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Research Collaboration

2011

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Research Collaboration 2011

A joint publication highlighting the research partnerships between
Tshwane University of Technology, University of Johannesburg, University of the Witwatersrand and the CSIR

Foreword

Dr Sibusiso Sibisi, CSIR CEO
Prof Nthabiseng Ogude, Tshwane University of Technology Vice-Chancellor
Prof Ihron Rensburg, University of Johannesburg Vice-Chancellor
Prof Loyiso Nongxa, University of the Witwatersrand Vice-Chancellor

The CSIR's partnerships with Tshwane University of Technology (TUT), University of Johannesburg (UJ) and University of the Witwatersrand (Wits) build human capacity as well as networks that provide access to new knowledge and research infrastructure. Through such 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 South Africa's development challenges. Although we undertake some high technology research, we have shown through various applications how these can contribute to improved health, transport, safety and information dissemination, including in rural areas.

We do this by creating an enabling environment that promotes excellence in teaching, scholarship and research. Through our partnerships, we strive to make our institutions into world leaders in their areas of research, and continue to look for additional opportunities of working together.

Overview

Dr Rachel Chikwamba, CSIR Group Executive: Strategic Alliances and Communication
Dr Prins Nevhutalu, Tshwane University of Technology, Deputy Vice-Chancellor: Research, Innovation and Partnerships
Dr Chris Masuku, University of Johannesburg, Executive Director: Research and Innovation
Dr Mahomed Moolla, University of the Witwatersrand, Head: Community University Partnerships

The research partnerships between three prominent universities - Tshwane University of Technology; University of Johannesburg; University of the Witwatersrand - and the CSIR, which are guided by their respective memoranda of agreement, continued to be productive during 2011. The three universities collaborate with the CSIR through research projects, teaching and supervision of student research, exchange of staff and the use of facilities.

Collaborative projects and supervised student research have produced a significant number of research outputs such as journal articles and conference papers.

The research has been enhanced by sharing facilities and equipment across these institutions, such as the Tissue Culture Laboratory (TUT), Sensor Laboratory (UJ), the High Voltage and Raman Spectrometry laboratories (Wits), as well as the National Centre for Nanostructured Materials and the Laser Rental Pool Programme (CSIR).

TUT, UJ and Wits have trained CSIR staff to acquire higher qualifications. Scholarships for full-time postgraduate training in areas relevant to the memorandum of understanding are awarded to students through programmes to which TUT, UJ, Wits and the CSIR contribute equal funding.

To augment teaching and research capacity, the universities have awarded honorary appointments to several CSIR researchers, while the CSIR has appointed university staff to its research advisory panels.

The productivity of the research collaborations between CSIR and TUT, CSIR and UJ, and CSIR and Wits is confirmed by the composite numbers below.

Research

Collaborative research projects implemented: 17

Researchers at both institutions collaborating on joint projects: 39

Joint outputs resulting from supervised and joint research: 82

Human Capital Development

CSIR researchers lecturing/ supervising students: 50

Students supported by the CSIR/university scholarship programme: 20

CSIR staff studying at the institutions: 78

Students who graduated: 23

CSIR staff who hold extraordinary professorships: 9

University staff appointed to CSIR research advisory panels: 1

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CSIR and Tshwane University of Technology Partnership

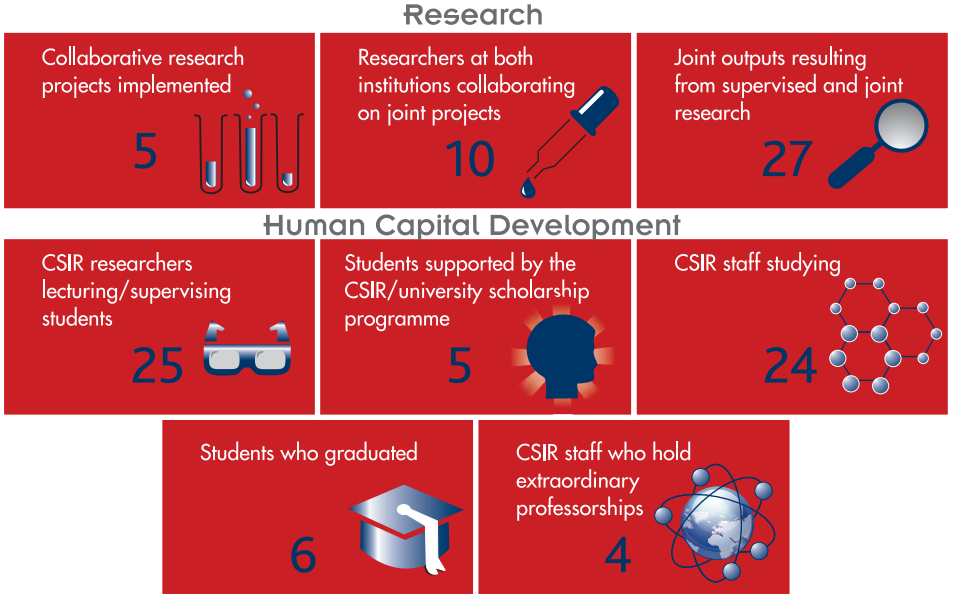
Introduction

TUT is committed to develop, through collaborative networks and partnerships, strong research and innovation (R&I) capacity in areas that are relevant to national and regional needs, priorities and opportunities. Priorities include staff development; increasing the number of postgraduate students and postdoctoral fellows; strengthening leadership and platforms for R&I; building an enabling environment and institutional culture for R&I; facilitating knowledge transfer and commercialisation, and increasing R&I funding and output.

This section of the report provides an assessment of the activities that have been performed jointly by the CSIR and Tshwane University of Technology during 2011. The relationship is implemented through a memorandum of understanding that identifies areas of research collaboration as well as human capital development.

The two institutions formally collaborate in the following areas:

- Information and communications technology with focus on computational intelligence and image analysis; mobile learning; next generation ICT architectures & systems; trusted service infrastructures; usability and development methodologies; living labs, and wireless mesh networks.
- Lasers with focus on laser therapy; assessment of heavy metals in soils and sediments; laser-assisted enhancement of mechanical properties of metallic components; development of a syllabus in industry physics; atmospheric aerosol backscatter and chemical constituents; welding of titanium alloys; photonic based approaches for pre-clinical and clinical facilities for isolation; and characterisation and differentiation of pluripotent stem cells.
- Biosciences with focus on bioremediation; biorefinery; biofuels; green chemistry and biocatalysis; agroprocessing; and formulation of active pharmaceutical ingredients.
- Built environment with focus on rural infrastructure and services and pavement engineering.
- Materials science and manufacturing with focus on metal alloys and processing; engineering design and analysis; natural fibre processing; renewable energy technologies; smart structures and materials; biomaterials; tissue engineering; electro-optic sending and imaging; and drug discovery systems.
- Pollution studies with monitoring of inorganic and organic contaminants in various environmental media.
- Treatment of mine water; and recovery of drinkable (potable) water and by-products.



Highlights and Achievements

Built Environment
Laboratory investigation of subgrade materials treated with eco-friendly prepared polyelectrolytes and their macroscopic surface properties – applications in engineering works

Dr Martin Mgangira, CSIR
Dr Peter Ndibewu, TUT

Background

A research project was initiated in 2008 by the CSIR to quantify the performance of chemical stabilisers through an experimental programme. The focus was on enzyme-based products. From an engineering point of view, assessment of performance was achieved through the measurement of strength properties of enzyme-treated soil materials. Preliminary studies using the scanning electron microscope (SEM) at the National Metrology Institute of South Africa (NMISA) revealed changes in the physical features of the treated material. The results indicated that the utilisation of advanced measurement techniques, at a micro-scale, could assist in the characterisation of pavement materials. The motivation for this approach was that properties at the micro-level play a role in the way materials respond to induced stresses at the macro-level.

It was also necessary to understand the mechanism of the surface interactions of the enzyme-based products with chemical groups on soil particles when mixed, as the interaction should play a role in the bond effectiveness of a given product in treated soils. The need to understand the mechanism of the surface interaction led to collaboration with the Department of Chemistry at TUT. The first phase of the collaboration was concluded in 2010, but work at TUT continues.

Response

Experiments were successfully conducted to characterise two commercially supplied enzyme-based chemical stabilisers (EBCS), then testing their polymeric and/or binding capacity on two subgrade materials of South African origin (red chert soil and black clay soil). Carefully planned experiments – performed both locally (at TUT and the CSIR) and internationally (SOLEIL, France) – have provided valuable scientific data to validate the hypothesis: that EBCS are polymeric and may possess properties that can be used or re-engineered to bind soil particles together during pavement construction or compaction (proof of concept).

In a short period, (2010-2013), the project has moved forward to the next step, involving identification of possible raw materials to be used in reaction chemistry experiments. This will allow the development of prototype products (polyelectrolytes in solutions) that should chemically react with clay materials (soil) irreversibly creating polymeric networks which can enhance pavement construction (engineering properties). The development of new technologies, and, thereafter, their testing and application will be the next step. However, fundamental research will continue alongside the development of products and technologies. New publications and capacity building will be the benchmark of all activities.

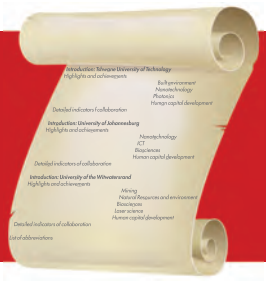
Progress

The chemistry work, which will be undertaken by TUT, will involve the development of novel high-value chemical stabilisers from soft waste sources through direct polymeric chain enhancement, or modification of complex nanocomposite formations using green chemistry mechanisms or routes.

Targeted product types are polyelectrolyte solutions, polyelectrolyte resins, liquid immersed encapsulated polymer modifiers, and liquid-based adhesives. The engineering work which will be conducted by the CSIR will focus on strength analysis of materials treated with various developed products.

Outputs

Peer-reviewed journal articles – 2
Conference papers – 2
Students trained – 5



Nanotechnology
Advanced testing and imaging of fire retardant nano-materials

Dr Bonex Mwakikunga, CSIR
Prof Walter Focke, UP
Dr Joseph Asante, TUT

Background

Fire is thought to have been invented in Africa more than a million years ago. It is arguably the most important discovery of all time. It transformed the early Stone Age to the Iron Age. Today fire is indispensable and ubiquitous, but it can be hazardous. Accidents happen when fire is not controlled. Removal of any one of the elements that make fire – fuel (material), oxygen and heat – leads to its extinction. By using fire-retardant materials in buildings, vehicle structures and garments, fire destruction can be prevented.

Response

This project emerged from the need to manage fire. The objective was to design, build and validate a bench scale fire tester, for small material samples, that provides reliable information on the effect of material properties and composition on burning behaviour. The idea is to simulate flaming combustion conditions in the core calorimeter at the micro level. This implies a dynamic method with real-time tracking of temperatures, mass loss, heat generation, and the composition of evolved and/or combustion gases. The project was initiated by the CSIR but now also includes TUT and the University of Pretoria (UP).

Progress

Fire-retardant materials are being produced at UP. The CSIR offers the laser testing facility (under patent). Another testing technique called cone calorimetry is offered by TUT, while the advanced imaging of effect of fire by scanning tunnelling microscopy (STM) and atomic force microscopy (AFM) are offered by the CSIR. Advanced imaging by STM has been properly calibrated on Cu (111), Si (100), Si (111), graphene and CuSb systems to a point where it is possible to see individual atoms of material surfaces.

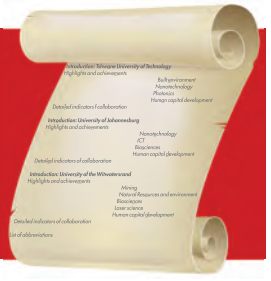
This technique is now being employed to study the surfaces of fire retardant materials before and after a fire incident. This will help us understand the surface structural differences between fire retardant materials and normal materials when exposed to fire, in a bid to understand the mechanisms for fire resistance in materials.

The research has benefited greatly from the equipment available from the three institutions: High resolution transmission electron microscope, Scanning tunnelling microscope, High resolution scanning electron microscope (CSIR), Cone Calorimeter (TUT), Laser-TGA (UP and CSIR) and Composite compatibilizer (UP).

A journal paper on laser pyrolysis flame characteristics has been produced jointly by UP and the CSIR. The impact of the project contained in the intellectual property under patent consideration will enable thermogravimetry analysis (TGA) manufacturers to include laser heating in their TGA designs, as well as inform garment manufacturers on materials best suited for fire protection.

Outputs

Peer-reviewed journal article – 1
Students trained – 3 (2 TUT, 1 UP)



Polymer-based nanomaterials: New class of high performing tailored adsorbents for water treatment

Dr Arjun Maity, CSIR
Prof Maurice Onyango, TUT

Background

The presence of high concentrations of chemical contaminants in both natural water supplies and industrial wastewater streams is a critical health and environmental issue due to their high toxicity and bioaccumulation through the food chain and hence in the human body. Several technologies have been employed to reduce or remove chemical contaminants from aqueous solutions such as chemical redox, precipitation, ion exchange, membrane process, electrodialysis and adsorption. Of these technologies, adsorption is a versatile and cost-effective technique for the removal of contaminants from water and hence has attracted attention in recent years. Consequently, various adsorption media have been developed. However, the majority of these adsorbents lack the large surface area required for adsorption. Furthermore, the active sites are not easily accessible and the diffusion paths are long, which results in low adsorption capacity, slow extraction dynamics and low adsorption efficiencies. These negative factors necessitate the development of novel media to ameliorate water quality.

Response

As part of the National Nanotechnology Flagship Programme, the collaborative research was initiated in 2009 to develop a new class of nanomaterials that has high capacity for water contaminants, exhibits fast contaminants removal kinetics and is low in cost. The project at its inception aimed at improving the selectivity, robustness and stability of the nanomaterials. Moreover, it was envisaged that design and construction of nano-device prototypes for water treatment would be accomplished. Through this, the project would create investment opportunities by engaging local industries and thus providing a step-change in water treatment technologies.

Progress

The initial stage of the project focused on developing a recipe to synthesise a new class of polymer-based nanoadsorbents. The number of processes involved in the synthesis has an economic ramification for industry. Therefore, the target was to develop a synthesis route that does not involve a number of processes. The researchers have succeeded in developing, for example, polypyrrole-magnetite, polypyrrole-polyanniline and xfoliated polypyrrole-organically modified montmorillonite clay nanocomposites using a one-pot synthesis. This approach improves efficiency, reduces waste generation and production costs. To understand the morphology, elemental, structural and other physico-chemical properties of the material, detailed material characterisation was done using a high resolution transmission electron microscope, attenuated total reflectance Fourier transform infrared spectroscopy, small angle X-ray scattering, x-ray photoelecton spectroscopy, electrospin resonance, and wide angle X-ray diffraction.

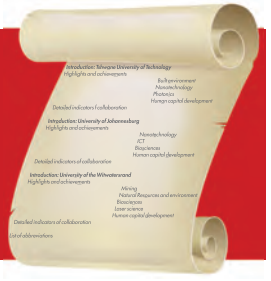
In line with the focus of the project, the developed materials were tested in treating water contaminated with chromium (VI). The initial phase was to explore the performance of the materials in removing Cr(VI) from aqueous solution in order to establish some performance parameters such as maximum adsorption capacity. As expected, there was an extremely high equilibrium uptake exhibited by the developed materials towards Cr(VI). Compared to most adsorbents reported in literature, the performance was quite remarkable.

In the second phase of the water treatment research, the materials are being tested in removing Cr(VI) from contaminated groundwater received from Lanxess (Pty), one of the biggest producers of chrome in Africa. The company recently found that the groundwater in its surrounding area is contaminated with Cr(VI) and sulphates (SO42-) resulting from various plant processes. The groundwater contained 149.6 mg/L of Cr(VI) and >1200 mg/L SO42-. Small scale laboratory columns as prototypes of industrial scale fixed beds are being used to explore the effects of the hydrodynamics and other process variable on the performance of the materials. So far excellent results have been obtained. In fact the materials have the ability to remove the Cr(VI) below detectable limits. Such treated water can be reused in the process resulting in enormous savings to the company.

The first doctoral degree through this research was be awarded in September 2012.

Outputs

Peer-reviewed journal articles – 5
Conference papers - 9
Students trained – 9



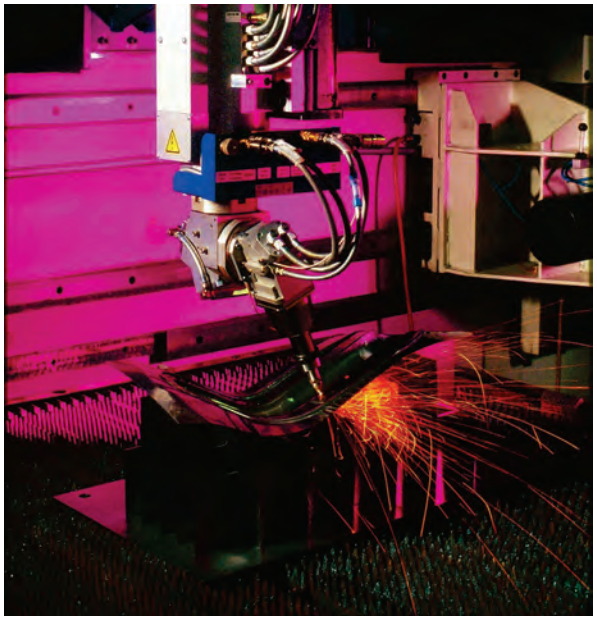
Photonics
Laser-assisted enhancement of mechanical properties of metallic components

Dr Sisa Pityana, CSIR
Dr Patricia Popoola, TUT

Background

The objective of this research is to develop novel multi-functional materials for automotive and structural application by using laser surface alloying of aluminium substrate with a combination of metallic and ceramic powdery materials. This is a further development in laser materials processing, which provides new tools for industrial and domestic use.

Lasers have become increasingly important tools for the manufacture of engineering materials. Systematic selection of the best material for any



application begins with an assessment of the required properties and costs of candidate materials. Materials selection is very important, especially from the perspective of component damage as a result of wear and corrosion attack and the attendant high cost of repairs.

The main goal of material selection is to minimise cost while meeting product performance goals. Often, engineers and manufacturers choose materials for their components from commercially available alternatives. Little attempt is made to design materials that offer tailored functional properties, specifically for unusual components with the desired improved performance.

Notwithstanding the contributions of various researchers in recent years, there is still little knowledge of laser applications with respect to materials development, especially for materials required in corrosive environments. Therefore, any innovative research contributions to address this problem will have ready application.

Response

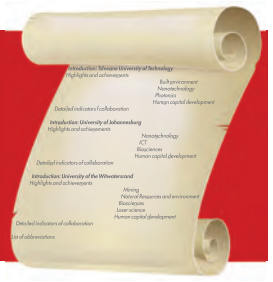
This research focused on the development of aluminium metal matrix composites by laser surface alloying. It has long been recognised that aluminium surface properties can be modified by the addition of reinforcements in the aluminium substrate, thereby forming aluminium metal matrix composites. The reinforcements are usually metals or ceramic particles. Different industries require different properties such as wear or corrosion improvement. The reinforcements are, therefore, selected based on their inherent property, and thus their contribution to the final property of the composite or corrosion improvement.

In this work, the researchers combined both types of reinforcements; the final product was a hybrid metal matrix composite, that is, a metal reinforced by inter-metallic, ceramic and metal phases. This type of composite offers unique advantages, because it possesses an improved high temperature property, good corrosion and wear-resistance, all in one substrate. The laser surface alloying technique was used in these investigations.

The research is not only important in its own right, but also for the opportunities it presents for further advances in materials development.

Outputs

Peer-reviewed journal articles – 2
Students trained – 3



Human Capital Development

Pinda Sifunda, CSIR
Hamilton Mphidi, TUT

Context of the collaboration

TUT and the CSIR support human capital development through several mechanisms. The joint TUT/CSIR scholarship programme supported five Master's students in 2011.

In the same year, 24 CSIR staff members – 8 Bachelor's, 10 Master's, 6 doctoral candidates – were supported by the CSIR to study for higher qualifications at TUT in disciplines including information technology, biotechnology, polymer technology, and linguistics, as well as several fields of engineering.

Some of the staff were co-supervised by TUT and CSIR researchers and worked on CSIR projects as part of their graduate programmes. Six of the staff completed their studies during the year.

CSIR staff members have been awarded honorary appointments by TUT. These include four extraordinary professorships, as well as 25 lecturers and supervisors. A selection of some of the student research and experiences follows.

Mabuatsela Maphoru

Mabuatsela Maphoru is studying for an MTech (Chemistry). "My research deals with oxidative coupling reactions of naphthols on promoted nanocrystalline platinum catalysys. The main reason I am doing this project is because the issue has not been extensively studied and yet it has the potential to lead to the production of organic dyes which can be used as hair dyes. As part of the research, I will test a variety of naphthol substrates on a platinum catalyst, using different support materials such as activated carbon, carbon nanotubes, alumina and silica for metals, with the aim of obtaining the activity profile of these different catalysts. The catalytic method that I am using is more environmentally-friendly compared with synthesis of typical colourants, such as binaphthoquinones or binaphthalenylidenediones. I have co-authored two conference papers based on my research, one of which won the first prize in the Master's category at the 2011 South African Chemical Institute Young Chemists/ Nanotechnology Young Researchers Symposium."

Mapula Razwinani

Mapula Razwinani is studying for an MTech (Biomedical Science) with particular interest in biological activity and chemical investigation of five South African indigenous medicinal plants. "The aim of my study is to investigate the anti-microbial, antifungal and anti-inflammatory cytotoxicity and anti-oxidant activities followed by isolation of compounds from five indigenous medicinal plants claimed by Venda traditional healers to be effective for cartilage regeneration. This could be a potentially cost-effective treatment for arthritis since the plants are freely available."

Tebogo Molele

Tebogo Molele is studying for an MTech (Metallurgical Engineering) with specific interest in phase transformation studies on zirconia reinforced Cu-Ni-Ti shape memory nanocomposite. "The growing demand for actuation mechanisms in higher temperature environments requires the development of High Temperature Shape memory Alloys. These will replace Ti-Ni-Cu based shape memory alloys which have low thermal stability and poor transformation behaviour. The introduction of Zirconia, which is an extremely refractory material with good thermal stability and transformation characteristics, into the matrices of the Ti-Ni-Cu to form a composite, will induce desirable shape memory properties. The university and the CSIR have given their full support to my research. I am also grateful to my co-supervisor from the CSIR."

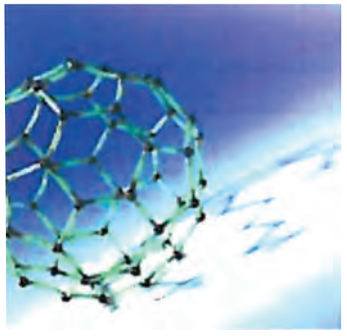
Supervised research
Removal of emerging contaminants for aqueous solution using nitrogen-doped carbon nanotubes - cyclodextrin nanocomposite

Keletso Mphahlele, CSIR
Supervisors: Dr Sabelo Mhlanga, Dr Suprakas Sinha Ray, CSIR
Prof Maurice Onyango, TUT

Background

The project explores the effect of using nitrogen-doped carbon nanotubes (N-CNTs) in comparison with undoped CNTs as an anchor for silver or iron metal nanoparticles. The metal/CNT was co-polymerised with cyclodextrin and is being tested for water purification.

The deposition iron and iron-silver nanoparticle on N-CNTs was investigated and compared, using three different deposition methods, namely: the microwave polyol method; the chemical wet impregnation method; and the deposition precipitation method. Nanotechnologies hold great promise for reducing the production of both wastes and industrial contamination, and improving the efficiency of energy production and use. However, the production, use and disposal of manufactured nanoparticles (NPs) will inevitably lead to discharges to air, soils and aquatic systems. Therefore, it is crucial to investigate their transport into and through the environment, and their impacts on environmental health.



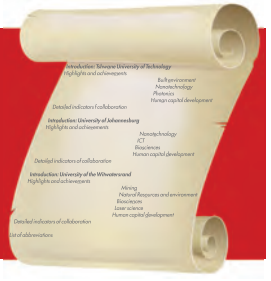
Current understanding is limited, but adverse effects are likely. Quantification and minimisation of these effects are essential, both for environmental protection and to ensure the long-term sustainability of the nanotechnology industry, with its associated benefits. Accurate knowledge of concentration and physico-chemical properties of manufactured NPs under realistic conditions is critical to understanding their fate, behaviour and toxicity in the natural aquatic environment, and a necessary first step in this process. Therefore, this research also investigates the leaching of the NPs in water, in order to minimise the environmental impact.

Response

The material that is synthesised is being tested for water purification; using the adsorption technology. The targeted contaminants include bisphenol A, paracetamol and aspirin.

Outputs

Peer-reviewed journal article – 1



Metal octacarboxyphthalocyanines/multiwalled carbon nanotubes hybrid for the development of dye solar cells

Nonhlanhla Mphahlele, CSIR
Supervisors: Dr Kenneth Ozoemena, Dr Lukas le Roux, CSIR
Dr Leskey Mduduzi Cele, TUT

Background

The photovoltaic (PV) cell has been of interest to renewable energy researchers for over 50 years. The PV cell converts solar irradiation to electricity, providing an ideal way of utilising nature's renewable energy, especially since the process does not pollute the environment. Photovoltaic cells have a remarkable potential to increase energy supply, and reduce dependence on synthetic fuels. The main challenge to their widespread use is their high production cost and the energy consumed during fabrication. Therefore, the initiatives to develop stable, low cost and efficient photovoltaic devices – such as dye solar cells (DSCs) – are of high priority.

Dye solar cells are an attractive option for the conversion of solar energy into electricity, because of their remarkable properties such as low cost, non-toxicity and easy fabrication relative to other photovoltaic cells. The process through which they convert solar energy to electricity is similar to photosynthesis in plants, with the major difference being that electricity is produced (with the aid of photosensitisers) whereas plants produce oxygen and sugar.

Improving the relatively low efficiency of dye solar cells is the focus of most research projects worldwide. Several methods and photosensitisers have been used but their efficiency has not exceeded 11%. The project investigated alternative photosensitisers that can enhance the long-term stability and efficiency of DSCs. Metallophthalocyanine (MPc) complexes, especially those containing diamagnetic metal centres (M = Zn, Ga, Si), are efficient photosensitisers with excellent photostability and light properties. A significant effort has been made to enhance photosensitisation in DSCs by modifying MPc with Carbon nanotubes (CNTs), which improves the electrochemical properties of MPc.

Response

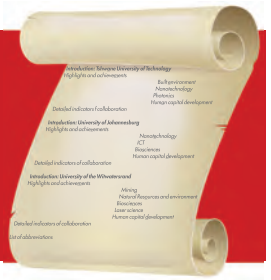
The project has succeeded in synthesising and characterising a MPc – multiwalled carbon nanotube (MWCNT) hybrid. The product (MPc – MWCNTs hybrid) was integrated in DSCs and tested in CSIR laboratories against commercial available dyes from Switzerland. The performance of this device still needs to be enhanced. Therefore, a coupling agent dicyclohexylcabodiimide (DCC) will be used to covalently incorporate the octacarboxylic group from the MPc with the amine functionalised carbon nanotubes. The interaction that occurs due to the existence of a formal bond between the MPc with MWCNTs is more effective in enhancing the cell performance.

The project was undertaken in collaboration with Tohoku University in Japan where the MPc material for the development of DSCs was synthesised.

The experience gained from the project was substantial, as both supervisors played an important role in supporting the project.

Outputs

Peer-reviewed journal article – 1



Laser surface alloying of martensitic stainless steel for improved service performance

Damilola Adebiyi, TUT
Supervisor: Dr Patricia Popoola, TUT

Background

Martensitic stainless steel (MSS) has good mechanical properties and moderate corrosion resistance and is suitable for a wide range of applications such as components of steam generators, pressure vessels, cutting tools, pump impellers, valves and turbines either in blades or shafts. However, the increasingly extreme and aggressive conditions demanded by current technological advance limits the potential use of MSS causing its failure during engineering applications. These failures include: low wear resistance and poor tribological behaviour and low hardness.

The main rationale of this research is to improve the properties of martensitic stainless steel by laser alloying it with stellite 6 and TiC. The success of this will:

- Provide a solution to the failure of MSS during engineering applications, thereby avoiding material loss and component damage in manufacturing industries;
- Enhance the industrial application of the materials, processes and techniques;
- Enable the application of laser technology and nanotechnology in the fabrication of a multifunctional MSS that can accommodate most applications; and
- Achieve overall benefits of cost reduction, and efficient and effective industrial operations.

Response

The 4.4 kW continuous wave (CW) Rofin Sinar Nd:YAG solid-state laser used for the surface alloying experiments was provided by the CSIR National Laser Centre (NLC). It was also through collaboration with the CSIR that the TiC and stellite 6 powders used for the experiment were obtained. The stereo and optical microscopes/image analyser and Vickers hardness tester at the CSIR NLC laboratory were used for the characterisation of the alloyed layers. TUT provided other tools and equipment, as well as supervision.

The results showed that laser alloying of MSS with TiC and stellite 6 significantly increased the hardness and wear resistance of the MSS. The wear resistance of the laser coating is about 3.5 times better than that of the substrate. The micro-hardness value of the coating ranges from 547.7 HV to about 1025 HV, which is almost four times that of the MSS substrate.

Future research

The future plan is to continue research in the field of LMP with an emphasis on additive manufacturing. Furthermore, LMP-based discussions and workshops will be hosted. Some of this research will follow the same experimental lines as in the past, and the outcomes will be published in relevant journals.

Detailed indicators of collaboration

Collaborative research projects implemented

University researchers	CSIR researchers	Name of project	Research area
Prof Mjumo Mzyece	Dr Fisseha Mekuria	Next Generation Wireless Networking	ICT
Prof Robert McCrindle	Dr Anton du Plessis	LIBS for Environmental monitoring	Lasers
Dr Patricia Popoola	Dr Sisa Pityana	Laser Assisted Enhancement of Mechanical Properties of Metallic Components	
Dr Joseph Asante	Dr Bonex Mwakikunga	Advanced Testing and Imaging of Fire Retardant Nano-Material	
Dr Shirley Motaung	Dr Patience Mthunzi	Optical Manipulation of Stem Cells	Nanotechnology

Joint outputs resulting from supervised and joint research

Peer-reviewed journal articles		
Authors	Title of paper	Journal
Wekesa BW; Steyn GS; Otieno FAO	Review of physical and socio-economic characteristics and intervention approaches of informal settlements	Habitat International, Vol. 35(2), Pages: 238-245 Apr 2011
Labuschagne PW; Kazarian SG; Sadiku RE	In situ FTIR spectroscopic study of the effect of CO2 sorption on H-bonding in PEG–PVP mixtures	Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy, Vol. 78(5), Pages: 1500-1506 May 2011
Labuschagne P; Kazarian SG; Sadiku RE	Supercritical CO2-assisted preparation of ibuprofen loaded PEG-PVP complexes	Journal of Supercritical Fluids, Vol. 57(2), Pages: 190-197 Jun 2011
Bhaumik M; Leswifi TY; Maity A; Srinivasu VV; Onyango MS	Removal of fluoride from aqueous solution by polypyrrole/Fe3O4 magnetic nanocomposite	Journal of Hazardous Materials, Vol. 186(1), Pages: 150-159 Feb 2011

Peer-reviewed journal articles		
Authors	*Title of paper*	*Journal*
Popoola API; Pityana SL; Popoola OM	*Microstructure and corrosion properties of Al(Ni/TiB2) intermetallic matrix composite coatings*	*The Journal of The Southern African Institute of Mining and Metallurgy, Vol. 111, Pages: 345-353 May 2011*
Popoola API; Pityana SL; Fedotova T; Popoola OM	*Quantitative study of the hardness property of laser surface alloyed aluminium AA1200*	*The Journal of The Southern African Institute of Mining and Metallurgy, Vol. 111, Pages: 335-344May 2011*
Fedotov I; Fedotova T; Pityana SL; Labuschange K; Shatalov M; Potgieter JH	*A mathematical model of laser surface heat-cooling treatment for medium carbon steel*	*The Journal of The Southern African Institute of Mining and Metallurgy, Vol. 111, Pages: 379-384 Jun 2011*
Popoola API; Pityana SL; Popoola OM	*The effect of multiple laser alloyed tracklines on the corrosion properties of Al-MMC*	*Journal of Laser Applications, Vol. 23(3), May 2011*
Wekesa BW; Steyn GS; Otieno FAO	*Review of physical and socio-economic characteristics and intervention approaches of informal settlements*	*Habitat International, Vol. 35(2), Pages: 238-245 Apr 2011*
Popoola API; Pityana S; Ogunmuyiwa E	*Microstructure and wear behaviour of AL/TiB2 metal matrix composite*	*Advanced Materials Research, Vol. 227, Pages: 23-26 Apr 2011*
Adebiyi DI; Fedotova T; Pityana SL; Popoola API	*Improved hardness of laser alloyed X12CrNiMo martensitic stainless steel*	*International Journal of the Physical Sciences, Vol. 6(14), Pages: 3336-3346 Jul 2011*
Popoola API; Pityana SL; Popoola OM	*Laser deposition of (Cu+ Mo) alloying reinforcements on AA1200 substrate for corrosion improvement*	*International Journal of Electrochemical Science, Vol. 6, Pages: 5038-5051 Oct 2011*
Ogunniran ES; Sadiku R; Sinha Ray S; Luruli N	*Effect of boehmite alumina nanofiller incorporation on the morphology and thermal properties of functionalized poly(propylene)/polyamide 12 blends*	*Macromolecular Materials and Engineering, Vol. 296, Pages: 12pp Aug 2011*

Authors	Title of paper	Journal
Jayaramudu J; Maity A; Sadiku ER; Guduri BR; Rajulu AV; Ramana CHVV; Li R	Structure and properties of new natural cellulose fabrics from Cordia dichotoma	Carbohydrate Polymers, Vol. 86(4), Pages: 1623-1629 Oct 2011
Ojijo V; Cele H; Ray S	Morphology and properties of polymer composites based on biodegradable polylactide/Poly[(butylene succinate)-coadipate] blend and nanoclay	Macromolecular Materials and Engineering, Vol. 296, Pages: 865–877 Nov 2011
Ogunniran ES; Sadiku R; Ray SS; Luruli N	Morphology and thermal properties of compatibilized PA12/PP blends with boehmite alumina nanofiller inclusions	Macromolecular Materials and Engineering, Vol. 297, Pages: 1-12 Dec 2011
Motshekga S; Pillai SK; Ray SS	Conventional wet impregnation versus microwave-assisted synthesis of SnO2/CNT composites	Journal of nanoparticle research, Vol. 13(3), Pages: 1093-1099 Mar 2011
Ojijo V; Malwela T; Sinha Ray S; Sadiku R	Unique isothermal crystallization phenomenon in the ternary blends of biopolymers polylactide and poly[(butylene succinate)-co-adipate] and nano-clay	Polymer, Pages: 1-14 Dec 2011
Ojijo V; Cele H; Ray S	Morphology and properties of polymer composites based on biodegradable polylactide/Poly[(butylene succinate)-coadipate] blend and nanoclay	Macromolecular Materials and Engineering, Vol. 296, Pages: 865–877 Nov 2011

Conference papers peer-reviewed		
Authors	Title of paper	Conference
Groom MJ; Tlale N; Kanakana G	Investigation and analysis of the actual process time against the allowable process time at the BMW plant Rosslyn South Africa	International Conference on Industrial Engineering, Systems Engineering and Engineering Management for Sustainable Global Development, Stellenbosch, South Africa, 21-23 September 2011, Pages: 9pp Sep 2011
Awuor F; Djouani K; Noelz G; Noelz T	Coupled interference based rate adaptation in ad hoc networks	IEEE Africon 2011, Livingstone, Zambia, 13-15 Sep 2011, Pages: 6pp

Conference papers peer-reviewed		
Authors	*Title of paper*	*Conference*
Fredrick Awuor F; Karim Djouaniy K; Guillaume Noelz G; Thomas Olwal T	*Rate adaptation in ad hoc networks based on pricing*	*Southern Africa Telecommunication Networks and Applications Conference (SATNAC 2011), East London, South Africa, 4-7 September 2011, Sep 2011*
Motaung S; Zvimba J; Maree J	*Thermal reduction of barium sulphate - a laboratory and full scale kiln evaluation*	*CSIR Emerging Researcher Symposium, CSIR ICC, Pretoria, 13 October 2011, Oct 2011*
Smit D; Herselman M; Eloff JHP; Ngassam E; Venter E; Ntawanga F; Chuang C-H; Van Greunen D	*Formalising Living Labs to achieve organisational objectives in emerging economies*	*IST-Africa 2011 Conference, Gaborone, Botswana, 11-13 May 2011*

Chapters in a Book		
Authors	*Title of the chapter*	*Book*
Olwal TO; Djouani K; Van Wyk BJ; Hamam Y; Siarry P	*Optimal control of transmission power management in wireless backbone mesh networks*	*Wireless Mesh Networks, Pages: 26p Jan 2011*
Shatalov MY; Marais J; Fedotov I; Tenkam MJ	*Longitudinal vibration of isotropic solid rods: from classical to modern theories*	*Advances in Computer Science and Engineering, Pages: 187-214 Dec 2011*
Shatalov MY; Joubert SV; Coetzee CE	*The vibration of a layered rotating planet and Bryan's effect*	*Advances in Geotechnical Earthquake Engineering: Soil Liquefaction and Seismic Safety of Dams and Monuments, Pages: 405-424 Dec 2011*

CSIR researchers lecturing/supervising students at TUT

Name of researcher	*Research area as defined in MoU*	*Type of collaboration*
Dr James Maina	*Built environment*	*Moderation*
Dr Daniel Moeketsi	*ICT*	*Supervision*
Dr Frans van den Bergh	*ICT*	*Supervision*

Name of researcher	Research area as defined in MoU	Type of collaboration
Dr Marelie Davel	ICT	Supervision
Dr Ntsibane Ntlatlapa	ICT	Supervision
Dr Quentin Williams	ICT	Supervision
Dr Nomusa Dlodlo	ICT	Supervision
Dr Albert Lysko	ICT	External examination, moderation
Andrew Smith	ICT	Supervision
Ann Singh	Lasers	Supervision
Dr Ndumiso Cingo	Lasers	Supervision
Dr Sisa Pityana	Lasers	Joint appointments
Rietha Oosthuizen	Natural environment	Supervision, lecturing
Gideon Ferreira	Electronics*	Supervision
Dr Konanani Rashamuse	Biosciences	Supervision
Dr Jac Wilsenach	Natural environment	Supervision
Dr John Zvimba	Natural environment	Supervision
Dr Christopher Meacock	Lasers	Supervision
Prof Kenneth Ozoemena	Materials science	Supervision
Dr Lukas le Roux	Materials science	Supervision
Avashnee Chetty	Materials science	Supervision
Lonji Kalombo	ICT	Supervision
Dr Sabelo Mhlanga	Materials science	Supervision
Dr Suprakas Sinha Ray	Materials science	Supervision
Dr Sean Moolman	Materials science	Supervision

*= Not in MoU

Students supported by the CSIR/TUT scholarship programme

Name	Area of study	TUT supervisor
Amelia Tebogo Molele	MTech (Metallurgical Engineering)	Dr Peter Olubambi
Linda Lethebane	MTech (Metallurgical Engineering)	Dr Peter Olubambi
Mabuatsela Virginia Maphoru	MTech (Chemistry)	Prof Josef Heveling
Ndouvhada Gumanii	MTech (Chemistry)	Dr Nonhlanhla Cele
Mapula Razwini	MTech (Biomedical Sciences)	Dr Shirley Motaung

CSIR staff studying at TUT

Name of CSIR staff	CSIR supervisor	TUT supervisor	Degree programme
Goodness Sithole	None	None	BTech (Information Technology)
Gadifele Mmoledi	None	None	BTech (Internal Audit)
Jacob Mahlaola	None	None	MTech (Information Technology)
Bethuel Nemakhavhani	Gideon Ferreira	None	BTech (Electronic Engineering)
Tina Ronneburg	Dr Konanani Rashamuse	Prof Renate Roux-van der Merwe	MTech (Biotechnology)
Mpho Kgampe	Dr Marelie Davel	Prof Johan van Niekerk	MTech (Language Practice)
Moshe Masonta	Dr Ntsibane Ntlatlapa	Prof Jacobus van Wyk	DTech (Electronic Engineering)
Khangwelo Muronga	None	None	MTech (Information Technology)
Bafana Radebe	Dr Jac Wilsenach	Prof Jannie Maree	MTech (Water Care)
Solly Motaung	Dr John Zvimba	Prof Jannie Maree	DTech (Natural Sciences)
Oscar Sono	Dr Christopher Meacock	Dr Dawood Desai	BTech (Mechanical Engineering)
Nonhlanhla Mphahlele	Prof Kenneth Ozoemena; Dr Lukas le Roux	Dr Leskey Mduduzi Cele	MTech (Chemistry)

Name of CSIR staff	CSIR supervisor	TUT supervisor	Degree programme
Thembisile Mahlangu	Avashnee Chetty	None	BTech (Chemical Engineering)
Thabiso Mapea	None	None	BTech (Electronic Engineering)
Mandla Vincent Khumalo*	None	Prof Jozsef Karger-Kocsis	MTech (Polymer Technology)
Bathabile Ramalapa*	Lonji Kalombo	Dr Leskey Cele	BTech (Chemistry)
Thomas Olwal*	None	Prof Barend Jacobus van Wyk	DTech (Electrical Engineering)
Philip Labuschagne*	Dr Sean Moolman	Prof Rotimi Sadiku	DTech (Polymer Technology)
Sticks Mabakane*	Dr Daniel Moeketsi	Prof Elmarie Biermann	MTech (Information Technology)
Thabo Ditsele*	None	Prof Charles Mann	DTech (Language Practice)
Kalonda Luhandjula	Dr Quentin Williams	Prof Ben van Wyk	DTech (Electronic Engineering)
Keletso Mphahlele	Dr Sabelo Mhlanga Dr Suprakas Sinha Ray	Prof Maurice Onyango	MTech (Chemical Engineering)
Vincent Ojijo*	None	Prof Maurice Onyango	MTech (Chemical Engineering)
Nomsa Mokgalaka	None	Lerato Tshabalala	BTech (Metallurgical Engineering)

*= Not in MoU

CSIR staff holding extraordinary professorships

Name of Researcher	Area of expertise
Dr Nomusa Dlodlo	Computer science
Dr Sisa Pityana	Laser physics
Dr Michael Shatalov	Mathematics
Dr Dean Brady	Biotechnology

CSIR and University of Johannesburg Partnership

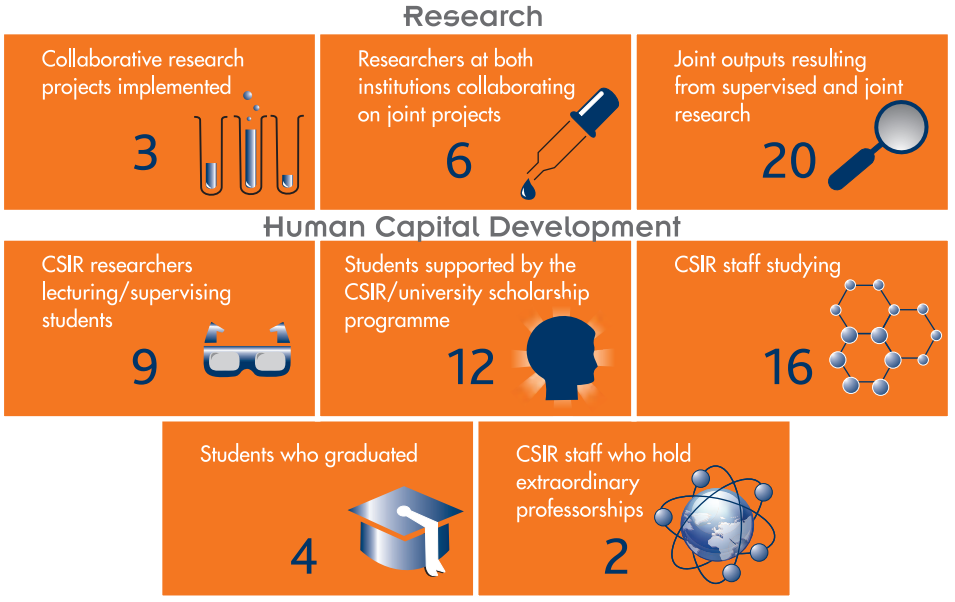
Introduction

In its pursuit of excellence in scholarship and research, the University of Johannesburg's objectives as a public benefit organisation include performing comprehensive and mutually beneficial research with partners, and undertaking transdisciplinary research at the highest international level of scholarship. The university recognises its role in contributing to research, development and the improvement of human capacity, primarily within South Africa but also in the rest of southern Africa.

This section of the report provides an assessment of the activities that have been performed jointly by the CSIR and University of Johannesburg during 2011. The relationship is implemented through a memorandum of understanding that identifies areas of research collaboration as well as human capital development.

The two institutions formally collaborate in the following areas:

- Biosciences with focus on synthetic biology.
- Materials science with focus on carbon-based nanomaterials and metals casting technology.
- Lasers with focus on biophotonics and laser processing.
- Natural resource management with focus on water resource management, climate change and renewable energy.
- Information communications technology with focus on information security and ICT education.
- Defence, Peace, Safety and Security with focus on electronic warfare research applications, and radar research and applications.
- Modelling and digital science with focus on information security; biometrics; digital intelligence; and mathematical modelling.
- Human capital development with focus on staff exchange, training of students and staff, and joint postgraduate supervision.



Highlights and Achievements

Nanotechnology
Development of advanced green plastics

Dr Suprakas Sinha Ray, CSIR
Prof Catherine Ngila, UJ

Background

Over the last few decades, advanced technology in petrochemical-based polymers has brought many benefits. However, it is increasingly evident that natural ecosystems have become disturbed and damaged, partially as a result of the improper disposal of non-degradable plastic materials. The environmental impact of persistent plastic wastes is an increasing global concern, the more so since alternative disposal methods are limited. Incineration of the plastic wastes produces carbon dioxide and so contributes to global warming. It sometimes produces toxic gases, which contribute to global pollution. Adequate landfill sites are also limited.

Furthermore, the petroleum resources from which plastics are made are finite. For this reason, there is an urgent need to develop renewable natural resource-based environmentally benign plastic materials that would be manufactured without using toxic or noxious components, and could allow composting to naturally occurring degradation products.

Response

One of the most promising polymers in this respect is polylactide (PLA) which is wholly made from agricultural products and is readily biodegradable. In this work, the research team is using a novel chemical approach which enables PLA properties to be improved by the sol-gel method. Sol-gel chemistry not only offers a route for the synthesis of ceramics or glasses, but can also be used to synthesise organo-functionalised hybrid structures, with much improved or new properties. Organically modified alkoxides of silicon open a new window to a class of materials. Therefore, incorporation of the organic moieties into the inorganic 3-dimensional SiO_2 combines the common properties of PLA and ceramics. Metal alkoxides and silicon alkoxides are the most versatile precursors for the sol-gel hybrid structures.

Hydrolysis and condensation of the alkoxides provide homogeneity at the molecular level. The organic group can serve as reaction rate controller or micro-structure designer during the chemical reactions. The final oxide structure binds to the organic group and becomes more flexible and soft, but also shows the basic ceramic properties like heat resistance, abrasion and scratch resistance. PLA-based hybrid materials can be synthesised by two different methods. The organic part can be easily embedded into the ceramic structure or linked by stable chemical bonds.

The main objective of this research is to develop novel bio-nanohybrids with tailored properties. Bio-based polymers such as PLA will be copolymerised with alkoxide structures to obtain hybrid materials. Additionally, surface-modified nanostructures will be incorporated to provide value-added functional properties, such as gas/water barrier, hard, durable, and transparent materials, like coatings.

The project is aligned with the National Nanotechnology Strategy. The project will also strengthen the existing platform for the development of new polymeric materials with multi-functional properties at the nano-scale level, leading to the fabrication and application of new nano-based products and processes, thus improving the competitiveness of the South African plastics industry.

Progress

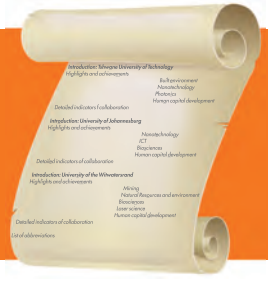
During three years, the project will investigate the PLA-based novel bio-degradable polymer hybrid structures in order to obtain:

- Novel properties such as hardness, scratch resistance, oxygen and humidity barrier.
- Optimum formulation of the hybrid structures for different kinds of substrates as coatings or bulk materials.
- Incorporation of the functional metal oxide structures into the hybrid polymer to provide better gas barrier, hardness and durability properties.

This project will advance graduate education and research by introducing materials chemistry and physics to the National Centre for Nanostructured Materials and UJ.

Outputs

Peer-reviewed journal articles – 4
Students trained – 7



ICT
Smart radio technology in next generation wireless networks for rural broadband Internet access

Dr Fisseha Mekuria, CSIR
Prof Bhekisipho Twala, UJ
Prof Mjumo Mzyece, TUT

Background

This collaborative research project aims to accelerate research and development (R&D) and postgraduate human capacity development (HCD) in smart radio technologies and wireless broadband networks. The main focus will be on developing smart radio wireless test-bed systems to address the need for reliable testing of intelligent (ambient aware) and high-capacity wireless broadband radio technologies, for improved Internet connectivity of rural communities.

The CSIR-university R&D activities will also help develop policy documents on dynamic spectrum management in collaboration with the Independent Communications Authority of South Africa (ICASA). Furthermore, the research and test-bed development for smart radio technologies, such as cognitive radio and television white space spectrum (TVWS - the spectrum freed due to analogue to digital TV migration), is expected to provide algorithms and spectrum management techniques for improving the capacity of existing wireless mesh network deployments.

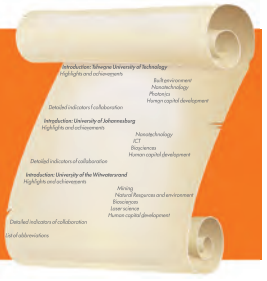
The project aims to combine the resources of the CSIR wireless research group and collaborating universities, and to elevate South Africa's R&D position on next generation smart radio technologies such as cognitive radio, which uses intelligent and ambient-aware spectrum-sensing mechanisms to allocate free and usable radio spectrum resources to future cognitive wireless devices and networks. Such smart wireless networks will be characterised by effective improvement in bandwidth capacity, reduction in power consumption and ultimately in the price of future wireless broadband Internet access networks, and associated societal services such as health and education.

Response

The response to collaborative research in the area of smart radio technologies from the universities, and public and private organisations, has been overwhelming. The CSIR is actively involved with ICASA in defining the R&D frontiers of future intelligent broadband wireless networks, and dynamic spectrum allocation. The project has also attracted interest from multinational companies including Google, ZTE, Ericsson and Nokia.

Outputs

Peer-reviewed journal article - 1
Conference papers - 3

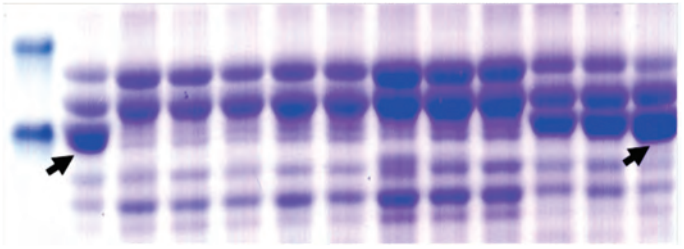


Biosciences
Sorghum is an ideal crop for biofortification and combating climate change

Zodwa Mbambo, Nompumelelo Mkhonza, Andile Grootboom, Dr Luke Mehlo, CSIR
Dr Lee Alagiozoglou, UJ

Background

Global changes in atmospheric CO_2, temperature, and light intensity, drought and poor soil nutrient status critically dictate future food security. Consequently, the nutritional quality of crops and the health status of vast communities in developing countries could be compromised. This requires the development of crops that can adjust to changes in both biotic and abiotic stress without significant impact on yield and nutritional quality. More than a billion people in semi-arid regions of the world rely on sorghum for



dietary calories and protein because other crops like maize, rice and wheat are not as well adapted to the prevailing harsh agricultural conditions. Unfortunately, a staple diet consisting of sorghum is impoverished and would lead to malnutrition. Sorghum's protein does not provide a balanced source of protein and calories. This is because its grain storage proteins are deficient in essential amino acids like lysine, methionine, tryptophan, and the protein is less digestible upon cooking. The grain is also deficient in vitamin A and its content of iron and zinc has limited bioavailability because it is bound by phytate. In order to realise the full genetic potential of this remarkable crop several shortcomings of sorghum have to be addressed.

Response

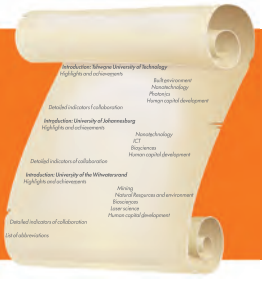
The research generated data that are central to efforts aimed at exploiting sorghum's vast genetic potential in addressing nutrition and climate change in marginal agro-ecological zones of poor countries. By using genetic engineering and non-GMO strategies like induced mutations, proof that sorghum possesses incredible biochemical and physiological compensatory capacity (a factor key to adjusting to changing stress environments) was obtained. It was further demonstrated that sorghum has tremendous genetic attributes and therefore immense potential for nutritional improvement. However, such nutritional improvements would be insignificant if one intrinsic aspect of sorghum is not addressed. Unlike most cereals, sorghum's grain

storage proteins are highly undigestible and become even less so upon cooking. This is because of the ability of sorghum proteins to cross link through disulfide chemical bonds and the interference of some chemical constituents like phenolics. Through genetic engineering, the research solved this problem by reducing the expression and accumulation of culprit proteins in the grain. Sorghum germplasm with such suppressed proteins had improved digestibility and, by extension, more available nutrients to consumers.

The results from this ongoing project will be at the forefront of research in nutritional fortification of cereal crops and in combating global changes in climate.

Outputs

Peer-reviewed journal article – 1
Student trained – 1



Human Capital Development

Pinda Sifunda, CSIR
Nandarani Maistry, UJ

Context of the collaboration

UJ and the CSIR support human capital development through several mechanisms. The joint UJ/CSIR scholarship programme supported 12 students (1 Honours, 6 Master's and 5 PhDs) in 2011.

In the same year, 16 CSIR staff members – 2 Bachelor's, 12 Master's, 2 doctoral candidates – were supported by the CSIR to study for higher qualifications at UJ in areas including human resources, environmental management, biological sciences, computer science, as well as several fields of engineering. These include 9 students who worked on CSIR projects as part of the graduate programmes. The students were based at the CSIR and co-supervised by UJ and CSIR researchers. Three of the staff completed their studies during the year.

CSIR staff members have been awarded honorary appointments by UJ. These include two extraordinary professorships, as well as nine lecturers and supervisors.

Bernard Mvula

Bernard Mvula is studying for a PhD with specific interest in differentiation potential of Adipose Derived Stem Cells (ADSCs) when co-cultured with Smooth Muscle Cells (SMCs) and the role of low intensity laser irradiation (LILI) on the differentiation potential of these ADSCs in the presence of the growth factors. Through the Laser Rental Pool Programme, he was able use lasers provided and serviced by the CSIR National Laser Centre (NLC). The laboratory is well-equipped for biochemical, molecular and cellular evaluation as well as tissue culture.

"This research will help to understand the differentiation potential of ADSCs when co-cultured with SMCs, and the impact of LILI on the differentiation potential, proliferation and viability of ADSCs, which would be beneficial in the treatment of several degenerative diseases.

"Collaboration could be further enhanced if more workshops could be organised by the CSIR for students and staff of LRC."

Supervised research
Mitigating the effects of scintillation in long-range optical surveillance applications

Philip Robinson, CSIR
Supervisor: Prof Willem Clarke, UJ

Background

The performance of optical systems in advanced military and naval applications is reduced by the effects of the atmosphere on travelling light rays. One such challenge is mitigating the effects of atmospheric scintillation in surveillance video. Pockets of air in the atmosphere move in a random fashion causing turbulence. Light from the target scene must travel through this turbulent atmosphere to reach the imaging system. The varying densities of the air pockets cause this light to be refracted by varying degrees and in a continually changing manner. This results in the target scene appearing blurred and to be wavering or shimmering. Objects in the scene appear to be moving even when stationary. This effect is referred to as 'heat shimmer' or 'heat scintillation' and in systems that need to capture images or video from more than 1 km away it can drastically reduce the effective range of these surveillance systems.

This challenge was the focus of a PhD research project. The work is funded through PRISM which is part of Armscor's LEDGER programme. The PRISM programme is managed by the CSIR Optronics Sensor Systems group.

Response

An algorithm was developed to try and combat the effects of heat shimmer on long range video surveillance.

The first step was to identify the three major degrading effects that are caused by heat shimmer – namely blurring, a loss of contrast and a geometric distortion which causes static objects in the scene to appear to waver. The algorithm tackles each of these three distortions individually. Firstly, a blind deconvolution algorithm is used to deblur the image. This algorithm detects the amount of blur and noise present in the video without any prior knowledge of the actual conditions in which the video was captured. This information is then used to undo some of the blurring present in the image and reconstructs the high-frequency information that was lost due to heat shimmer. The second step in the algorithm is to use adaptive histogram equalisation techniques, to better distribute the information in the video across the full colour range, to make details easier to discern. This is called contrast enhancement.

The final stage of the algorithm is the most difficult: Features in each frame of the video are selected and tracked as they move during the video sequence. It is then determined which features are moving in a periodic wavering motion caused by atmospheric turbulence and which features are actually objects exhibiting real motion which must be ignored. Once it is known which features are moving due to heat shimmer it can be determined what the true position of those features are and the image can be warped using a triangulated mesh so that the features lie in their true positions. This process stabilises the wavering in the video while preserving any real motion present in the scene.

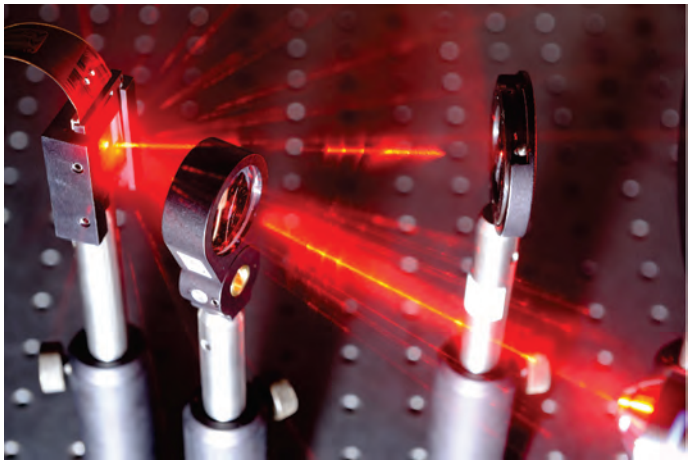
The research work has significant implications for long-range optical surveillance for the South African military and navy. Addressing the problem of scintillation mitigation will lead to improvements in areas such as target tracking and covert operations. The research has been done in close consultation with other researchers in the CSIR Optronic Sensor Systems team and presented at several workshops to ensure transfer of knowledge.

Photodynamic therapy of various cancer cells *in vitro:* Toxicity, localisation and biochemical response

Palesa Sekhejane, UJ
Supervisor: Prof Heidi Abrahamse, UJ

Background

The UJ Laser Research Centre (LRC) is involved in diverse research areas on the application of laser irradiation to biological models *in vitro*. Among these areas is Photodynamic Therapy (PDT) which focuses on the response of cancer cells after treatment. PDT is a treatment modality that combines a photosensitive drug called a photosensitizer and light. The drug is activated or excited at a specific wavelength to yield its oxidative effects such as production of singlet oxygen and other radicals that are important for cancer eradication. PDT has become a subject of interest, due to its attractive features such as selective affinity for cancer cells.



Response

The aim of the research is to determine the suitable working concentration (dose) that is non-toxic when inactive; the sub-cellular localisation of the drug as it is important for elucidation of the mode of action; as well as to examine the biological responses after therapy for various cancer cell lines. Along with other findings, the research has recently shown that Zinc Phthalocyanine localises mainly in the lysozomes in colorectal cancer cells (DLD-1 and CaCo-2), lung cancer cells (A549) and breast cancer cells (MCF-7). Lysozomes are vital acidic organelles that contain proteases and hydrolytic enzymes that are important for cell suicide, since they cause cellular pH to decrease and digest compartmental membranes such as outer mitochondrial membrane. Subsequently, this may lead to spillage of mitochondrial contents that may activate apoptosis. Therefore, Zinc Phthalocyanine can be considered an ideal photosensitizer.

UJ's Laser Research Centre is collaborating with the CSIR by accessing laser instruments and holding joint workshops and conferences. This relationship has also created an opportunity for financial support through the UJ/CSIR scholarship programme. The interaction between the LRC and the CSIR encourages the exchange of research ideas and planning of future collaboration. This partnership could escalate PDT technology by working with enhanced drugs that require smaller doses, and increase delivery time and specificity.

Aqueous synthesis and characterisation of CdSe/ZnO and Ag/ZnO nanomaterials

Ben Rakgalakane, UJ
Supervisor: Dr Makwena Justice Moloto, UJ

Background

Colloidal semiconductor nanocrystals (NCs), also known as quantum dots (QDs), such as Cadmium selenide (CdSe), have found application in different areas such as medicine, biology, and most recently in analytical chemistry. Cadmium selenide nanocrystals and their core/shell systems have been considered useful in many applications like optoelectronic devices, light sensors, biological labels and chemical libraries.

The reason for the wide use of quantum dots, in various fields, is their photo-physical properties which make them unique compared to classic organic dyes and fluorescent proteins. These properties include: broad absorption spectra; very narrow and more systematic emission spectra; long fluorescence lifetime; ability to be functionalised with different bio-active agents, and, stability against photo bleaching – QDs are 100 to 1000 times more stable against photobleaching. A single light source can be used to excite QDs with different emission wavelengths, such as ultraviolet, visible and near-infrared spectra, and mid-infrared.

A further advantage of nanocrystals (NCs) over their bulk counterparts, such as silicon, is the ability to engineer their band-gaps by varying their sizes. The size variation is achieved by controlling variables such as synthesis temperature and time. Additionally, the optical and electrical properties of the nanocrystals are influenced by their shapes such as rods, fractals, bipods, tripods, dots and tubes. These various morphologies have been synthesised by a range of methods including the aqueous route, organometallic, hydrothermal, solvothermal, microwave and chemical vapour deposition.

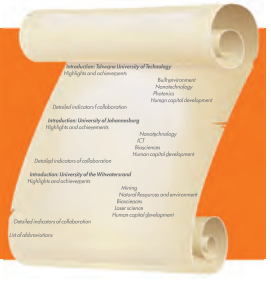
Response

The research has shown that CdSe/ZnO core/shell can be formed using low concentration of the shell precursor. Further, using high shell precursor concentrations will not produce core/shells but a mixture of both materials. Other important variables to consider are pH and temperature.

"The bursary made a huge impact towards my studies as it funded my tuition and living expenses. For this I will be forever grateful for the CSIR/UJ sponsorship."

Outputs

Peer-reviewed journal article - 1



Detailed indicators of collaboration

Collaborative research projects implemented

University researchers	CSIR researchers	Name of project	Research area
Prof Japie van Wyk	Dr Glen Snedden	BALLAST	Defence and security
Prof Bheki Twala	Dr Fisseha Mekuria	Next Generation Wireless Networking	ICT
Prof Catherine Ngila	Dr Ray Suprakas	Development of advanced green plastics	Nanotechnology

Joint outputs resulting from supervised and joint research

Peer-reviewed journal articles		
Authors	**Title of paper**	**Journal**
Das S; Gupta R; Kabundi A	Forecasting regional house price inflation: a comparison between dynamic factor models and vector autoregressive models	Journal of Forecasting, Vol. 30(2), Pages: 288-302 Mar 2011
Mthethwa TP; Moloto MJ; De Vries A; Matabola KP	Properties of electrospun CdS and CdSe filled poly(methyl methacrylate) (PMMA) nanofibers	Materials Research Bulletin, Vol. 46(4), Pages: 569-575 Apr 2011
De Klerk AR; Wepener V	The influence of biotope and sampling method on the assessment of the invertebrate community structure in endorheic reed pans in South Africa	African Journal of Aquatic Science, Vol. 36(1), Pages: 67-74 May 2011
Msiza IS; Mathekga ME; Nelwamondo FV; Marwala T	Fingerprint segmentation: an investigation of various techniques and a parameter study of a variance-based method	International Journal of Innovative Computing, Information and Control, Vol. 7(9), Pages: 5313-5326 Sep 2011
Bolokang AS; Phasha MJ; Oliphant C; Motaung D	XRD analysis and microstructure of milled and sintered V, W, C, and Co powders	International Journal of Refractory Metals and Hard Materials, Vol. 29(1), Pages: 108-111 Jan 2011

Authors	Title of paper	Journal
Ogunniran ES; Sadiku R; Ray SS; Luruli N	Morphology and thermal properties of compatibilized PA12/PP blends with boehmite alumina nanofiller inclusions	Macromolecular Materials and Engineering, Vol. 296, Pages: 1-12 Dec 2011
Ojijo V; Cele H; Ray S	Morphology and properties of polymer composites based on biodegradable polylactide/poly[(butylene succinate)-co-adipate] blend and nanoclay	Macromolecular Materials and Engineering, Vol. 296(9), Pages: 865-877 Nov 2011
Hyoung JC; Ray SS	A review on melt-state viscoelastic properties of polymer nanocomposites	Journal of Nanoscience and Nanotechnology, Vol. 11(10), Pages: 8421-8449 Oct 2011
Bandyopadhyay J; Sinha Ray S	Determination of structural changes of dispersed clay platelets in a polymer blend during solid-state rheological property measurement by small-angle X-ray scattering	Polymer, Vol. 52(12), Pages: 2628-2642 May 2011
Jayaramudu J; Maity A; Sadiku ER; Guduri BR; Rajulu AV; Ramana CHVV; Li R	Structure and properties of new natural cellulose fabrics from Cordia dichotoma	Carbohydrate Polymers, Vol. 86(4), Pages: 1623-1629 Oct 2011
Adekunle AS; Ozoemena KI; Mamba BB; Agboola BO; Oluwatobi OS	Supercapacitive properties of symmetry and the asymmetry of two electrode coin type supercapacitor cells made from MWCNTS/nickel oxide nanocomposite	International Journal of Electrochemical Science, Vol. 6, Pages: 4760-4774 Oct 2011
Adekunle AS; Mamba BB; Agboola BO; Ozoemena KI	Nitrite electrochemical sensor based on prussian blue/single-walled carbon nanotubes modified pyrolytic graphite electrode	International Journal of Electrochemical Science, Vol. 6, Pages: 4388-4403 Sep 2011
Bolokang AS; Phasha MJ	Novel synthesis of metastable HCP nickel by water quenching	Materials Letters, Vol. 65(1), Pages: 59–60 Jan 2011

Conference papers peer-reviewed		
Authors	Title of paper	Conference
Mofolo MRO; Lysko AA; Olwal TO; Clarke WA	Beam steering for circular switched parasitic arrays using a combinational approach	IEEE Africon 2011, Livingstone, Zambia, 13-15 September 2011, Sep 2011

Authors	Title of paper	Conference
Mofolo MRO; Lysko AA; Clarke WA; Olwal TO	Effects of variations in structural parameters on performance of switched parasitic arrays	Southern Africa Telecommunication Networks and Applications Conference (SATNAC 2011), East London, South Africa, 4-7 September 2011, Pages: 6pp Sep 2011
Lysko AA; Mofolo M	Influence of a realistic loading on characteristics and design of ESPAR	Southern Africa Telecommunication Networks and Applications Conference (SATNAC 2011), East London, South Africa, 4-7 September 2011, Pages: 4p Sep 2011
Thejane T; Nelwamondo FV; Malumedzha TC; Marwala T	Otoacoustic emissions: a review on existing human auditory system modelling approaches	22nd IASTED International Symposia on Modelling and Simulation, Calgary, Canada, 4-6 July 2011, Pages: 102-109 Jul 2011
Modungwa D; Tlale NS; Twala B	Techniques applied in design optimization of parallel manipulators	4th Robotics and Mechatronics Conference of South Africa (RobMech 2011), CSIR International Conference Centre, Pretoria, 23-25 November 2011, Nov 2011
Motshekga SC; Pillai SK; Sinha Ray S; Jalama K; Krause RWM	An easy two-step microwave assisted synthesis of SnO2/CNT hybrids	35th International Conference and Exposition on Advanced Ceramics and Composites (ICACC'11), Florida, USA, 23-28 January 2011, Nov 2011

Chapter in a Book		
Authors	Title of the chapter	Book
Msiza IS; Mistry J; Leke-Betechuoh B; Nelwamondo FV; Marwala T	On the introduction of secondary fingerprint classification	State of the Art in Biometrics, Pages: 105-120 Jul 2011

CSIR researchers lecturing/supervising students at UJ

Name of researcher	Research area as defined in the MoU	Type of collaboration
Dr Fulufhelo Nelwamondo	Modelling	Supervision
Dr Albert Lysko	ICT	Supervision
Jan Eloff	ICT	External examination
Dr Ray Suprakas	Materials science	Supervision
Dr Sreejarani Pillay	Materials science	Supervision
Dr Ntsika Msimang	Modelling and digital science	Supervision
Dr Ndeke Musee	Natural resource management	Supervision
Dr Justin Jordaan	Biosciences	Supervision
Jeremy Green	Mining*	Supervision

* = Not in MoU

Students supported by the CSIR/UJ scholarship programme

Name	Area of study	University supervisor
Antonio Rodrigues Corregedor	PhD (Electronic Engineering)	Prof Francois Du Plessis
Sello Manoto	PhD (Laser Science)	Prof Heidi Abrahamse
Thabile Ndlovu	PhD (Chemistry)	Prof Bheki Mamba
Tebogo Pilgerene Phetla	MSc (Chemical Engineering)	Dr Freeman Ntuli
Ben Pesana Rakgalakane*	MSc (Nanotechnology)	Dr Makwena Justice Moloto
Carina Alicia Renison	MSc (Chemistry)	Prof Bradley Williams
Palesa Rose Sekhejane	PhD (Laser Science)	Prof Heidi Abrahamse
Xolani Sikhakhane	MSc (Biochemistry)	Dr Marianne Cronjé
Caroline Hardy	PhD (Signal Processing)	Prof André Nel

* = Graduated in 2011

Name	Area of study	University supervisor
Vanessa O'Neil	MSc (Biochemistry)	Prof Liza Bornman
Tebogo Masakale	BSc Honours (Information Technology)	Dr Carl Marnewick
Lerato Hlekelele	MSc (Chemical Technology)	Dr Sarah Manki Maoela

CSIR staff studying at UJ

Name of CSIR staff	CSIR supervisor	UJ supervisor	Degree programme
Desiree Dike	None	None	BA (Hons) (Human Resources)
Elizabeth Molapo	None	None	BA (Hons) (Human Resources)
Khonzi Hlophe	Jeremy Green	Dr Francois du Plessis	MEng (Electronic & Electrical)
Riaan van Wyk	None	Prof Andre Nel	MEng (Electronics)
Melusi Thwala	Dr Ndeke Musee	Prof Victor Wepener	PhD (Biological Sciences)
Mofolo Mofolo	Dr Albert Lysko	Prof William Clarke	MEng (Electronic & Electrical Engineering)
Andrish Reddy*	Dr Justin Jordaan	Prof Deon Bezuidenhout	MEng (Mechanical Engineering)
Justinus Shadung	Dr James Dabrowski	Dr Silke Bollmohr	MSc (Aquatic Health)
Silumko Mlonyeni*	Sakkie Hattingh	Dorina Ionescu	MTech (Mechanical Engineering Technology)
Ntethelo Mngenge	Dr Ntsika Msimang	Dr Fulufhelo Nelwamondo	MEng (Electrical Engineering)
Sarah Motshekga*	Dr Sreejarani Pillay	Dr Kalala Jalama	MTech (Chemical Engineering)
Hastings Cele	None	Dr Suprakas Sinha Ray	PhD (Applied Chemistry)
Tshegofatso Thejane	Dr Fulufhelo Nelwamondo	Prof Tshilidzi Marwala	MEng (Electrical Engineering)
Kegomoditswe Noreen Molotsi	Prof Marthie Grobler	Dr Bobby Tait	MSc (Informatics)

Name of CSIR staff	CSIR supervisor	UJ supervisor	Degree programme
Phindile Moabalobelo	Dr Fulufhelo Nelwamondo	None	MEng (Electrical Engineering)
Tinny Mgabile	None	Dr Fulufhelo Nelwamondo	MPhil (Electrical Engineering)

CSIR staff holding extraordinary professorships

Researcher	Area of expertise
Dr Suprakas Sinha Ray	Nanotechnology
Dr Fulufhelo Nelwamondo	Modelling

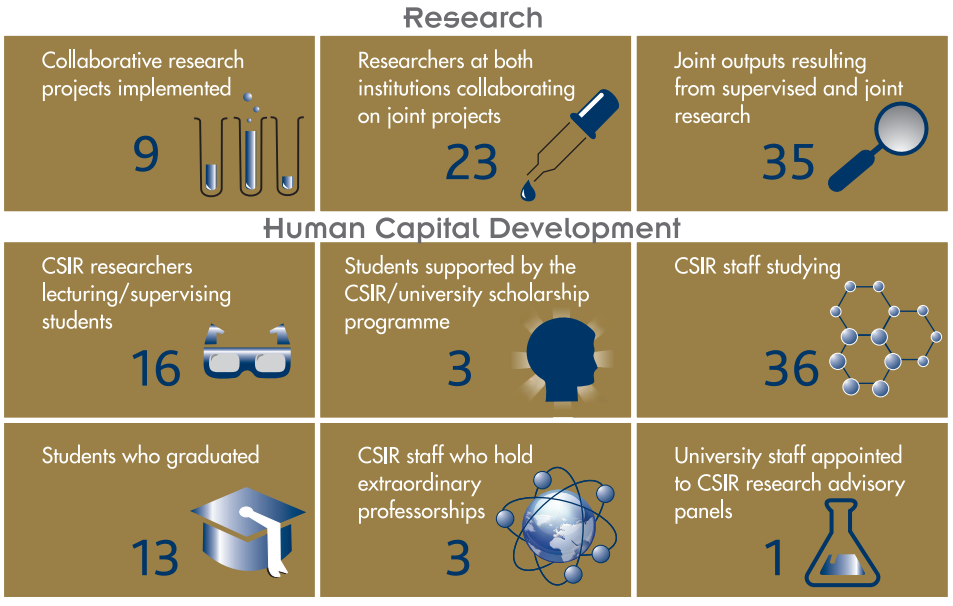
CSIR and University of the Witwatersrand Partnership

Introduction

Wits aims to become one of the TOP 100 universities in the world by the time it turns 100 in 2012. This ambition can only be achieved by undertaking leading research through joint activities with other higher learning institutions and research institutions. Consequently the relationship with the CSIR, as well as the university's newly established 21st Century Institutes (Mining, Cities, Molecular Bioscience, Evolutionary Science, Development, Population, Health & Society and Global Change & Sustainability) are crucial elements of its strategy for achieving this goal.

This section of the report provides an assessment of the activities that have been performed jointly by the CSIR and Wits during 2011. The relationship is implemented through a memorandum of understanding, (valid until 2013), that identifies human capital development as well as research collaboration in the fields of:

- Materials science and manufacturing with focus on aerospace engineering; light metals development; advanced battery materials, and lab-on-chip technologies
- Built environment with focus on architecture and planning; and civil and environmental planning
- Natural resource management with focus on environmental science; mining engineering; and geosciences
- Information communications technology with focus on software engineering; next generation networks; mobile computing & sensor technology; and open source video processing
- Defence, peace, safety and security with focus on systems modelling; and aeronautical systems
- Biosciences with focus on biomedical engineering; and drug discovery and development
- Nanoscience
- Human capital development with focus on staff exchange; funding of students; joint postgraduate supervision; joint appointments and secondments.



Highlights and Achievements

Mining
Observational studies to mitigate seismic risks in mines

Dr Ray Durrheim, CSIR
Prof Hiroshi Ogasawara, Wits

Background

Seismicity poses a serious risk to workers in deep and overstressed mines (e.g. the deep gold and platinum mines in South Africa) and people living close to plate boundaries (e.g. in Japan and the west coast of the United States of America). The three main aims of the project are to:

- Learn more about earthquake preparation and triggering mechanisms by deploying arrays of sensitive sensors within rock volumes where mining is likely to induce seismic activity;
- Learn more about earthquake rupture and rock-burst damage phenomena by deploying robust strong ground motion sensors close to potential fault planes and within mining excavations; and
- Upgrade the South African surface national seismic network in the mining districts.

Response

The five-year collaborative project, which is being implemented under the auspices of an inter-governmental agreement between Japan and South Africa, commenced in August 2010. The project is supported by several Japanese government institutions including the Japan Science and Technology Agency (JSTA), and the Japan International Cooperation Agency (JICA).

Several South African counterpart organisations, including the CSIR, the Council for Geoscience, and Wits collaborate on the project, and are supported with funding from the Department of Science and Technology (DST) and mining companies (viz. Anglogold Ashanti, Gold Fields Ltd and First Uranium), who also host the experimental sites. JICA has provided instruments and sent Japanese specialists to South Africa.

The core team involves about 60 researchers from various universities and research organisations, with approximately equal numbers from South Africa and Japan. In addition, many contractors and technicians are involved in establishing and maintaining the three experimental sites.

Progress

There have been several achievements. Faults at Ezulwini, Moab Khotsong and Driefontein gold mines, considered likely to become seismically active during mining activity, were modelled using pre-existing geological information supplemented by cores and camera images from new boreholes. About 90% of about 70 planned boreholes totalling more than 2 km in length have been drilled at project sites to locate fault zones accurately and to deploy sensors. Acoustic-emission sensors, geophones, accelerometers, strain and tilt meters, and controlled seismic sources were installed to monitor: the deformation of the rock mass; the accumulation of damage during the earthquake preparation phase; and changes in stress produced by the propagation of the rupture front.

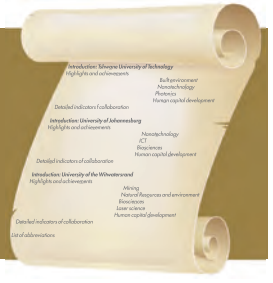
The suite of sensors has greater sensitivity and dynamic range than those typically used in civil or mining engineering applications, making it possible to record very small changes in stress and strain, as well as violent rock mass deformation associated with large seismic events. These data sets will be integrated with measurements of stope closure, strong ground motion in stopes, and seismic data recorded by the mine-wide network.

Although the research is still in its early stages, the establishment of research sites is virtually complete and baseline measurements are being made. Seismicity is expected to increase in the latter half of 2012 as mining activity approached the faults that were identified as capable.

The knowledge gained during the course of the project, will contribute to efforts to improve seismic hazard assessment and mitigate the rockburst risk in South African mines.

Outputs

Peer-reviewed conference papers – 2



Natural Resources and Environment
Ecosystem health and the sustainable development in the Olifants River

Dr Stephan Woodborne, CSIR
Prof Mary Scholes, Wits

Background

The need for increased power generation to support South Africa's economy has led to the development of coal-fired power stations that will exploit the coal field near the Waterberg area. Despite the increased attention given to clean technologies, it is likely that deposition of nitrogen and sulphur from coal burning emissions will increase. Both nitrogen and sulphur pollution may be chemically transformed to the oxidised state of the elements and in this form the deposition is acidic (acid rain). In order to manage and mitigate the impacts that increased deposition will have on the ecosystem, it is necessary to resolve the deposition rate as part of a mass balance, and then to determine the ecosystem assimilative capacity. Stable isotopes of sulphur and nitrogen reflect the source of the deposition, and are a useful tool in the partitioning of pollution loads between different sources, including natural ones.

Response

This project aims to prove the concept that stable isotopes of sulphur and nitrogen can be used to partition atmospheric deposition of these elements between pollution sources and natural sources. In order to achieve this, it was necessary to implement the sulphur isotope method at the CSIR. The plan for the project allowed for the collaboration to extend to the 'proof of concept' stage only, leaving further exploration to the industries affected.

Progress

The original research design involved the measurement of sulphur isotopes in aquatic organisms from streams in the Waterberg area. The original proposed project implementation in the Waterberg failed to achieve substantive results as the target samples and aquatic invertebrates contained insufficient sulphur to make viable measurements. However, the same research design was implemented as part of an MSc degree project at Wits. This project partitioned sulphur and nitrogen deposition in soil organic samples after it was demonstrated that the natural and pollution sources have distinct isotopic signals.

The technology was also used to trace fish movements in aquatic systems and an Honours research project at the University of Pretoria demonstrated that the invasive silver carp in Lake Flag Boshielo has a distinctive sulphur isotope signal that derives from pollution sources in the upper Olifants River catchment. The student also participated in a CSIR research programme aimed at identifying the cause of the mass crocodile mortality events that have taken place in Kruger National Park since 2008. In this case, the sulphur isotope technology was able to distinguish between the fish from the Olifants River with a pollution sulphur source, versus fish from the Letaba River in which sulphur has a geological origin. This project was definitive in identifying the cause of the crocodile deaths.

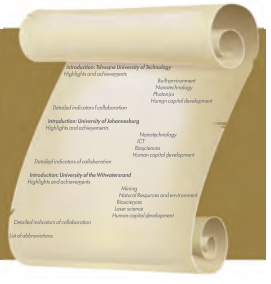
The principles that underlay these projects – that isotopes can be used to source and budget nitrogen and sulphur pollution – was the premise of the CSIR programme at the Kruger National Park. Nitrogen and carbon isotopes had been used to test the hypothesis that pollution was the cause of the crocodile mass mortalities in the Olifants River system. However the research yielded a somewhat different conclusion. It appeared that the foodweb structure at various locations in the rivers at the Kruger National Park were similar in most respects, except in the area in which the crocodiles mortalities were occurring. In particular, fish sampled at the confluence of the Olifants and Letaba Rivers seemed to have a different trophic structure from fish sampled upstream in both rivers. The target fish species, the barbel (Clarias gariepinus), that is a common diet fish for crocodiles, is pelagic and moves between different river systems. Barbel sampled at the confluence could come from either the Olifants or the Letaba Rivers.

Sulphur isotope analysis of the fish assemblages showed that fish from the Olifants River had a very clear isotopic signal that was distinct from that of fish from the Letaba River. The Olifants River carries the polluted sulphur source isotopic signal, while the Letaba River carries the geological or natural isotopic signal. In this way, the fish assemblages sampled at different locations could be assigned their latent river territory, and the emergent patterning clarified the foodweb structures. It is now concluded that the crocodile crisis was caused by ecological change and not pollution.

Further analyses will be required to produce a convincing dataset to market to industry. The way forward for this project lies in a collaborative effort that is being conceptualised between the CSIR and Wits.

Outputs

Students trained – 2



Biosciences
BP 36: A novel microbicide from a South African indigenous medicinal plant to help fight the spread of HIV

Dr Vinesh Maharaj, CSIR
Prof Viness Pillay, Wits

Background

The CSIR's collaboration with traditional healers on the use of medicinal plants in South Africa led to the identification of a plant for the treatment of the human immunodeficiency virus (HIV). The plant under investigation is used by an individual in the Eastern Cape to treat HIV-positive patients. Reports by the indigenous knowledge holder on the blood viral loads measured by local clinics underlie the potential use of the plant for the development of anti-HIV products. A manufacturing method for the production of the active spray-dried extract in a quality-controlled environment has been developed.

The active compound in the extract has been isolated though a precipitation process. The anti-HIV activity of the spray-dried extract has been shown to have good activity when tested against clinical isolates of HIV in the peripheral blood mononuclear cell (PBMC) assay, both in the United States and South Africa, with excellent therapeutic windows. No cytotoxicity, mutagenicity and hERG effects were seen in in vitro assays. The substance has an SI index of greater than 4 000. In the current form, it would be difficult to develop the active compound as an oral treatment for HIV, as high-molecular weight agents often have poor bio-availability following oral administration. However, large molecules with potent anti-HIV activity are ideal for topical use and potent development as a microbicide. Unlike the other carbohydrate microbicides which have poor anti-HIV properties, research has shown the compound to have good anti-HIV activities.

Response

Several clinical studies have been performed on potential microbicides. All of these have been formulated as gels with Tenofivir being the most recent and having demonstrated efficacy in a controlled study. During interactions with the principal investigators of these studies, indications were that many of the trials had failed due to poor user compliance, for example; the user forgets to use the gel. Alternative application methods which reduce dependence on the user to apply the gel could increase the chances of success of microbicides. Wits has been developing a slow release 'caplet' technology. This allows the application of the microbicide (formulated into a caplet) into the vagina. This can be effective for up to 72 hours. The CSIR has combined its efforts with Wits, where the microbicide in currently being used in other research.

Progress

A primary production method for the preparation of a spray-dried extract was established. The spray-dried extract of the plant was shown to have an IC50 of 1-1.5 μg/mL with a selectivity index (SI) of greater than 500 against a HIV sub-type C clinical isolate (mostly prevalent in South Africa and in sub-Saharan Africa) in the PBMC assay. The spray-dried extract was subjected to a precipitation process resulting in a gel which was analysed though high resolution mass spectrometry and nuclear magnetic resonance (NMR). Indications are the presence of galacturonic acid moieties typical of pectins. The compound was shown to compare favourably with azidothymidine (AZT) in the same assay. The compound was also screened against 10 sub-type C clinical isolates, and showed a good anti-HIV profile against most of these isolates.

The research has also shown, through a target-based assay, (time of addition assay), that the extract containing the compound acts as an HIV entry inhibitor, substantiating its use as a topical microbicide. In vitro cytotoxicity, mutagenicity and hERG have not shown any toxicity. An area in the Eastern Cape has been earmarked for supply of the plant material. A trial cultivation programme has been initiated by the CSIR to establish an agro-processing community business.

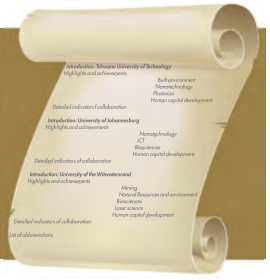
The drug release studies of the active substance within the formulation are ongoing. In addition to the caplet application, the active substance has been formulated into the classical gel by the CSIR, while the drug release profiles are also ongoing. In both cases, there are challenges in developing an analytical method to determine the active compounds, due to size and complexity.

Further collaboration

Once the release profiles of the microbicide in both the caplet and gel have been determined, further *in vitro* toxicity and *in vivo* toxicity studies are planned. Some of these will be done at Wits. Subject to the success of the toxicity studies using the different formulations, a clinical trial will provide the final proof of concept studies required for a potential licensee to develop further.

Outputs

Students trained – 4



Laser Science
Laser applications in paleoanthropology

Dr Anton du Plessis, CSIR
Prof Lee Berger, Wits

Background

The objective of this research project is to advance laser technology use and implementation in the field of archaeology in general, and paleoanthropology in particular. One major objective is to investigate the potential for laser preparation of fossils, which invariably involves the removal of encasing calcified clastic matrix (rock – from embedded fossils). Current technology employs mechanical and chemical methods, which are potentially damaging to the fossil.

Response

Laser technology offers advantages because the removal of rock can be semi-automated. The non-contact ablation process used with laser processing does not involve chemicals or pressure, both of which can be very damaging to the fossil. Laser processing can also damage the fossils via removal of not only rock, but also fossil materials. For this purpose, a variety of methods are considered. One method of controlling the laser processing is the use of laser-induced breakdown spectroscopy (LIBS). Results from this study – indicating the feasibility of the technique – are encouraging and have been submitted for publication.

Progress

Initial work was aimed at finding unique ablation thresholds, in order to determine if rock material can be selectively ablated without a process control mechanism. This work is encouraging for final surface cleaning of fossils, but is not a practical solution due to the high power required for fast bulk removal. The work is continuing and includes the use of a femtosecond laser, as well as an industrial micro-processing workstation. It is envisaged that a variety of high-power laser systems will be tested to compare bulk removal rates with manual preparation techniques. The first removal of a small fossil will take place in 2012, using a layered visual inspection processing method. The next step will be to incorporate LIBS as a processing control tool. This demonstration is scheduled for 2013. Future steps could include the incorporation of 3D computer aided design (CAD) information of the location of fossils within a block of rock (e.g. produced using X-ray tomography) as input for laser processing, leaving a small layer of rock around the fossil for a human operator to carefully remove using standard technology.

In addition to the potential for laser preparation of fossils, another aspect of the project involves fossil replicas. High-quality replicas of fossils are made using casting techniques and hardened plastic. Unfortunately, this process not only places the specimen at risk, but the result has a non-authentic look and feel. In this project, laser processing is being investigated to produce replicas from alumina. Currently, subtractive manufacturing is applied, whereby a block of alumina is processed using 3D CAD information of the fossil, and unwanted material is removed until the final replica is produced. Laser additive manufacturing can also be applied in future, as this new technology holds promise for building small parts such as fossil replicas, in a variety of materials.

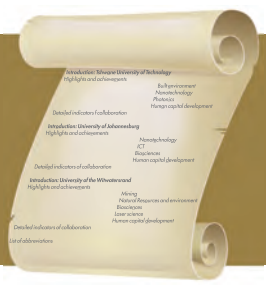
This technique could be very useful for fragile fossils that cannot be removed from host rock, by acquiring 3D CAD information from an X-ray tomography scan of the rock, and using this information to produce an exact replica of the embedded fossil. Although this is already done using other 3D printing methods, laser production holds the advantage of producing this at potentially higher resolution and in improved materials.

Future work

The project aims to produce new knowledge in the form of publications on the above topics, as well as technology demonstrators in the field of paleoanthropology. The impact of the work could be huge, considering the potential number of fossil finds which have been identified. The result could be more finds of early hominins from Malapa and other sites, which could provide more information on South Africa's place in early human evolution.

Outputs

Peer-reviewed journal articles – 5



Human Capital Development

Pinda Sifunda, CSIR
Dr Mahomed Moola, Wits

Context of the collaboration

Wits and the CSIR support human capital development through several mechanisms. The joint Wits/CSIR scholarship programme supported three PhD students in 2011.

In the same year, 36 CSIR staff members – 5 Bachelor's, 17 Master's and 14 PhD candidates – were supported by the CSIR to study for higher qualifications at Wits in areas including media studies, mathematics, innovation management, computer science, ecology, and seismology, as well as several fields of engineering. These included 12 students who worked on CSIR projects as part of their graduate programmes. The students were based at the CSIR and co-supervised by Wits and CSIR researchers. Thirteen of the staff completed their studies during the year.

A large number of CSIR staff members have been awarded honorary appointments by Wits. These include four extraordinary professorships, as well as 17 lecturers and supervisors. A selection of some of the student research and experiences follows.

Thobeka Kente

Thobeka Kente expects to complete her PhD on synthesis of gallium nitride (GaN) nanostructures for sensor applications and catalysis in December 2012. "The project entails the investigation of new Green routes to the synthesis of GaN. Novelty resides in all aspects of the project: First, while GaN is a well known material, comprehensive synthesis approaches, based on Green Chemistry principles, have not been applied to it. Second, functionalisation of GaN (to give fGaN) has been little investigated. Finally, the fGaN will be used as catalyst supports for catalysis and sensing applications. Controlling the size and shape of the GaN nanomaterials will be emphasised and correlated with the application of these materials in catalysis.

The project will develop new materials at the nano-scale level, leading to the development and application of new nano-based catalysts and processes which improve the competitiveness of local industries. The material will be useful for chemical sensing and catalyst support."

Zikhona Tetana

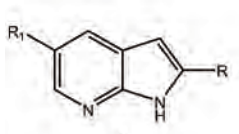
Zikhona Tetana expects to complete her PhD on the use of nanomaterials for photochemical degradation of organic pollutants in water in December 2012.

"Wits encourages one to speak up when facing challenges in research and other areas of life. I have had a great experience with the CSIR; the visits by CSIR representatives to Wits are quite useful as they listen to student's concerns. So far I am content and I would like to thank the Wits-CSIR scholarship authorities for their generous financial contributions towards my degree. I would like to be a research scientist so as to contribute to solving the problems of our world."

Tlabo Leboho

Tlabo Leboho is currently doing a PhD in synthetic organic chemistry. "My research involves synthesising new molecules or natural products. I am expecting to finish my studies at the end of 2012. My PhD project is about synthesising Novel 7-Azaindole Derivatives.

"I am interested in synthesising molecules of general formulae (1) and (2). 7-Azaindoles, which share structural similarity with indole, and are expected to show similar or improved biological activity in some instances due to the extra nitrogen in the ring. Motivated by biological activity shown by indole-containing compounds, we decided to explore 7-azaindoles for their biological activity. South Africa, and the rest of the continent, has the highest death rate as a result of malaria. This project's importance relies on producing pro drug compounds that can be screened or tested against malaria and various cancer cell lines."



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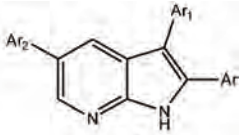

2

Electronic transport in rock of metal-filled single-walled carbon nanotubes (SWNT)

Siphephile Ncube, Wits
Supervisor: Prof Somnath Bhattacharyya, Wits

Background

Pulsed laser ablation is highly effective in the synthesis of high quality nanomaterials. Filling the hollow of carbon nanotubes (CNTs) with chosen materials opens new possibilities of generating one dimensional structures, hence broadening the application area of these nanostructures. To date, filled CNTs have been produced using *ex situ* filling methods (which alters the structure of the tube) and the only *in situ* filling process to date that yielded results is the chemical vapour deposition process, which lacks control. Since the pulsed laser ablation process produces CNTs of a higher quality, the research study is currently developing a method to fill the CNTs in *situ* during pulsed laser ablation. Filling will be more efficient due to the flexibility of pulsed laser ablation and it might be possible to control the degree of filling. It is anticipated that this method will lead to extensive study of the chemistry and physics of the filled nanotubes which might find application in the development of materials with new magnetic and electronic properties.

We are also looking for device applications of the thin layer of carbon which is grown through laser ablation. In order to produce films of low defect density, several grown parameters including the deposition temperature and the flow rate, were maintained. Finally, we are growing semiconductor nanowires by laser ablation and checking their potential for electronic device applications.

Response

The CSIR National Laser Centre (NLC) has been very supportive. Being part of the laser rental pool programme has afforded us the chance to interact with other researchers and keep up to date with current developments in other related fields. The research has received significant support in all aspects of the laser operation – from installation to general maintenance queries. The training course provided has helped to broaden our knowledge and confidence as operators of the equipment. We believe that the collaboration between the NLC and laser users is highly efficient. We have also been able to develop a labview programme for beam control.

The laser-furnace has contributed enormously to our research work, giving us the opportunity to explore and develop novel ideas from synthesis level. Our laboratory has acquired state-of-the-art equipment and Wits has made available various characterisation facilities for extensive analysis of the synthesised material. We aim to further this research by finding applications in the development of materials with properties which can be tuned precisely for device fabrication.

Future collaboration

Future work will focus on the synthesis of graphene in an attempt to exploit the enhanced control afforded uniquely by laser ablation to synthesise graphene and functionalised graphenes. As a synthesis method, laser ablation-assisted growth of graphene has not yet been achieved. Through laser ablation, superlattice structures of one-dimensional nanowires will be deposited. The temperature-dependent transport properties will be investigated in conjunction with magneto-resistance and carrier density-dependent measurements, to establish novel nanoelectronic devices.

Detailed indicators of collaboration

Collaborative research projects implemented

University researchers	CSIR researchers	Name of project	Research area
Dr Ray Durrheim	Dr Alex Milev; Thabang Kgarume	JST JICA SATREPS project: Observational studies to mitigate seismic risks in mines	Mining
Prof Lee Berger	Dr Anton du Plessis	Laser application in Paleoanthropology	Lasers
Prof Elias Sidderas-Haddad	Dr Andrew Forbes	Nano-structures of Wox and Vox	
Prof Piketh Stuart	Dr Siva Venkataraman	Atmosphere research over South Africa and Indian Ocean	Remote sensing
Prof Montaz Ali	Dr Louis Coetzee; Viren Govender	Ability Based Technology Interventions	ICT
Dr Somnath Bhattacharyya Prof Neil Coville Dr Elias Sideras-Haddad	Dr Sabelo Mhlanga; Tlhogi Mabena; Keletso Mphahlele	Synthesis and characterization of nitrogen-doped CNTs	Nano science
Dr Frank Kienhofer	Shikar Sharma	Mobility research	Defence and security
Prof Viness Pillay	Dr Vinesh Maharaj	A novel microbicide from a SA indigenous medicinal plant to help fight the spread of HIV	Health
Prof Mary Scholes	Dr Stephan Woodborne	Ecosystem health and sustainable development in the Olifants River	Environment

Joint outputs resulting from supervised and joint research

Peer-reviewed journal articles		
Authors	Title of paper	Journal
Edward VA; Huch M; Dortu C; Thonart P; Egounlety M; Van Zyl PJ; Singh S; Holzapfel WH; Franz CMAP	Biomass production and small-scale testing of freeze-dried lactic acid bacteria starter strains for cassava fermentations	Food Control, Vol. 22(3-4), Pages: 389-395 Mar 2011

Authors	Title of paper	Journal
Gravestock D; Rousseau AL; Lourens ACU; Moleele SS; Van Zyl RL; Steenkamp PA	Expeditious synthesis and biological evaluation of novel 2,N6-disubstituted 1,2-dihydro-1,3,5-triazine-4,6-diamines as potential antimalarials	European Journal of Medicinal Chemistry, Vol. 46(6), Pages: 2022-2030 Jun 2011
Wessels KJ; Mathieu R; Erasmus BFN; Asner GP; Smit IPJ; Van Aardt JAN; Main R; Fisher J; Marais W; Kennedy-Bowdoin T; Knapp DE; Emerson R; Jacobson J	Impact of communal land use and conservation on woody vegetation structure in the Lowveld savannas of South Africa	Forest Ecology and Management, Vol. 261(1), Pages: 19-29 Jan 2011
Govender M; Shikwambana L; Mwakikunga BW; Sideras-Haddad E; Erasmus RM; Forbes A	Formation of tungsten oxide nanostructures by laser pyrolysis: stars, fibres and spheres	Nanoscale Research Letters, Vol. 6(166), Pages: 1-8 Feb 2011
Symes CT; Woodborne SM	Estimation of food composition of Hodotermes mossambicus (Isoptera: Hodotermitidae) based on observations and stable carbon isotope ratios	Insect Science, Vol. 18(2), Pages: 175-180 Apr 2011
Symes CT; McKechnie AE; Nicolson SW; Woodborne SM	The nutritional significance of a winter-flowering succulent for opportunistic avian nectarivores	Ibis, Vol. 153(1), Pages: 110-121 Jan 2011
Shackleton CM; Scholes RJ	Above ground woody community attributes, biomass and carbon stocks along a rainfall gradient in the savannas of the central lowveld, South Africa	South African Journal of Botany, Vol. 77(1), Pages: 184–192 Jan 2011
Machio C; Nyabadza D; Sibanda V; Chikwanda HK	Characterization of mechanically alloyed f.c.c. Ti-Mg-based powders	Powder Technology, Vol. 207(1-3), Pages: 387-395 Feb 2011
Oboirien BO; Engelbrecht AD; North BC; Du Cann VM; Verryn S; Falcon R	Study on the structure and gasification characteristics of selected South African bituminous coals in fluidised bed gasification	Fuel Processing Technology, Vol. 92(4), Pages: 735-742 Apr 2011
Shackleton CM; Scholes RJ; 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
Naidoo K; Skews BW	Dynamic effects on the transition between two-dimensional regular and Mach reflection of shock waves in an ideal, steady supersonic free stream	Journal of Fluid Mechanics, Vol. 676, Pages: 432-460 Apr 2011
Fedotov I; Fedotova T; Pityana SL; Labuschange K; Shatalov M; Potgieter JH	A mathematical model of laser surface heat-cooling treatment for medium carbon steel	Journal of The Southern African Institute of Mining and Metallurgy, Vol. 111, Pages: 379-384 Jun 2011

Authors	Title of paper	Journal
Wise RM; Dye PJ; Gush MB	A comparison of the biophysical and economic water-use efficiencies of indigenous and introduced forests in South Africa	Forest Ecology and Management, Vol. 262(6), Pages: 906–915 Sep 2011
McLaren M; Sidderas-Haddad E; Forbes A	Accurate measurement of microscopic forces and torques using optical tweezers	South African Journal of Science, Vol. 107(9/10), Pages: 8pp Sep 2011
McCarthy TS; Tooth S; Jacobs Z; Rowberry MD; Thompson M; Brandt D; Hancox PJ; Marren PH; Woodborne S; Ellery WN	The origin and development of the Nyl River floodplain wetland, Limpopo Province, South Africa: trunk-tributary river interactions in a dryland setting	South African Geographical Journal, Vol. 93(2), Pages: 172-190 Dec 2011
Mwenge Kahinda J; Taigbenu AE	Rainwater harvesting in South Africa: challenges and opportunities	Physics and Chemistry of the Earth, Vol. 36(14-15), Pages: 968–976 Aug 2011
Mabena LF; Ray SS; Mhlanga SD; Coville NJ	Nitrogen-doped carbon nanotubes as a metal catalyst support	Applied Nanoscience, Vol. 1(2), Pages: 67-77 May 2011
Everson CS; Dye PJ; Gush MB; Everson TM	Water use of grasslands, agroforestry systems and indigenous forests	Water SA, Vol. 37(5), Pages: 781-788 Dec 2011
Oboirien BO; Engelbrecht AD; North BC; Eramus RM; Falcon R	Mineral-char interaction during gasification of high-ash coals in fluidized-bed gasification	Energy & Fuels, Vol. 25(11), Pages: 5189-5199 Sep 2011
Symes CT; Woodborne SM	Variation in carbon and nitrogen stable isotope ratios in flight feathers of a moulting White-bellied Sunbird Cinnyris talatala	Ostrich, Vol. 82(3), Pages: 163-166 Nov 2011
Sibanda MM; Focke WW; Labuschagne FJWJ; Moyo L; Nhlapo NS; Maity A; Muiambo H; Massinga P; Crowther NAS; Coetzee M; Brindley GWA	Degradation of insecticides used for indoor spraying in malaria control and possible solutions	Malaria Journal, Vol. 10(307), Pages: 12pp Oct 2011
Engelbrecht FA; Landman WA; Engelbrecht CJ; Landman S; Bopape MM; Roux B; McGregor JL; Thatcher M	Multi-scale climate modelling over Southern Africa using a variable-resolution global model	WaterSA, Vol. 37(5), Pages: 647-658 Dec 2011
Land KJ; Mbanjwa MB; Govindasamy K; Korvink JG	Low cost fabrication and assembly process for re-usable 3D polydimethylsiloxane (PDMS) microfluidic networks	Biomicrofluidics, Vol. 5(3), Pages: 6pp Sep 2011

Authors	Title of paper	Journal
Singh M; Kijko A; Durrheim R	First-order regional seismotectonic model for South Africa	Natural Hazards, Vol. 59, Pages: 383-400 Oct 2011

Conference papers peer-reviewed		
Authors	**Title of paper**	**Conference**
Mbanjwa MB; Land K; Jewell LL; Gledhill IMA	Experimental and numerical studies of emulsion formation in a microfluidic T-junction	2nd African Conference on Computational Mechanics (AfriCOMP11), University of Cape Town, Cape Town, 5-8 January 2011, Jan 2011
Cawse K; Robin A; Sears M	The effect of noise whitening on methods for determining the intrinsic dimension of a hyperspectral image	Workshop on Hyperspectral Image and Signal Processing: Evolution in Remote Sensing (WHISPERS 2011), Lisbon, Portugal, 6-9 June 2011, Pages: 4 Jun 2011
Dickens JS; Green JJ; Van Wyk MA	Human detection for underground autonomous mine vehicles using thermal imaging	26th International Conference on CAD/CAM, Robotics and Factories of the Future (CARs&FOF 2011), Kuala Lumpur, Malaysia, 26-28 July 2011, Pages: 12pp Jul 2011
Wessels KJ; Mathieu R; Erasmus BFN; Asner GP; Smit IPJ; Van Aardt JAN; Main R; Fisher J	Impact of communal land use and conservation on woody vegetation structure in the Lowveld savannas of South Africa: lidar results	34th International Symposium on Remote Sensing of Environment, Sydney, Australia, 10-15 April 2011, Pages: 4pp Apr 2011
Matooane M; Garland RM; Engelbrecht F; Wright C; Olwoch J; Bopape M-J	Climate change and human health: oppressive temperatures in Southern Africa	27th Annual Conference of the South African Society for Atmospheric Sciences: the Interdependent Atmosphere, Land and Ocean, Hartbeespoort, 22-23 September 2011, Pages: 2p Sep 2011
Dickens JS; Van Wyk MA; Green JJ	Pedestrian detection for underground mine vehicles using thermal images	IEEE Africon 2011, Livingstone, Zambia, 13-15 September 2011, Pages: 6pp Sep 2011

Authors	Title of paper	Conference
Garland RM; Matooane M; Bopape MJ; Engelbrecht F; Naidoo M; Wright CY; Olwoch J	Climate change impacts on human health in South Africa	2011 National Association for Clean Air National Conference (NACA 2011), East London, South Africa, 13-14 October 2011, Pages: 5pp Oct 2011
Teleka R; Green J; Brink S; Sheer J	Automated tools to be used for ascertaining structural condition in South African hard rock mines	4th Robotics and Mechatronics Conference of South Africa (RobMech 2011), CSIR International Conference Centre, Pretoria, 23-25 November 2011, Pages: 5pp Nov 2011
Bradley RA; Goliger AM; Gohnert M	Wind tunnel study of cross vault structures	13th International Conference on Wind Engineering, Amsterdam, Netherlands, 10-15 July 2011, Pages: 8pp Jul 2011
Raborife M; Zerbian S; Ewert S	Developing a corpus to verify the performance of a tone labelling algorithm	22nd Annual Symposium of the Pattern Recognition Association of South Africa (PRASA), Emerald Casino and Resort, Vanderbijlpark, South Africa, 22-25 November 2011, Pages: 126-131 Nov 2011
Moloantoa JR; Rammutla KE; Mosuang TE; Erasmus TE; Hillie KT	XRD, DRS, and SEM studies of the effects of metal dopants (Pt and Au) on the structural and optical properties of TiO2	56th Annual Conference of the South African Institute of Physics (SAIP2011), St George Hotel, Pretoria, 12-15 July 2011, Jul 2011

CSIR researchers lecturing/supervising students at Wits

Name of researcher	Research area as defined in MoU	Type of collaboration
Llewellyn van Wyk	Built environment	Supervision
Dr Jeremy Gibberd	Built environment	Supervision
Dr Adam Goliger	Built environment	Supervision
Dr Ray Durrheim	Mining	Lecturing, supervision

Name of researcher	Research area as defined in MoU	Type of collaboration
Dr Igle Gledhill	Defence and security	Supervision
Nelis Willers	Defence and security	Supervision
Jacques Cilliers	Defence and security	Supervision
Dr Fulufhelo Nelwamondo	Modelling	Supervision
Dr Louis Coetzee	ICT	Supervision
Dr Konrad Wessels	ICT	Supervision
Dr Frans van den Bergh	ICT	Supervision
Terence van Zyl	ICT	Supervision
Dr Sally Archibald	Natural resource management	Lecturing, supervision
Dr Stephan Woodborne	Natural resource management	Supervision
Dr Bob Scholes	Natural resource management	Lecturing, supervision
Dr Willem de Lange	Agricultural Economics & Conservation Ecology	Supervision

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Zikhona Nobuntu Tetana	PhD (Nanomaterials)	Prof Neil Coville
Thobeka Kente	PhD (Nanotechnology)	Prof Neil Coville

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Name of CSIR staff	CSIR supervisor	Wits supervisor	Degree programme
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Nandi Malumbazo*	None	Prof Nicola Wagner	PhD (Chemical Engineering)
Paulin Mbecke*	None	Prof Muhammed Jahed	PhD (Public and Development Management)
Hazel Mufhandu	Dr Makobetsa Khati	Prof Lynn Morris	PhD (Virology)
Kathleen Smart	Dr Bob Scholes; Dr Belinda Reyers	Dr Barend Erasmus	PhD (Ecology)
Charlotte Mashaba*	Dr Eugenia Barros	Dr Monde Ntwasa	MSc (Molecular and Cell Biology)
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Malcolm Govender	Dr Andrew Forbes	Prof Elias Sideras-Haddad	MSc (Physics)
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Kavendra Naidoo*	None	Prof Beric William Skews	PhD (Aerospace Engineering)
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Yasmin Shapurjee*	None	Sarah Charlton	BSc (Town and Regional Planning)
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Researcher	*Area of expertise*
Dr Ray Durrheim	*Seismology*
Dr Bob Scholes	*Savanna ecology and global change*
Dr Sally Archibald	*Global change and dynamic ecosystems*

WITS staff serving on CSIR advisory panel

Name of staff	*Area of expertise*
Dr Lucienne Abrahams	*ICT*

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List of Abbreviations

ADSC	Adipose Derived Stem Cell
AFM	Atomic Force Microscopy
AZT	Azidothymidine
CAD	Computer Aided Design
CNTS	Carbon nanotubes
CSIR	Council for Scientific and Industrial Research
CW	Continuous wave
DCC	Dicyclohexylcabodimide
DSC	Dye solar cell
DST	Department of Science and Technology
EBCS	Enzyme-based Chemical Stabilisers
GMO	Genetically Modified Organism
HCD	Human Capacity Development
HIV	Human Immunodefficieny Virus
ICASA	Independent Communications Authority of South Africa
ICT	Information and Communications Technology
JICA	Japan International Cooperation Agency
JSTA	Japan Science and Technology Agency
LIBS	Laser-induced breakdown spectroscopy
MSS	Martensitic Stainless Steel
NMISA	National Metrology Institute of South Africa
LIBS	Laser-Induced Breakdown Spectroscopy
LILI	Low Intensity Laser Irradiation
LMP	Laser Material Processing
LRC	Laser Research Centre
LSA	Laser Surface Alloying
MWCNT	Multi Walled Carbon Nano Tube
Mpc	Metallophthalocyanine
Ncs	Nanocrystals
N-CNTs	Nitrogen-doped carbon nanotubes
NLC	National laser Centre
NMR	Nuclear Magnetic Resonance
Nps	Nanoparticles
PBMC	Peripheral blood mononuclear cell
PDT	Photodynamic Therapy
PLA	Polylactide
PV	Photovoltaic
QD	Quantum Dots
SEM	Scanning Electron Microscope
SI	Selectivity Index
SMC	Smooth Muscle Cells
STM	Scanning Tunnelling Microscopy
TV	Television
TVWS	Television White Space Spectrum
R&D	Research and development
TGA	Thermogravimetry Analysis
TUT	Tshwane University of Technology
UJ	University of Johannesburg
UP	University of Pretoria
Wits	University of the Witwatersrand

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