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Faculty: Engineering	***Department:*** Mechanical and Mechatronic Engineering

Division:

Design & Mechatronics / Mechanics / Thermo fluids / <u>Renewable Energy</u>

Research field:

Solar PV Technology

General description of research field:

Thermo-mechanical and materials modelling, analysis, design and manufacture of thin-film solar cells.

Modelling of lattice behaviour and inter-atomic diffusion in epitaxial crystalline thin film structures, using continuum-based finite element analysis. Applications include photovoltaic thin films and thin film coatings for corrosion resistance and radiation protection.

Lys van onderwerpe/*List of topics:* ***(Mark applicable degree with an X)***	***MEng (Structured)***	***MEng (Research)***	**PhD**	**Funding**
1. Finite Element Analysis of Lattice Deformation in Crystalline PV Nanofilms. The deposition of nanofilms at high temperatures through physical vapour deposition in the production of PV panels leads to internal stress due to chemical effects (thermal expansion) and lattice misfits. This study will focus on epitaxially grown crystalline hetero-structures (at least two different crystalline layered structures) on a glass substrate. A continuum-based finite element model will be developed based on the decomposition of the deformation tensor to incorporate the effects of chemical and lattice (misfit) deformation. An appropriate stress-strain model for such anisotropic elastic materials will be investigated. The aim of this study is to predict the deformation of PV panels due to internal stresses. A particular case PV panel which is currently manufactured in South Africa will be investigated. **Specific requirements:** Interest in solar PV technology. Background in finite element analysis, solid mechanics (including plasticity). Use of Abaqus (Simulia) for FE modelling.		X		**Funding through the CRSES.**
2. Design of a Flexible Dye Sensitised Solar Cell. Dye-sensitised Solar Cells (DSCs), also known as Gratzel Cells is a thin-film photoelectrochemical (PEC) type solar cells, and is the latest in the spectrum of solar cells to be developed, as compared to crystalline and amorphous type	X			**Funding through the CRSES.**

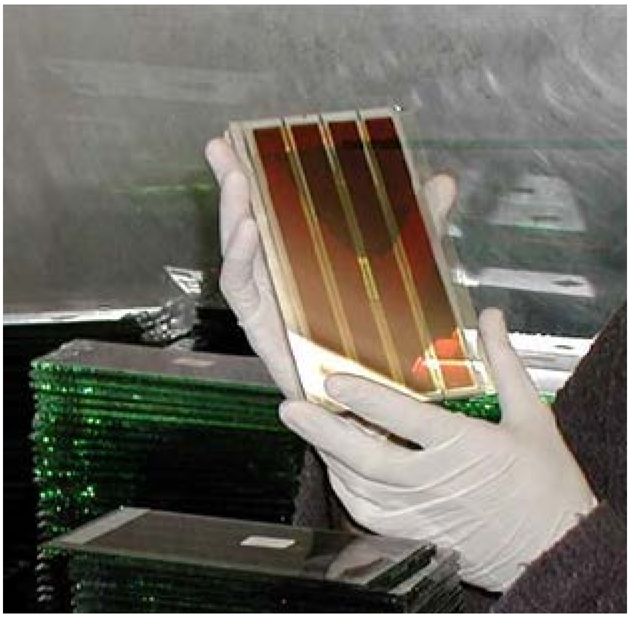
solar cells. This photoelectrochemical technology utilises a nanomaterial form of TiO_2 as the thinfilm semiconductor material, coated on a conductive transparent substrate. The semiconductor is sensitised by a special ruthenium-based dye to allow for absorption of photon energy. Electron flow is via an electrolyte closing the loop between the semiconductor coated anode and a conductive cathode substrates. Electricity generation can be achieved using visible light spectrum, and it is therefore suitable for indoor applications, thereby avoiding direct radiation damage.

Although first commercialised around 2005, and with lower efficiencies compared to its counterparts, the technology has undergone rapid innovation over the past 4-5 years towards flexible cells using conductive polymer-based substrates and screen-printing technology. This technology is particularly useful in applications requiring robust solar cells that can conform to complex profiles.

This study involves the complete design of a flexible DSC for continuous fabrication in an extrusion-based production process, designed for a specific household application. This project will also investigate the formulation of conductive polymers from raw materials, and the treatment of the substrates to allow for adhesion of the semi-conductor coating during screen printing.

Specific requirements:

Interest in solar PV technology. Background in mechanical design (use of CAD software is essential) and manufacture, and materials. Photochemistry, nanomaterials. .



3. Thermal Stress induces Failure Analysis in Thin-Film Solar Cell. Solar cells are often designed for particular temperature-humidity conditions. These cells will behave differently when presented with high-temperature and low precipitation conditions. Techniques for cooling down the cells are then used to guard against mechanical failure (such as cracking, delaminating, buckling, etc) and subsequent efficiency loss. The aim of this research is to develop a thermo-mechanical model (based on fracture mechanics) for polycrystalline-based thin-film multi-layered solar cells, and to numerically (using finite element software) solve the (shear) stress formation in the composite structure to analysis different failure modes. A series of calculations will be carried out to determine sensitivity to temperature and to provide manufacturing guidelines (relating to cell size) to manufacturers for high temperature and low precipitation environments. **Specific requirements:** Interest in solar PV technology. Background in stress analysis, fracture mechanics and composite structures. Heat transfer. Finite element modelling and analysis using ANSYS or Abaqus.	**X**			**Funding through the CRSES.**