THE CSIR PHOTONICS CENTRE

science & innovation
Department:
Science and Innovation
REPUBLIC OF SOUTH AFRICA

CSIR
Touching lives through innovation

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ABOUT THE CSIR

The Council for Scientific and Industrial Research (CSIR) is a leading scientific and technology research organisation that researches and develops transformative technologies to accelerate socioeconomic prosperity in South Africa. The organisation's work contributes to industrial development and supports a capable state.

The CSIR is an entity of the Department of Science and Innovation (DSI).

The organisation plays a key role in supporting the public and private sectors through directed research that is aligned with the national priorities, the organisation's mandate and its science, engineering and technology competencies.

Impact is at the core of our business and the following objectives ensure that we achieve our mission:

- Conduct research, development and innovation of transformative technologies and accelerate their diffusion;
- Improve the competitiveness of high-impact industries to support South Africa's re-industrialisation by collaboratively developing, localising and implementing technology;
- Drive socioeconomic transformation through RD&I that supports the development of a capable state;
- Build and transform human capital and infrastructure; and
- Diversify income and maintain financial sustainability and good governance.

Our core values are the driving force behind our ability to conduct cutting-edge research and technological innovation to improve the quality of life of South Africans. These values make for an **EPIC** team – one that pursues **Excellence**, celebrates **People**, personifies **Integrity** and welcomes **Collaboration**.

ABOUT THE MANUFACTURING CLUSTER

FUTURE PRODUCTION: MANUFACTURING

CSIR Future Production: Manufacturing focuses its science, engineering and technology base on contributing towards South Africa's re-industrialisation by developing or facilitating the uptake of new technologies that will improve the competitiveness and productivity of strategic local economic sectors. This includes technologies and paradigms articulated through the fourth industrial revolution (4IR). The CSIR's competences in manufacturing enable it to assist the state to better address socioeconomic development through technologically enhanced service delivery.

This cluster builds world-class capabilities for the engineering and production industries in South Africa, which includes localising and developing transformative and efficient ways of manufacturing existing and new products. The outcome includes more local original equipment manufacturers, expanding exports and capturing a larger share of global high-value manufacturing.

Titanium additive manufacturing and materials engineering are examples of capabilities in new and advanced materials, and new technologies for product and product manufacturing. Expertise in digital transformation and product lifecycle management that combines product, process and business model innovation over the full lifecycle of a product, and a learning factory to support skills development and training in 4IR domains further strengthens the CSIR's offering in manufacturing.

Advanced Materials Engineering: Applying expertise and infrastructure to lead in areas such as structural design and analysis, and the development of advanced casting and powder metallurgy technologies. This domain houses the Light Metals Development Network and the Titanium Centre of Competence, which are multiuser national platforms that support industrialisation Initiatives.

Industrial Sensors: Focusing on the custom development of products in the field of inspection and monitoring systems and working with private and public sector players of all sizes on sensor innovations. Also pursuing use of ultrasonics in medical diagnostics.

Centre for Robotics and Future Production: Focusing on disruptive technologies that dominate the 4IR, with the aim of enabling the local manufacturing industry to be globally competitive. Technology areas that the centre incubates include industrial robotics, industrial artificial intelligence and future production systems.

Photonics Centre: Supporting the development of photonics, specifically laser-based technologies for advanced manufacturing applications. This includes applications in laser-based surface engineering, additive manufacturing, processing technologies and the associated facilities open to industry partners. It also includes medical imaging for diagnosis; use of lasers in corrective treatments; detecting antibodies, enzymes and cell phenotypes; and miniaturisation technology, including biosensors.

Industry Connect: Supporting industry by improving competitiveness in niche areas, fostering new technology development, de-risking technology, facilitating technology transfer, and undertaking supplier development. This is in line with the CSIR objective to collaboratively innovate and localise technologies and provide high-impact industries with access to infrastructure and expertise. This includes the Aerospace Industry Support Initiative managed on behalf of the Department of Trade, Industry and Competition.

ABOUT THE PHOTONICS CENTRE

The Photonics Centre focuses on developing technology-based solutions in the field of laser-based technologies. This includes applications in laser-based surface engineering, additive manufacturing and processing technologies. These technologies, expert and world-class facilities are available for support to innovators technologies industry partners and researchers across Africa.

OUR CAPABILITIES

BIOPHOTONICS

The CSIR's biophotonics research team follows a laser-driven lab-on-a-chip approach, which has the potential of converting any test to a point-of-care diagnostic format. Since infectious diseases such as human immunodeficiency virus (HIV) are still reported as major causes of mortality, particularly in the developing world, innovation around point-of-care diagnostics has the potential to reduce the burden of disease. Improvement of the current HIV diagnostics to incorporate immediate CD4 count and viral load testing would have a massive impact in informing treatment decisions and management. Knowing exactly when to start antiretroviral treatment and monitoring its effectiveness may help alleviate some of the current challenges endured by HIV patients, such as the development of viral resistance.

The point-of-care diagnostics approach undertaken by this team seeks to develop a laser-driven cost-effective HIV-1 diagnostic device that is easy to use at point-of-care settings and in low-resourced settings.

The design of a photonics-based cell-sorting micro-chip, coupled with super-resolution imaging and spectroscopic techniques, could pave the way for the invention of highly specific HIV-1 diagnostic tools: A kit that not only confirms the presence of HIV-1, but is able to also indicate genotypic information and the viral load. The biophotonics team has set out to develop an optical tweezer and/or deflection system that will be able to sort HIV-1-infected cells from a mixed population of cells. In particular, the team plans to apply and use, for the first time, laser light of novel beam shapes to study single molecule analysis in HIV-1-infected cells.

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OUR CAPABILITIES

NOVEL LASERS

The CSIR novel lasers research group conducts research in novel high-power and high-energy laser systems and laser sources for high-power laser-enabled manufacturing, such as selective laser melting, laser cutting, drilling, welding and marking. The primary focus is on developing new laser and monitoring technologies for selective laser-melting additive manufacturing of both metal and polymer parts.

The group's capabilities include the delivering and positioning of multikilowatt laser beams, beam shaping of high-power laser beams and compensating for thermo-optical distortions.

Research and development of high-power bulk mid-infrared laser sources with wavelengths at 1 μm, 1.3 μm, 1.9 μm, and 2 μm; Designing and developing fibre laser sources at 1 μm and 2 μm; and designing and developing high-power mid-infrared optical parametric oscillator sources at wavelengths from 3 μm to 8 μm, and at 12 μm.

The group conducts research and development in collaboration with stakeholders across the high-power manufacturing value chain. The CSIR aims to improve the manufacturing speed, quality and traceability of final parts for the aerospace and medical industries.

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OUR CAPABILITIES

LASER-ENABLED MANUFACTURING

The CSIR enables South African manufacturers to stay at the cutting edge of laser technology through laser-based manufacturing. This group of the CSIR Photonics Centre has a diverse and specialised portfolio of laser technologies, such as laser welding, laser hardening, laser shock peening, metal additive manufacturing also known as 3D printing and a mobile laser refurbishment system for onsite processing applications.

Over the years, the CSIR has built an impressive track record working with a number of reputable industry players. Each of the research and development partnerships that the CSIR has engaged in has benefitted immensely from the use of laser-based technology solutions to improve the competitiveness of their product lines. These diverse laser technology solutions have the ability to reduce costs, enhance performance, provide opportunities for innovative design and extend the lifespan of equipment in the industrial market.

The CSIR has a footprint that extends across various sectors. However, some of the key markets of interest for this group are the defence, mining, tooling, marine and transport industries.

The laser-based manufacturing group focuses its efforts on research and development and industry and includes laser engineering services and laser-enabled manufacturing, through which tailored solutions and products are provided to clients.

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NATIONAL PROGRAMMES

The National Programmes portfolio supports national and continental research and development initiatives at research organisations, higher education institutions (HEIs), and stakeholders in the public and private sectors that are active in the research, development and utilisation of photonics-based technologies. The National Programmes portfolio hosts four programmes, namely, the African Laser Centre (ALC), Collaborative Programme in Additive Manufacturing (CPAM), Photonics Prototyping Facility (PPF) and Laser Rental Pool Programme.

AFRICAN NATIONAL LASER CENTRE

The African National Laser Centre (ALC) is a New Partnership for Africa's Development (NEPAD) flagship initiative and is funded by the DSI through its Africa Multilateral Cooperation programme. The centre was launched at the Ministerial NEPAD summit in Johannesburg, South Africa, in November 2003. It is a virtual organisation that brings together researchers from across Africa in the fields of lasers and spectroscopy.

The ALC was started as a fledgling programme within the CSIR Photonics Centre and is aimed at encouraging research collaborations between African researchers and facilitating researcher and student exchanges between African institutes that are active in photonics-based research. Based on funding made available by the DSI, the ALC in South Africa supports four programmes, which are the ALC Research Collaboration Programme, the ALC Scholarship Programme, the ALC Training Programme and the ALC Knowledge Exchange Programme.

COLLABORATIVE PROGRAMME IN ADDITIVE MANUFACTURING

The Collaborative Programme in Additive Manufacturing (CPAM) aims to increase the manufacturing readiness of additive manufacturing, which will lead to the adoption and utilisation of additive manufacturing as an accepted and viable advanced manufacturing technology. The programme focuses on supporting research, development and innovation in additive manufacturing at South African research institutions, in cooperation with industrial partners. The CPAM focuses on four main themes, namely, the qualification of metal additive manufacturing for industrial applications, a design-for-additive manufacturing programme, an industrialisation of polymer additive manufacturing programme and an industry development programme.

PHOTONICS PROTOTYPING FACILITY

The Photonics Prototyping Facility (PPF) supports the development of photonics-based prototypes for market evaluation and testing. Through the facility, stakeholders have access to the dedicated facilities and skills that support the development of photonics-based product prototypes. The purpose of the PPF is to support and stimulate the growth of the South African photonics industry by providing the opportunity to develop technologies to a point of market readiness.

The facility was established by the CSIR and is funded by the DSI. The PPF works closely with industry partners to support the development of photonics-based product prototypes to enable and stimulate the growth of the South African photonics industry, increase its competitiveness, and support the growth of enterprises and associated job creation through the expansion of the photonics industry's product portfolio.

LASER RENTAL POOL PROGRAMME

The CSIR has access to an extensive equipment base in the field of photonics, specifically laser sources, photonics-based diagnostics and ancillary equipment that can be used to enable photonics and photonics-based application research and development programmes. The CSIR Laser Rental Pool programme was established in the year 2000 and provides the laser and ancillary equipment required for laser and laser application-related research at South African HEIs. The CSIR Laser Rental Pool programme is funded by the DSI, and provides researchers at HEIs access to state-of-the-art equipment, based on a strong research programme motivation. Through the programme, scientific, engineering and technical support is available to researchers to support the equipment required for their research projects. The programme focuses on supporting laser-related research in all research fields in the natural, engineering and health sciences fields, and strongly encourages collaborative research among different institutions. The fund allows access to equipment for use at the host institution of applicants, as well as access to equipment housed at facilities of the CSIR Photonics Centre.

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OUR FACILITIES

BIOPHOTONICS FACILITY

Biophotonics investigates the development and application of optical or photonics-based techniques to facilitate single molecule and/or cell studies. It is a multidisciplinary, directed research field that cuts across various scientific disciplines, including biological sciences, medicine, chemistry and physical sciences. CSIR biophotonics research is undertaken in a laboratory equipped with specialised lasers of different regimes.

Biophotonics researchers at the CSIR use lasers of different regimes to optically micro-manipulate embryonic stem cells for tissue engineering investigations; neuroblastoma cells for neurodegenerative studies; HIV-1-infected cells for targeted antiretroviral drug delivery and to answer basic questions in HIV-1 pathogenesis; as well as cancerous cells to study intricate bioprocesses at single cell level.

Currently, CSIR biophotonics researchers focus on developing point-of-care diagnostic devices. These devices are intended to enable early disease diagnosis and expand access to previously under-served populations in resource-limited settings. These medical devices or tools can diagnose diseases in a patient's community, generally outside a formal clinic setting. Point-of-care diagnostics enable CSIR research to focus on the development of photonics-based technologies and methods for detecting biological states of health and disease, diagnosing those states, and monitoring changes in those states.

Photonics-based technologies allow early detection of diseases, and the use of light and optics affords many advantages because of the multi-dimensional data that can be collected and analysed.

TECHNIQUES AND EQUIPMENT USED IN POINT-OF-CARE RESEARCH

OPTICAL TRAPPING AND CELL SORTING

The ability to trap, sort and separate rare cells, or sort diseased from healthy cells, is of significant value in biology and medicine. Optical cell sorting allows the sorting of rare or precious cell samples in nanoliter volumes of analyte, and this offers prospects for potential measurements and manipulation of biological materials such as cancer cells, HIV-infected cells and stem cells. Optical sorting of a population of cells is possible using a variety of laser beam configurations for both active and passive sorting in fluid, flow-free micro-sample chambers. For optical trapping and cell sorting, the experimental systems utilise a tuneable single continuous wave diode laser beam at 1 064 nm, producing a maximum output power of 1.5 W. For cell sorting purposes, a specialised conical surface lens that transforms a laser beam into a ring-shaped distribution is inserted on the beam part. The sample is inserted on a motorised moving stage. The image of the trapped/sorted cells is viewed through a video camera illuminated with an illumination system.

RAMAN SPECTROSCOPY

Raman spectroscopy is one of the main diagnostic techniques in analytical chemistry. It is developing into an important method in biology and medicine as a real-time clinical diagnostic tool for the identification of disease, and evaluation of living cells and tissue. It is an optical technique based on inelastic scattering of monochromatic laser photons during which the frequency of photons of laser light slightly changes upon an interaction with a sample. For this technique, the biophotonics team makes use of the Raman spectroscopy system, which is combined with the cell trapping system. The Raman excitation light is MIL-S-1064, a laser diode at 1 064 nm. This detection system comprises a fibre optic that guides Raman scattering into a spectrometer that is coupled with a charged-coupled device camera.

OUR FACILITIES

TECHNIQUES AND EQUIPMENT USED IN POINT-OF-CARE RESEARCH CONTINUED

SURFACE PLASMON RESONANCE

For the surface plasmon resonance work, we use a homemade system that comprises a coherence cube laser diode light source at 640 nm with a maximum power output of 60 mW, a half-wave plate combined with polarised beam splitter to select p-polarisation light, an equilateral prism, glass coverslips coated with gold thin film, and a sample cell and spectrometer coupled with a charged-coupled device (or photodiode) as a detection system.

OPTICAL TRANSFECTION AND TRANSLOCATION

The ability to introduce genetic material into a cell – whether into a prokaryotic cell (transformation) or a eukaryotic cell (transfection) – has allowed the exploration of the molecular mechanisms within cells and the production of genetically engineered organisms. Gene, drug and/or vaccine delivery schemes with minimum cytotoxicity and an immunogenic response that can be applied under sterile tissue-culture protocols and can offer targeted treatment of a large number of individual cells, organelles and organs among other things, are highly desirable. Optical injection allows membrane impermeable substances such as drugs, fluorophore, macromolecule or nucleic acid to translocate inside a cell after laser has transiently permeabilised the cell membrane.

This optical photo-poration experimental arrangement uses a regenerative amplifier femtosecond titanium sapphire laser, which delivers light pulses at 800 nm wavelength, 1 KHz repetition rate with 113 fs pulse duration and average power of 1 W. The beam from the laser is directed through a half-wave plate and a polarising beam splitter to control the power at the sample plane. The automated beam shutter is often used to control the laser-cell interaction time. The photo-poration beam is coupled into a 60x microscope objective. A sample imaging system consisting of illumination system, a 50x long working distance objective and a CCD camera is used to visualise and record the cell photo-poration investigations.

LOW-LASER LIGHT THERAPY

Low-laser light therapy uses a continuous wave diode laser operating at a wavelength of 640 nm, with a maximum output power of 100 mw. The original beam from the diode laser is magnified about 20 times, using a two-lens telescope to overfill the entire area of the sample.

SAMPLE PREPARATION AND ANALYSIS

For cell culture, cell growth, sample preparation and sample analysis, different equipment is used, including biosafety cabinets, incubators, polymerase chain reaction machine and microscopes.

OUR FACILITIES

LASER-ENABLED MANUFACTURING FACILITY

The CSIR develops and customises laser-based technologies to improve the efficiency and competitiveness of numerous industry players, large state-owned companies, such as Eskom and Denel, as well as render valuable support to government initiatives, such as the Aerospace Industry Support Initiative. The ability to provide this specialised support is rooted in a first-rate laser-based manufacturing facility with highly specialised equipment.

A diverse range of manufacturers are benefitting from using laser-based technology solutions to improve the competitiveness of their product lines. With a two-pronged approach in laser-based technology solutions for industry, the CSIR has steadily extended its reach across sectors, such as defence, power-generation, mining, tooling, marine and transport.

The organisation offers a number of laser technology solutions and services, outlined below.

LASER WELDING

The laser welding process joins components using a laser source, with or without any filler material. This form of laser refurbishment process can be used in automotive body panels, light-weight structures and stainless-steel tubing.

LASER ABLATION

Laser ablation selectively removes material from a structure with a laser. With the small laser spot size and accurate positioning of the workpiece, very small features can be machined with high precision. In addition, material such as ceramics and hardened steels can be easily machined.

LASER SHOCK PEENING

Laser shock peening is a process that aims to solve industrial problems. This innovative surface treatment induces compressive residual stresses on and beneath the surface through high-magnitude shock waves generated by a high-energy laser pulse. Laser shock peening is applied over a variety of engineering sectors where surface degradation is a major concern. This laser process is applicable for the energy and aerospace industries.

LASER CLADDING

Laser refurbishment is the process of repairing worn, damaged or faulty components. The laser cladding process is applicable for the repair of moulds, shafts, turbine blades and press tools.

OUR FACILITIES

A MOBILE LASER SYSTEM FOR LASER-BASED REFURBISHMENT

Over the years, the CSIR has amplified its laser-based manufacturing competences, specifically in laser-based refurbishment, a laser-weld overlay or cladding technology. Specialised equipment in the laser-based manufacturing facility is the mobile laser system used in the repair of turbine blades, bearing journals, gears and drive shafts.

This capability is invaluable for the refurbishment of large and high-value components as it translates to faster response times and significant cost saving for industry. Laser-based refurbishment also offers the opportunity to repair components that were previously scrapped due to industry not having access to this new, low-heat inputs repair process.

Eskom experienced the benefits of using the CSIR's mobile-refurbishment system first hand.

In 2011, some of the water tanks at the Eskom Power Station had developed stress-corrosion cracking. Managed by the CSIR team, a laser-based cladding procedure was designed for the in-situ sealing of water vessels. The team successfully managed to extend the service life of the Eskom Power Station tanks with more than five years.

Additionally, using the same technology, the CSIR plays an instrumental role in Eskom's turbine blade refurbishment programme. This programme helps to ensure that Eskom's operations are uninterrupted. It entails repairing cracks and leading-edge erosion, as well as rebuilding turbine journal and blade tenons.

A LASER ENGINEERING NET-SHAPING 3D PLATFORM TO BUILD PARTS

The CSIR's laser engineering net-shaping 3D platform makes it possible to create fully functional parts made from titanium, nickel, metal matrix composites and zirconium. The platform also has the capability to improve existing parts through the deposition of new surface layers, build-up damaged areas and perform hybrid manufacturing processes for complex geometries. This additive manufacturing platform has proven to be particularly beneficial to the automotive and aerospace industries.

To help ensure that South African manufacturers remain competitive through advanced, innovative laser-based manufacturing, the CSIR also has valuable expertise in and access to equipment for 3D laser and pipe cutting, laser hardening and welding.

OUR FACILITIES

METAL ADDITIVE MANUFACTURING (3D PRINTING)

The laser-based facility also has an additive manufacturing value offering. "Additive Manufacturing" is defined by the ASTM as the "Process of joining materials to make objects from 3D model data, usually layer upon layer, as opposed to subtractive manufacturing methodologies. Additive Manufacturing (more commonly known as 3D printing) is a new advanced manufacturing technology that offers industry a number of advantages compared to the more conventional manufacturing technologies."

The diverse laser technology solutions have the ability to reduce costs, enhance performance, provide opportunities for innovative design and extend the lifespan of equipment in the industrial market. Technologies that form part of the additive manufacturing offering include laser-engineered net shaping, the Aeroswift custom-built 3D printing system and a miniature selective laser melting system known "the Hummingbird".

- 3D printing, considered the future of niche manufacturing, can make any shape, without wasting valuable metal powder;
- South African-printed 3D parts are already flying in aeroplanes and used in other industries; and
- South Africa's Aeroswift 3D printers are large powder-bed fusion machines.

Demand for 3D printing is high in industries like medical prosthetics and aviation, where clients need a small number of complex parts made out of high-value materials like titanium. Other industries have started to explore On-Demand Additive Manufacturing of spare parts, that is has become attractive to business supply chains.

But using the giant printer to produce parts is not the end game for the Aeroswift team – they want to build printers. The machine was built with a dual goal: produce parts and do research and development. It is important to have industrial versions of the Aeroswift technology available to develop and support a competitive industry.

OUR FACILITIES

NOVEL SOLID-STATE LASER FACILITY

The CSIR's solid-state laser research and development laboratory is housed in a class 1 000 clean room facility with isolated class 100 and class 10 areas for highly sensitive dust-free work. The laboratory is well equipped with a range of optical diagnostic equipment that supports the development, analysis and optimisation of novel laser systems across the optical spectrum.

The research conducted in novel solid-state lasers is mainly aimed at power and energy scaling, while maintaining good beam quality of the laser output. This includes research into novel laser concepts and geometries, thermal handling, laser resonator design and numerical modelling of the laser. Other areas of interest are special operating regimes, such as high-spectral purity and single frequency.

CSIR researchers and engineers work closely with clients to develop tailored laser sources suited for their application. The researchers develop the right light for the job, delivering custom laser prototypes directly to clients. With access to facilities and experts at the Advanced Photonics Manufacturing Facility, rugged laser systems can be manufactured and standard laser systems, based on existing designs, are set to be produced in the near future. Should the required laser already be available commercially, CSIR laser technology experts also offer specialised consulting services to help perfect the solution.

The CSIR is well positioned to provide industry with access to state-of-the-art facilities and equipment. Using this facility, researchers have designed and developed a number of cutting-edge laser systems over the past years and have considerable expertise in efficient solid-state lasers in the visible and infrared region. Specifically, novel infrared laser sources have been developed operating at 1 μm, 1.3 μm, 1.9 – 2.1 μm and 3 – 5 μm. Some of the CSIR's most recent successes in this domain include the use of thulium and holmium gain material to achieve power and energy scaling in bulk crystal rod and slab lasers.

In terms of engineering capabilities, the facility has been pivotal in the development of rugged and portable laser systems that can withstand different environmental conditions, as well as ultra-compact lasers with strict size and efficiency requirements.

OUR FACILITIES

THE PHOTONICS PROTOTYPING FACILITY (PPF)

Photonics is revolutionising the 21st century with its novel and influential technologies. Even though it is a driving force in accelerating economic growth, South Africa and the rest of Africa have a miniscule market share of this growing economy. One of the major contributing factors to this lack of impact is that, frequently, many invented photonics technologies are not commercialised, let alone prototyped in Africa. The barriers to cross this innovation chasm are a lack of a skilled workforce – scientific and business expertise needed to industrialise technologies – and a lack of funding to develop the necessary infrastructure and facilities.

The CSIR PPF aims to address this problem by providing world-class facilities, technical support, equipment and scarce skills to assist in industrialising these untapped technologies. The PPF supports the development of photonics-based products, specifically the prototype-development phase, to test the market for acceptance of the planned product. Several economic sectors make use of these technologies, including industrial manufacturing, energy, lighting and displays, information and communications, defence, security and sensors, and life sciences.

The facility hosts a state-of-the-art infrastructure such as laser, optical and workshop facilities, and is available for small, medium and micro enterprises support. Through the PPF, the CSIR makes a range of expertise and skills available to develop these prototypes.

CAPABILITIES FOR PHOTONICS PROTOTYPING:

- The design and development of portable photonics-based point-of-care diagnostics for HIV and TB;
- The design and development of a range of compact laser sources;
- The design and development of laser-based systems for manufacturing, 3D printing and other materials processing applications;
- The development of laser-based devices for detection and illumination applications, specifically lidar and other atmospheric monitoring applications;
- The development of photonics-based sensor products for application in a wide range of applications; and
- Mechanical, electronics and industrial design capabilities to support prototype development.

OUR TECHNOLOGIES

SMARTPHONE BIOSENSING FOR POINT-OF-CARE APPLICATION

For patients living in rural areas or remote areas, healthcare is not always readily available. In clinical settings, such as clinics and hospitals, laboratory tests requiring expensive equipment and well-trained technicians to perform them are used to diagnose a patient's illness.

Due to the large volume of routine samples that require testing or the lack of appropriate equipment for performing the diagnostic tests, it can take several days to process analytical results. This means that treatment of patients is delayed, while their conditions deteriorate. To address these challenges, there is a need for point-of-care diagnostic devices that are portable and can be used anywhere the patient can be found.

The CSIR team has developed a smartphone-based system for point-of-care diagnostics. The system employs an optical setup for manipulating and directing the light from a smartphone camera to transmit wavelengths in the range of visible spectrum used for detection of infections in samples.

Using the camera of the smartphone as a primary feature, the device can capture multiple images that yield spectra of optical output from biomolecules.

This technology makes it possible to perform spectrometric analysis using only a smartphone rear camera and a disc grating. This makes it possible to quantitatively measure how much of the light was absorbed by and transmitted through a sample.

In addition, because smartphones are connected to the Internet, test results can be saved in the cloud or transmitted to the people that a patient wants to send them to.

ADDITIVE MANUFACTURING TECHNOLOGY

Additive manufacturing is a method of making complex three-dimensional objects by creating an object from multiple layers of materials in succession. Most 3D prints are created with a process called Fused Deposition Modeling, which uses melted thermoplastics in a process similar to inkjet printers. Other processes are used for metal or ceramic printing.

The CSIR houses an additive manufacturing research and development facility and is collaborating with industry partner Aerosud to apply this technology in various applications. The CSIR's advancement of additive manufacturing in South Africa will have a positive effect on the entire production value chain for both small and big manufacturing industries.

The CSIR's research focuses on high-speed large-area Selective Laser Melting for titanium components, as well as laser metals deposition for new near-net shape and refurbishment application. The CSIR works with industry leaders such as Eskom, Transnet, Anglo American, and other industrial and manufacturing companies locally to develop new technologies for applications.

The CSIR has recently inked a research project with Anglo-American to implement 3D printing technology in the mining industry through the on-demand fabrication of spare parts at Anglo operations.

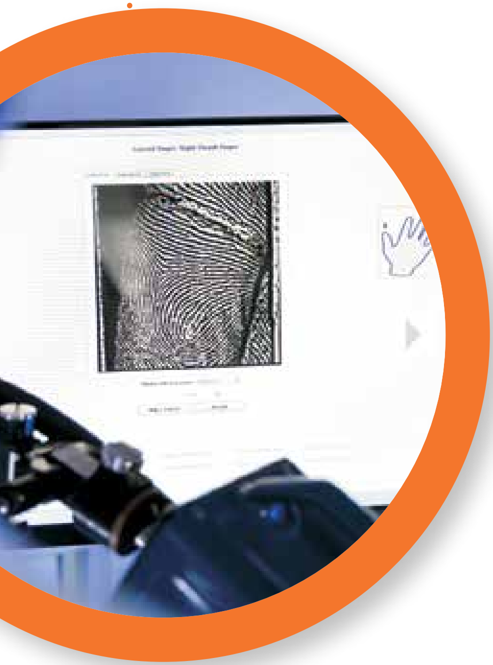
OPTICAL COHERENCE TOMOGRAPHY TECHNOLOGY

The CSIR Photonics Centre developed a high-speed, large-area Optical Coherence Tomography (OCT) system for fingerprint biometrics. The system images large surface areas (a 25 by 25 mm area) to a depth of 11 mm (sample dependant), acquiring 3-D images in less than three seconds.

OCT, which works by using light instead of electrons, is a non-invasive imaging technique capable of providing deep-layer information about any type of sample. OCT is frequently viewed as an equivalent of ultrasound. Because it can provide higher resolution images in-situ and in real time, OCT has become a useful tool in medical and other related fields. The technology is also usable in the fields of high security access control and safety and security, giving it the ability to capture live fingerprints.

The OCT fingerprint acquisition technology incorporates software developed at the CSIR, which can extract both a surface and an internal fingerprint from OCT scans.

By blending two types of fingerprint information together, a new super fingerprint is created. This enhanced 'hybrid' fingerprint contains the best qualities of both the original fingerprints.



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