

# CSIR National Laser Centre Biophotonics test bed facility



**Applications of photonics-based techniques in surgery and medicine continue to increase rapidly. This is mainly due to the fact that such techniques hold a series of inherent advantageous properties compared to more conventional medical techniques. For instance, by applying optical techniques, treatments and diagnostic procedures can be done non-invasively, which reduces the inconvenience for the patients as well as the risk of spreading infectious diseases. Furthermore, photonics-based medical equipment is typically relatively inexpensive and can also be made transportable, allowing for outpatient treatment and early diagnostics at first level patient care. This is of substantial importance in the South African context, specifically in terms of deployment of medical diagnostic and therapeutic equipment in remote/rural areas.**

**Figure 1: The BioBed R&D platform – CSIR National Laser Centre**



Currently, the Biophotonics Group at the CSIR National Laser Centre is focusing on projects related to photodynamic therapy (PDT). To facilitate these and other future projects, the group has established a generic in-house platform for preclinical testing of novel photonics based medical applications. As illustrated in the figure above, this so-called biophotonics test bed (BioBed) platform consists of four core technologies:

**Tissue spectroscopy:**

Fundamental optical characterisation of biological media, i.e. determination of absorption and scattering properties of human tissue, and body fluids.

**Photon migration modelling:**

Pretreatment planning and analysis using mathematical modelling and computer simulations of light propagation in human tissue.

**Biological tissue models:**

Manufacture and assembly of synthetic biological human tissue models for preclinical testing of biomedical photonics applications and fundamental light-tissue interaction studies.

**Multimodal medical imaging:**

Non-invasive (and non-ionising) imaging and tomographic analysis of the morphological and physiological effects of photonics-based therapies.



**Examples of photonics based medical applications are:**

- Photodynamic therapy (i.e. cancer therapy using light-activated drugs).
- Laser surgery (in ophthalmology, dermatology, oncology, cardiology, etc.)
- Optical biopsy (e.g. non-invasive cancer diagnostics, tissue glucose measurements, and hemodynamic monitoring).
- Optical imaging (e.g. fluorescence-, photo-acoustic-, or optical coherence tomography).

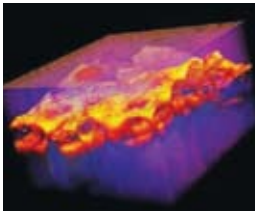
To implement the BioBed platform at the CSIR National Laser Centre, a biological cell culture laboratory has been established and is closely integrated with adjacent optical laboratories. This

enables the Biophotonics Group to manufacture synthetic three-dimensional (3D) biological tissue models from human cell samples, which can be induced with various forms of lesions, e.g. cancer. Consequently, such 3D biological tissue models constitute a very convenient, cost-effective, and realistic but risk-free environment for preclinical testing and optimisation of novel biomedical photonics applications.

In order to non-invasively monitor and quantify the morphological effects of various photonics-based therapeutic modalities, and to aid in the development of novel medical diagnostic techniques as well, an optical coherence tomography (OCT) system has also been acquired and implemented.

This OCT system allows researchers to perform non-destructive *in vivo* cross-sectional real-time imaging of biological tissue as shown in Figure 2. The OCT system typically provides images with a resolution of  $\sim 20 \mu\text{m}$  down to a depth of 2-3 mm. Likewise, fluorescence imaging facilities have also recently been established, which, in combination with the OCT system, will enable very specific and detailed medical diagnostics of e.g. cancer.

Figure 2



As implied, the field of biophotonics is highly multidisciplinary. Therefore, to succeed, collaboration

between various disciplines, e.g. physics, medicine, biology, and engineering is crucial. Accordingly, one of the key drivers for establishing the BioBed platform at the CSIR was to facilitate such multidisciplinary biomedical photonics collaboration in South Africa and a number of such projects have already been launched.

These objectives are further underlined by the fact that the CSIR National Laser Centre Biophotonics Group has obtained status as a Department of Science and Technology Centre of Competence, implying that the group aims to be a national hub for biomedical photonics research and is committed towards establishing joint cross-disciplinary research and development projects with South African partners as well as rendering services in the form of training courses, contract investigations and tests.

The CSIR National Laser Centre strongly encourages any interested companies, research institutions or students with suggestions on new potential collaboration projects, to contact the organisation for further discussions and exploration.



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