CSIR National Laser Centre Rental Pool Programme, which are characterized by a narrow linewidth and tuneable frequency in a large spectral range. Through saturated absorption spectroscopy, the frequencies of these lasers are locked to the appropriate transitions of the rubidium (Rb) atom. One laser is used as the trapping laser and the other as the repump laser that maintains the atoms in the correct quantum state for trapping. The magneto optical trapping setup consists of two symmetric magnetic

coils with oppositely directed currents, and six polarized laser beams intersecting on the zero-field position of the magnetic gradient. The magneto-optical trapping takes place in a metal sealed vacuum system into which Rb vapour is introduced by an Rb getter. Relative measures of the number of trapped atoms and the time that atoms remain in the trap will be made by observing the amount of the fluorescence from the trapped atoms with a photodiode.

### Progress

By using saturated absorption spectroscopy, rubidium hyperfine structure has been observed. The lasers' frequencies are locked to the required hyperfine transitions. All the hardware of the setup for magneto optical trapping is in place. Recently, modifications have been made to the vacuum system and the alignment of the six trapping beams, in order to avoid technical problems experienced in the past. A complete understanding of the polarisation requirements has been achieved by comparing measurement and calculation. Completion of the beam alignment and beam expansion, and fine-tuning of the experimental parameters are the next steps to achieve magneto optical trapping.

# Visual servo control of a human-following robot

Michael Burke, CSIR • Supervisors: Japie Engelbrecht, Dr Willie Brink, Prof Kristiaan Schreve, SU

## Background

The ability of a mobile robot to track and follow a moving target is needed in a wide variety of applications, particularly when the coordination of multiple robots is required. Cooperative robotics requires that individual robots are aware of the positions and behaviours of surrounding agents prior to any useful collaborative action.

A leader-follower formation control task requires that a mobile robot follows a target, maintaining a specified range and relative orientation. Such a task is particularly useful for robotic convoys, where a lead vehicle is tele-operated and a cascade of agents follow, thus allowing the transport of supplies or vehicles through dangerous areas, without risk to human lives. Leader-follower formation control is also envisaged to be of great use in intelligent transportation systems.

The leader-follower formation control definition also applies to the case of uncooperative or unpredictable targets. Uncooperative targets include elusive, manoeuvring objects and collaborating independent agents without the ability to communicate their intentions. A good example of the latter is that of a human-following robot. Robots with the ability to follow humans could prove particularly useful, especially within the service robotics industry. They could follow humans to a specific point and then move back and forth ferrying loads. Another potential application is in search and rescue, where

a robot follows teams of medics, and returns stabilised patients to field hospitals, with only a single medic required, leaving others free to undertake alternative work.

## Response

The problem addressed in this work was the design and implementation of a suitable visual servo control system that allows a wheeled mobile robot to track and follow a human.

## Progress

Traditional approaches to human-following typically involve a controller that causes platforms to navigate directly towards targets, but this work showed that better following performance can be achieved through the use of a controller that incorporates target orientation information. In the case of human following, the inclusion of target orientation information requires that a definition and means of estimating a human's orientation be available. This work developed a human orientation measure that was shown to be suitable for the purposes of wheeled platform control, together with a method of extracting this using only a single camera. A hybrid controller combining both the traditional approach of navigating directly towards targets and this orientation information was shown to perform significantly better than the traditional approach, given the limitations of monocular vision.



## Outputs

Peer-reviewed conference papers – 2

## Femtosecond pump probe spectroscopy of light harvesting complexes and phthalocyanines

Saturnin Ombinda-Lemboumba, CSIR • Supervisors: Dr Anton du Plessis, CSIR • Dr Christine Steenkamp, Prof Erich Rohwer, SU

### Background

Nanodevices based on biological materials can degrade into harmless substances and be absorbed into an organism's own structure. Energy transfer in light harvesting complexes (LHCs) is of major interest in femtosecond spectroscopy and will remain so for several years until the energy transfer processes are fully understood, and systems can be synthesised to mimic energy transfer in photosynthetic systems so that the energy transfer can be controlled and manipulated. Commercial relevance is found in highly efficient biological solar cells, among others.

On the other hand, the processes of light absorption and energy transfer are also central to Photodynamic Therapy (PDT). Phthalocyanines are a new class of photosensitisers used for PDT. These drugs are used to treat small and superficial tumours. Particular attention has been given to zinc phthalocyanine (ZnPc) in order to find suitable photosensitisers that can be clinically used as photodynamic cancer drugs. However there are ultrafast processes in ZnPc that are used for the destruction of the cancer.

### Response

Research on the fundamental processes that are involved in chemical reaction mechanisms is of critical importance for understanding chemical and biological phenomena. The aim of this study was to investigate energy transfer in synthesised artificial functional light harvesting complexes, by studying energy transfer in natural light harvesting complex II (LHC II), as well as ultrafast processes in



zinc phthalocyanine (ZnPc) systems.

Most of the work was done at the femtosecond laboratory at CSIR National Laser Centre. However, experiments on ZnPc in a DMF solvent were carried out at the femtosecond laboratory Laser Research Institute at Stellenbosch University.

### Progress

The research has permitted the establishment of time constants of energy transfer from chlorophyll b to chlorophyll a, as well as the energy equilibrium from chlorophyll a to chlorophyll a in light harvesting complex II. The time constants obtained correspond to the values given in the literature. On the other hand, the study done on ZnPc

indicated that there are three time constants involved in energy transfer: two time constants of a few picoseconds which are associated with solvent relaxation and vibrational relaxation; and a new longer time constant (in the order of 40 ps) discovered, is related to the dielectric solvent dynamic relaxation of the excited state of ZnPc. The research complements the work presented in literature which lack data in picosecond time scale.

### Outputs

Peer-reviewed journal article – 1  
Conference paper – 1



## Estimated environmental risks of engineered nanomaterials in Gauteng

Nomakhwezi Nota, CSIR • Supervisors: Dr Ndeke Musee, CSIR • Prof Chris Aldrich, SU

### Background

The increase in nanotechnology-based products, (or nanoproducts), has resulted in substantial but unquantified releases of engineered nanomaterials (ENMs) into different environmental compartments. In previous studies, the quantities of ENMs released into the environment were estimated using models, due to lack of metrology. The scientific data in these studies indicated that ENMs pose a risk to various environments. However, the only ENM currently known to be of significant concern is nano-TiO<sub>2</sub> (nTiO<sub>2</sub>).

### Response

The study modelled releases of ENMs into aquatic and terrestrial environments in Gauteng Province. High and low efficiency regimes of wastewater treatment plants (WWTP) were considered.

### Progress

Results indicated that high quantities of ENMs were released into aquatic environments from both high and low

efficiency WWTP. These values increased substantially for low efficiency plants. Concentrations of ENMs in Gauteng's terrestrial environment were found to be too low to warrant concern. Unlike previous studies, the research indicated that nAg also poses risk to the aquatic environment. This means that ENMs are of immediate concern in environmental protection, and data is needed to validate the modelling results. The findings predicted higher risks for water-scarce regions, where there is little or no dilution of ENMs after release into the environment.

The comparatively high concentrations of ENMs observed in this study could lead to the potential inefficiency of wastewater treatment facilities by inhibiting the activity of bacteria responsible for waste treatment, given that most of the ENMs exhibit high antibacterial properties. This could lead to poor quality of drinking water and damage to aquatic organisms. Results from this study have potential use in regulation and release of nanomaterials into water and agricultural soils by standards regulatory authorities.

"Through the CSIR studentship programme, my profile as a researcher was established and now I am a qualified research scientist. Acknowledgements are extended to the DST sponsorship."

### Outputs

Conference papers – 4  
Peer-reviewed journal article – 1

# Detailed Indicators of Collaboration

## Collaborative research projects implemented

| CSIR researchers                                          | SU researchers                                    | Name of project                                                                                              | 2011 | 2012 | Research area          |
|-----------------------------------------------------------|---------------------------------------------------|--------------------------------------------------------------------------------------------------------------|------|------|------------------------|
| Dr Petrus van Zyl                                         | Prof Emile van Zyl                                | Industrial Biologics (Chitinases)                                                                            |      | •    | Biosciences            |
| Dr Dean Brady;<br>Dr Fritha Hennesey;<br>Dr Daniel Visser | Dr Heinrich Volschenk                             | Plantbio Biofuels platform: LEAF                                                                             | •    | •    |                        |
| Bernardt Duvenhage                                        | Riaan van den Dool                                | Super resolution                                                                                             |      | •    |                        |
| Marius Olivier                                            | Prof Willem Perold                                | Light detection research                                                                                     | •    | •    | Defence and security   |
| Dr Glen Snedden                                           | Meyer von Backstrom;<br>Dr Johan van der Spuy     | BALLAST: Various topics                                                                                      | •    | •    |                        |
| Dr Glen Snedden                                           | Dr Johan van der Spuy                             | FUTURE: Flutter Excitation FP7                                                                               | •    | •    |                        |
| Dr Dirk Bezuidenhout;<br>Dr Igle Gledhill                 | Dr Pieter Neethling                               | Research Study on Molecular Modelling                                                                        | •    |      |                        |
| Dr Febe de Wet                                            | Prof Thomas Niesler;<br>Prof Christa van der Walt | Preparing automatic oral proficiency assessment technology for industry                                      | •    | •    | ICT                    |
| Dr Selvan Govender                                        | Prof Pieter Swart                                 | Development of novel functionalised polymers for urban water treatment                                       | •    | •    | Built Environment      |
| Dr Craig Long                                             | Prof Albert Groenwold                             | High performance computing methods applied to finite element modelling of propagating elastic waves in rails | •    | •    | Advanced manufacturing |
| Dr Rajesh Anandjiwala                                     | Prof Dimitri Dimitrov                             | Greenpac                                                                                                     | •    |      |                        |
| Dr Willie du Preez                                        | Prof Dimitri Dimitrov                             | Titanium Centre of Competence (Machining of Titanium)                                                        | •    |      |                        |
| Dr Hulda Swai                                             | Prof Paul van Helden                              | TB nano drug delivery                                                                                        | •    | •    | Health                 |
| Dr Lourens Botha                                          | Prof Erich Rohwer                                 | Spatio-temporal shaping of ultrashort pulses                                                                 | •    | •    | Lasers                 |

| CSIR researchers                                                                                         | SU researchers                       | Name of project                                                                                                            | 2011 | 2012 | Research area       |
|----------------------------------------------------------------------------------------------------------|--------------------------------------|----------------------------------------------------------------------------------------------------------------------------|------|------|---------------------|
| Dr Nebo Jovanovic                                                                                        | Dr Willem de Klerk;<br>Cou Pienaar   | EAU4 FOOD                                                                                                                  |      | •    | Natural environment |
| Ashton Maherry;<br>Phil Hobbs; Dr Paul Oberholster; Dr Evison Kapangaziwiri; Dr Jean-Marc Mwenge-Kahinda | Dr Roychudhury,<br>Corne Engelbrecht | The development of a current risk based platform for the Waterberg area from an environmental and human health perspective |      | •    |                     |
| Dr Michelle Audouin                                                                                      | Prof John van Breda                  | TSAMA HUB                                                                                                                  | •    | •    |                     |
| Dr Brian van Wilgen, CSIR                                                                                | Prof Dave Richardson                 | Ecology and management of invasive alien plants                                                                            | •    |      |                     |

## Joint outputs resulting from supervised and joint research

| Authors                                                               | Title of paper                                                                                                                                                   | Publication                                                             |
|-----------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------|
| <b>Peer-reviewed journal articles</b>                                 |                                                                                                                                                                  |                                                                         |
| Donaldson R; Van Niekerk A; Du Plessis D; Spocter M                   | Non-metropolitan growth potential of Western Cape Municipalities                                                                                                 | Urban Forum, Vol 23, Pages: 367-389<br>Jan 2012                         |
| Broughton EK; Brent AC; Haywood L                                     | Application of a multi-criteria analysis approach for decision-making in the energy sector: The case of concentrating solar power in South Africa                | Energy and Environment, 12pp<br>Mar 2012                                |
| Bugan RDH; Jovanovic NZ; De Clercq WP                                 | The water balance of a seasonal stream in the semi-arid Western Cape (South Africa)                                                                              | Water SA, Vol. 38(2), Pages: 2012-212<br>April 2012                     |
| Van Wilgen BW; Richardson DM                                          | Three centuries of managing introduced conifers in South Africa: benefits, impacts, changing perceptions and conflict resolution                                 | Journal of Environmental Management, Vol. 106, Pages: 56-68<br>May 2012 |
| Ntshotsho P; Reyers B; Esler KJ                                       | No evidence-based restoration without a sound evidence base: a reply to Guldmond et al.                                                                          | Restoration Ecology, Vol. 20(2), Pages: 158-159<br>Mar 2012             |
| Mouton M; Postma F; Wilsenach J; Botha A                              | Diversity and characterization of culturable fungi from marine sediment collected from St. Helena Bay, South Africa                                              | Microbial Ecology, Vol. 64(2), Pages: 311-319<br>Aug 2012               |
| Mashimbye ZE; Cho MA; Nell JP; De Clercq WP; Van Niekerk A; Turner DP | Model-based integrated methods for quantitative estimation of soil salinity from hyperspectral remote sensing data: a case study of selected South African soils | Pedosphere, Vol. 22(5), Pages 640-649<br>Oct 2012                       |

| Authors                                                                      | Title of paper                                                                                                                                                         | Publication                                                                                         |
|------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------|
| <b>Peer-reviewed journal articles</b>                                        |                                                                                                                                                                        |                                                                                                     |
| Oberholster PJ; Myburgh JG; Ashton PJ; Coetzee JJ; Botha A-M                 | Bioaccumulation of aluminium and iron in the food chain of Lake Loskop, South Africa                                                                                   | Ecotoxicology and Environmental Safety, Vol. 75(1), Pages: 131-141<br>Jan 2012                      |
| Kruger AC; Goliger AM; Retief JV; Sekele SS                                  | Clustering of extreme winds in the mixed climate of South Africa [journal article]                                                                                     | Wind and Structures Vol. 15(2), Pages: 87-110<br>Jan 2012                                           |
| Chamier J; Crouch AM                                                         | Improved photoelectrochemical detection of mercury (II) with a TiO <sub>2</sub> -modified composite photoelectrode                                                     | Materials Chemistry and Physics, Vol. 132(1), Pages: 10-16<br>Jan 2012                              |
| Reyers B; Polasky S; Tallis H; Mooney HA; Larigauderie A                     | Finding common ground for biodiversity and ecosystem services                                                                                                          | BioScience, Vol. 62(5), Pages: 503-507<br>May 2012                                                  |
| Taljaard S; Slinger JH; Morant PD; Theron AK; Van Niekerk L; Van der Merwe J | Implementing integrated coastal management in a sector-based governance system                                                                                         | Ocean & Coastal Management, Vol. 67, Pages 39-53<br>Oct 2012                                        |
| McLaren M; Agnew M; Leach J; Roux FS; Padgett MJ; Boyd RW; Forbes A          | Entangled Bessel-Gaussian beams                                                                                                                                        | Optics Express, Vol. 20(21), Pages: 23589-23597<br>Oct 2012                                         |
| Romero J; Giovannini D; McLaren MG; Galvez EJ; Forbes A; Padgett MJ          | Orbital angular momentum correlations with a phase-flipped Gaussian mode pump beam                                                                                     | Journal of Optics, Vol. 14(8), 5pp<br>Aug 2012                                                      |
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| Authors                                                                                                                                                                                                                                                 | Title of paper                                                                                                            | Publication                                                                     |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------|
| O'Kennedy MM; Crampton BG; Lorito M; Chakauya E; Breese WA; Burger JT; Botha FC                                                                                                                                                                         | Expression of a $\beta$ -1,3-glucanase from a biocontrol fungus in transgenic pearl millet                                | SA Journal of Botany, Vol. 77, Pages: 335-345<br>Apr 2011                       |
| Egoh BN; Reyers B; Rouget M; Richardson DM                                                                                                                                                                                                              | Identifying priority areas for ecosystem service management in South African grasslands                                   | Journal of Environmental Management, Vol. 92(6), Pages: 1642-1650<br>Jun 2011   |
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| Oberholster PJ; Musee N; Botha A-M; Chelule PK; Focke WW; Ashton PJ                                                                                                                                                                                     | Assessment of the effect of nanomaterials on sediment-dwelling invertebrate Chironomus tentans larvae                     | Ecotoxicology and Environmental Safety, Vol. 74(3), Pages: 416-423<br>Mar 2011  |
| Musee N; Thwala M; Nota N                                                                                                                                                                                                                               | The antibacterial effects of engineered nanomaterials: implications for wastewater treatment plants                       | Journal of Environmental Monitoring, Vol. 13(5), Pages: 1164-1183<br>Apr 2011   |
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| Authors                                                                                                                                | Title of paper                                                                                                                                                              | Publication                                                                                              |
|----------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|
| <b>Peer-reviewed journal articles</b>                                                                                                  |                                                                                                                                                                             |                                                                                                          |
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| Kamper H; De Wet F; Hain T; Niesler T                  | Resource development and experiments in automatic SA broadcast news transcription                                                    | 3rd International Workshop on Spoken Languages Technologies for Under-Resourced Languages (SLTU 2012), Cape Town, South Africa, 7-9 May 2012, Pages: 102-106<br>May 2012 |
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| Kruger AC; Goliger AM; Retief JV              | Integration and implications of strong wind producing mechanisms in South Africa                                                                                    | 13th International Conference on Wind Engineering, Amsterdam, Netherlands, 10-15 July 2011<br>Jul 2011                                     |
| Bergh J; Gerber A; Meyer T; Van Zijl L        | Path analysis for ontology comprehension                                                                                                                            | 7th Australasian Ontology Workshop (AOW 2011), Perth, Australia, 5 December 2011<br>10pp<br>Dec 2011                                       |
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| Authors                         | Title of paper                                                                                                      | Publication                                                                                                                                                  |
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| Burke M; Brink W                | Gain-scheduling control of a monocular vision-based human-following robot                                           | 18th World Congress of the International Federation of Automatic Control (IFAC 2011), Milano, Italy, 28 August-2 September 2011, Pages 8177-8182<br>Aug 2011 |
| Dunn D; Von Backstrm TW         | Numerical investigation into the unsteady effects of non-axisymmetric turbine endwall contouring on secondary flows | 20th International Symposium on Air Breathing Engines (ISABE 2011), Göteborg, Sweden, 12-16 September 2011, 9pp<br>Sep 2011                                  |
| Pretorius WB; Das S; Mostert PJ | Application of a nonparametric approach to analyze delta-pCO <sub>2</sub> data from the Southern Ocean              | 53rd Annual Conference of the South African Statistical Association, Pretoria, 31 October-4 November 2011, 12pp<br>Nov 2011                                  |
| Pretorius WB; Das S; Mostert PJ | Application of nonparametric approach to analyze DpCO <sub>2</sub> data from the Southern Ocean                     | Proceedings of the 53rd Annual Conference of the South African Statistical Association, Pretoria, 1-3 November 2011<br>Nov 2011                              |

## CSIR researchers lecturing/supervising students

| Name of researcher             | Research area as defined in MoU     | Type of collaboration             | 2011 | 2012 |
|--------------------------------|-------------------------------------|-----------------------------------|------|------|
| Dr Michelle Audouin            | Natural resources/environment       | Lecturing and supervision         |      | •    |
| Dr Esbeth van Dyk              | Built environment                   | Supervision                       | •    | •    |
| Dr Adam Goliger                | Built environment                   | Supervision                       | •    | •    |
| Herman le Roux                 | Defence and security*               | External examination              | •    | •    |
| Johan Smit                     | Defence and security*               | Supervision                       | •    |      |
| Dr Igle Gledhill               | Defence and security*               | Supervision                       | •    |      |
| Dr Bennie Broughton            | Defence and security*               | Supervision                       | •    | •    |
| Nelis Williers                 | Defence and security*               | Supervision                       | •    | •    |
| Dr AURORA Gerber               | ICT                                 | Supervision                       | •    | •    |
| Dr Febe de Wet                 | ICT                                 | Supervision                       | •    |      |
| Mario Marais                   | ICT                                 | External examination              | •    | •    |
| Chris Burger                   | ICT                                 | Supervision                       | •    | •    |
| Dr Anton du Plessis            | Laser technology                    | Lecturing, supervision            | •    |      |
| Dr Lourens Botha               | Laser technology                    | Supervision                       | •    | •    |
| Christoph Bollig               | Laser technology                    | Supervision                       | •    | •    |
| Andre Theron                   | Natural resources/environment       | Supervision                       | •    | •    |
| Dr Christine Colvin            | Natural resources/environment       | Supervision, lecturing            | •    |      |
| Gerhadus Diedricks             | Natural resources/environment       | Supervision, external examination | •    | •    |
| Jac Wilsenach                  | Natural resources/environment       | Supervision                       | •    |      |
| Lara van Niekerk               | Natural resources/environment       | Lecturing                         | •    |      |
| Dr Ndeke Musee                 | Natural resources/environment       | Supervision                       | •    | •    |
| Dr Nebo Jovanovic              | Natural resources/environment       | Supervision                       | •    | •    |
| Petrus van Zyl                 | Biosciences                         | Supervision                       | •    | •    |
| Avashnee Chetty                | Materials science and manufacturing | Supervision                       |      | •    |
| Dr Colin Kenyon                | Biosciences                         | Supervision                       |      | •    |
| Dr Hermann Uys                 | Laser technology                    | Supervision                       |      | •    |
| Dr Derik Minnaar               | Defence and security*               | Supervision                       |      | •    |
| Dr Frikkie Mostert             | Defence and security*               | Supervision                       |      | •    |
| Dr Fernando Camisani-Calzolari | Defence and security*               | Supervision                       |      | •    |

\* = Not in MoU

| Name of researcher      | Research area as defined in MoU | Type of collaboration | 2011 | 2012 |
|-------------------------|---------------------------------|-----------------------|------|------|
| Natasha Govender        | Modelling and digital science*  | Supervision           |      | •    |
| Dave Phelps             | Built environment               | Supervision           |      | •    |
| Roy van Ballegooyen     | Natural resources/environment   | Supervision           |      | •    |
| Dr Bettina Genthe       | Natural resources/environment   |                       |      | •    |
| Dr Paul Oberholster     | Natural resources/environment   | Supervision           |      | •    |
| Dr Daniel Esser         | Laser technology                | Supervision           | •    | •    |
| Dr Belinda Reyers       | Natural resources/environment   | Supervision           | •    | •    |
| Dr Raymond Sparrow      | Biosciences                     | Supervision           | •    | •    |
| Dr Stef Roux            | Laser technology                | Supervision           | •    | •    |
| Dr Patrick O'Farrell    | Natural resources/environment   | Supervision           | •    | •    |
| Dr Luthando Dziba       | Natural resources/environment   | Supervision           | •    | •    |
| Dr Njabulo Siyakatshana | Modelling and digital science*  | Supervision           | •    | •    |
| Dr Simukai Utete        | Modelling and digital science*  | Supervision           | •    | •    |
| Dr Andrew Forbes        | Laser technology                | Supervision           | •    | •    |

\* = Not in MoU

## Students supported by the CSIR/SU scholarship programme

| Name of CSIR staff         | SU supervisor                             | Degree programme          | 2011 | 2012 |
|----------------------------|-------------------------------------------|---------------------------|------|------|
| Charles Rigby              | Dr Christine Steenkamp; Prof Erich Rohwer | PhD (Physics)             |      | •    |
| Pedri Claassens            | Dr James Lloyd; Dr Gavin George           | MSc (Plant Biotechnology) |      | •    |
| Marinel Janse van Rensburg | Prof Ingrid Rewitzky                      | MSc (Mathematics)         |      | •    |

\* = Not in MoU



## CSIR staff studying

| Name of CSIR staff     | CSIR supervisor                        | SU supervisor                            | Degree programme                             | 2011 | 2012 |
|------------------------|----------------------------------------|------------------------------------------|----------------------------------------------|------|------|
| Tumelo Uoane           | Dr Njabulo Siyakatshana                | Dr Mapundi Banda                         | PhD (Applied Mathematics)                    |      | •    |
| Andre Theron           | None                                   | Geoff Toms                               | PhD (Civil Engineering)                      |      | •    |
| Andri Barnard          | Avashnee Chetty                        | Prof Bert Klumperman                     | MSc (Applied Science)                        |      | •    |
| Anjo Theron            | Dr Colin Kenyon                        | Prof Ian Wiid                            | PhD (Molecular Biology)                      |      | •    |
| Attie Hendricks        | Dr Hermann Uys                         | Dr Christine Steenkamp                   | PhD (Laser Physics)                          |      | •    |
| Chris Burger           | None                                   | Prof Thomas Jones                        | DEng (Electrical and Electronic Engineering) |      | •    |
| Greg Forsyth           | None                                   | Dr Ailsa Holloway                        | MSc (Geography)                              |      | •    |
| Kobus Myburgh          | Dr Derik Minnaar                       | Prof Johann de Swardt                    | MEng (Electronics)                           |      | •    |
| Liesl Burger           | Dr Andrew Forbes                       | Prof Erich Rohwer                        | PhD (Physics)                                |      | •    |
| Marius Olivier         | Dr Frikkie Mostert                     | Prof Willem Perold                       | MSc (Electronic Engineering)                 |      | •    |
| Martin Pelser          | Dr Fernando Camisani-Calzolari         | Prof Hendrik du Mouton                   | MSc (Electronic Engineering)                 |      | •    |
| Mogomotsi Keaikitse    | Natasha Govender                       | Dr Willie Brink                          | MSc (Applied Mathematics)                    |      | •    |
| Nicolene Botha         | Dr Lourens Botha; Dr Anton du Plessis  | Prof Heinrich Schwoerer                  | PhD (Laser Physics)                          |      | •    |
| Niel Goslett           | None                                   | Prof Andre Roux                          | MPhil (Futures Research)                     |      | •    |
| Odirilwe Selomane      | Dr Belinda Reyers                      | Prof Karen Esler                         | PhD (Conservation Ecology)                   |      | •    |
| Padhraic O' Connor     | Dave Phelps                            | Geoff Toms                               | MSc (Civil Engineering)                      |      | •    |
| Patrick Shabangu       | Roy van Ballegooyen                    | Prof Francois Smit; Dr Hardus Diedericks | MSc (Applied Mathematics)                    |      | •    |
| Seanette van Rooyen    | Herman Le Roux                         | Prof Ben Herbst                          | MSc (Mathematics)                            |      | •    |
| Shir Botha             | Dr Bettina Genthe; Dr Paul Oberholster | Prof Anna-Maria Botha-Oberholster        | MSc (Molecular Biology)                      |      | •    |
| Sumaya Israel (Clarke) | Dr Nebo Jovanovic                      | Dr Andrei Rosenov                        | PhD (Soil and Water Chemistry)               |      | •    |
| Thomas Roos            | None                                   | Prof Thomas Harms                        | PhD (Mechanical Engineering)                 |      | •    |
| Wayne Koen             | Dr Daniel Esser                        | Prof Erich Rohwer; Dr Lourens Botha      | PhD (Physics)                                |      | •    |
| Mpendulo Ginindza      | None                                   | Dr Alan Brent                            | MPhil (Sustainable Development)*             | •    |      |

\* = graduated

# = left CSIR/no longer studying

| Name of CSIR staff           | CSIR supervisor                            | SU supervisor                           | Degree programme                                 | 2011 | 2012 |
|------------------------------|--------------------------------------------|-----------------------------------------|--------------------------------------------------|------|------|
| Azeza Fredricks <sup>#</sup> | None                                       | Prof Johan Mouton                       | DPhil (Science and Technology Studies)           | •    |      |
| Andre Munian                 | None                                       | Prof Louw Hoffman;<br>Dr Lutz Auerswald | PhD (Biochemistry)*                              | •    |      |
| Stefan Brink                 | None                                       | Prof Chris Aldrich                      | MEng (Electrical Engineering)                    | •    |      |
| Andre Breytenbach            | None                                       | Dr Adriaan van Niekerk                  | PhD (Geographical Information Systems)           | •    |      |
| Luther Terblanche            | Dr Gerhardus Diedericks                    | Dr Francois Smit                        | PhD (Applied Mathematics)                        | •    |      |
| Phumza Ntshotsho             | Dr Belinda Reyers                          | Prof Karen Esler                        | PhD (Conservation Ecology)*                      | •    |      |
| Nametso Mongwaketsi          | Dr Raymond Sparrow                         | Prof Bert Klumperman                    | PhD (Chemistry and Polymer Science) <sup>#</sup> | •    |      |
| Dwain Dunn                   | None                                       | Prof Theo von Backstrom                 | PhD (Mechanical Engineering)                     | •    |      |
| Riaan van den Dool           | None                                       | Dr Stefan van der Walt                  | PhD (Image Processing)                           | •    |      |
| Melani McLaren               | Dr Andrew Forbes;<br>Dr Stef Roux          | Prof Erich Rohwer                       | PhD (Physics)                                    | •    | •    |
| Ryan Blanchard               | Dr Patrick O'Farrell                       | Prof David Richardson                   | PhD (Botany)                                     | •    | •    |
| Gideon van der Kolf          | None                                       | Dr Iain Peddle                          | MSc (Electronic Engineering)                     | •    |      |
| Ramathabathe Madigoe         | Dr Lourens Botha                           | Prof Erich Rohwer                       | MSc (Laser Physics)                              | •    |      |
| Oliver Collett               | Dr Daniel Esser                            | Dr Lourens Botha                        | MSc (Laser Physics)*                             | •    |      |
| Seshni Govender              | Dr Petrus Van Zyl                          | Prof Emile van Zyl                      | MSc (Microbiology)                               | •    | •    |
| Ilse Kotzee                  | None                                       | Dr Belinda Reyers                       | PhD (Conservation Ecology)                       | •    |      |
| Thozamile Yapi               | Dr Patrick O'Farrell;<br>Dr Luthando Dziba | Prof Karen Esler                        | MSc (Conservation Ecology)                       | •    |      |
| Andre Smit                   | Dr Lourens Botha                           | Prof Erich Rohwer                       | PhD (Physics)                                    | •    |      |
| Nomakhwezi Mzamo             | Dr Ndeke Musee                             | Prof Chris Aldrich                      | MSc (Chemical Engineering)*                      | •    | •    |
| Michael Burke                | None                                       | Japie Engelbrecht;<br>Dr Willie Brink   | MSc (Electronic Engineering)*                    | •    |      |
|                              | None                                       | Japie Engelbrecht;<br>Dr Willie Brink   | PhD (Electronic Engineering)                     |      | •    |

| Name of CSIR staff         | CSIR supervisor         | SU supervisor                                | Degree programme              | 2011 | 2012 |
|----------------------------|-------------------------|----------------------------------------------|-------------------------------|------|------|
| Vincent Kheswa             | Dr Njabulo Siyakatshana | Prof Mapundi Banda                           | MSc (Nuclear Physics)*        | •    |      |
| Jaco de Wit                | None                    | Dr Gert-Jan van Rooyen                       | PhD (Electronic Engineering)* | •    |      |
| Saturnin Ombinda-Lemboumba | Dr Anton du Plessis     | Dr Christine Steenkamp;<br>Prof Erich Rohwer | PhD (Physics)*                | •    |      |
| Belinda Matebese           | Dr Simukai Utete        | Prof Mapundi Banda                           | PhD (Applied Mathematics)     | •    |      |
| Darryl Naidoo              | Dr Andrew Forbes        | Prof Erich Rohwer                            | PhD (Physics)                 | •    |      |

\* = graduated      # = left CSIR/no longer studying

## CSIR researchers holding extraordinary professorships

| Name of Researcher  | Area of Expertise                    | 2011 | 2012 |
|---------------------|--------------------------------------|------|------|
| Dr Brian van Wilgen | Conservation ecology                 |      | •    |
| Dr Belinda Reyers   | Conservation ecology                 | •    | •    |
| Dr Andrew Forbes    | Beam propagation                     | •    |      |
| Dr Thulani Dlamini  | Catalysis                            | •    |      |
| Dr Lourens Botha    | Laser development and photochemistry | •    | •    |
| Dr Anton du Plessis | Laser spectroscopy                   | •    |      |
| Dr Michelle Audouin | Sustainability Science               |      | •    |

## SU researchers serving on CSIR Advisory Panels

| Name of Researcher   | Area of Expertise | 2011 | 2012 |
|----------------------|-------------------|------|------|
| Prof Bert Klumperman | Polymer science   | •    | •    |
| Prof Emile van Zyl   | Microbiology      | •    | •    |

# List of Abbreviations

|              |                                                              |                |                                                 |
|--------------|--------------------------------------------------------------|----------------|-------------------------------------------------|
| <b>ADMET</b> | Absorption, Distribution, Metabolism, Excretion and Toxicity | <b>MIM</b>     | Metal Injection Moulding                        |
| <b>AMD</b>   | Acid Mine Drainage                                           | <b>MoU</b>     | Memorandum of Understanding                     |
| <b>CAO</b>   | Carnegie Airborne Observatory                                | <b>NADH</b>    | Nicotinamide Adenine Dinucleotide               |
| <b>CCUAS</b> | Civil Commercial Unmanned Aircraft System                    | <b>NMR</b>     | Nuclear Magnetic Resonance                      |
| <b>CFD</b>   | Computational Fluid Dynamics                                 | <b>PDT</b>     | Photodynamic Therapy                            |
| <b>CPUT</b>  | Cape Peninsula University of Technology                      | <b>PE</b>      | Polyethylene                                    |
| <b>CSIR</b>  | Council for Scientific and Industrial Research               | <b>PEI</b>     | Polyethyleneimine                               |
| <b>DME</b>   | Dimethyl Ether                                               | <b>PEMFC</b>   | Proton Exchange Membrane Fuel Cell              |
| <b>DMG</b>   | Dimethylglyoxime                                             | <b>PGM</b>     | Platinum Group Metals                           |
| <b>DST</b>   | Department of Science and Technology                         | <b>PHI</b>     | Post Harvest Innovation                         |
| <b>ENMS</b>  | Engineered Nanomaterials                                     | <b>PLA</b>     | Polylactic Acid                                 |
| <b>GNSS</b>  | Global Navigation Satellite Systems                          | <b>R&amp;D</b> | Research and Development                        |
| <b>GPS</b>   | Global Positioning System                                    | <b>RO</b>      | Reverse Osmosis                                 |
| <b>FDA</b>   | Food and Drug Administration                                 | <b>SAEON</b>   | South African Environmental Observation Network |
| <b>GDH</b>   | Glucose dehydrogenase                                        | <b>SAM</b>     | Spectral Angle Mapper                           |
| <b>GIS</b>   | Geographical Information System                              | <b>SANDF</b>   | South African National Defence Force            |
| <b>HCD</b>   | Human Capital Development                                    | <b>SARVA</b>   | South African Risk and Vulnerability Atlas      |
| <b>HCF</b>   | High Cycle Fatigue                                           | <b>SDSS</b>    | Spatial Decision Support System                 |
| <b>HIV</b>   | Human Immunodeficiency Virus                                 | <b>SSM</b>     | Spectral Similarity Measurement                 |
| <b>IAT</b>   | Institute of Advanced Tooling                                | <b>SU</b>      | Stellenbosch University                         |
| <b>ICT</b>   | Information and Communication Technology                     | <b>TB</b>      | Tuberculosis                                    |
| <b>IGNSS</b> | International Global Navigation Satellite Systems Service    | <b>TEC</b>     | Total Electron Content                          |
| <b>HPC</b>   | High Performance Computing                                   | <b>TiCoC</b>   | Titanium Centre of Competence                   |
| <b>HRIG</b>  | Human Rabies Immune Globulin                                 | <b>UFS</b>     | University of the Free State                    |
| <b>HSAM</b>  | High Speed Laser Additive Manufacturing                      | <b>UCT</b>     | University of Cape Town                         |
| <b>IMT</b>   | Institute of Marine Technology                               | <b>UWC</b>     | University of the Western Cape                  |
| <b>LHCs</b>  | Light Harvesting Complexes                                   | <b>VUV</b>     | Vacuum Ultra Violet                             |
| <b>Lidar</b> | Light Detection And Ranging                                  | <b>WWTP</b>    | Waste Water Treatment Plant                     |

# Acknowledgements

## Prepared by

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