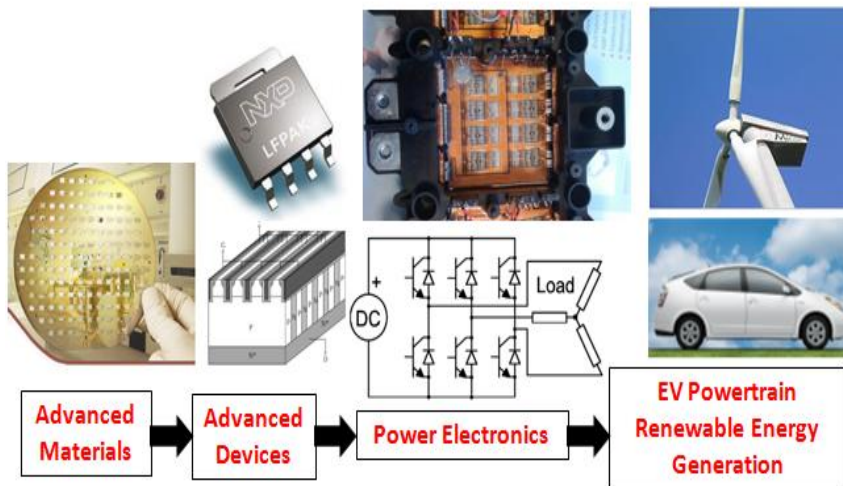


## Electrothermal Modelling of Power Semiconductor Devices for Renewable Energy Conversion

With the increased penetration of renewable energy into the electrical grid, power semiconductor device switches are becoming an indispensable part of the power system. Power semiconductor devices like insulated gate bipolar transistors (IGBTs) and metal oxide on semiconductor field effect transistors (MOSFETs) are increasingly being used to convert electrical power generated from renewable sources like wind turbines and solar cells. This is more so the case for high-voltage DC (HVDC) transmission of wind generated electrical power from off-shore wind turbines to the on-shore electrical grid. These power conversion devices are invariably fabricated out of silicon; however, recent advances have been made in new wide bandgap semiconductors like silicon carbide and gallium nitride. Reliability is critical, hence, predictive electrothermal reliability modelling has become critical especially in the light of advanced semiconductor material systems. The goal of this project is to develop advanced reliability predictive electrothermal models for high voltage power converters implemented in advanced material systems like silicon carbide and gallium nitride.



The objective of this project is to develop models that can accurately predict the lifetime of the semiconductor devices that make up the power converter. By coupling electrical, thermal and mechanical equations into predictive models, the number of cycles to failure can be evaluated. This information can be fed into

the design process where the semiconductor devices can be optimized for higher efficiency. Existing electrothermal modelling packages either use finite element or finite difference models to solve semiconductor equations with high precision. In these packages, the carrier flow equations are coupled with heat flow equations for a fully coupled electrothermal solution. However, this was initially developed for microelectronic applications with very short electrical and thermal time constants and small physical dimensions. They have been adapted for power electronic applications with long electrical and thermal time constants using various techniques; however, they have not kept up to speed with advances in power electronics. Other modelling packages use compact electrical and thermal models that treat devices like lumped elements. This, however, does not capture the complexity of critical failure modes like thermal runaway in high temperature power electronics. The hypothesis that will be explored in this project is a multi-scale modelling approach that uses finite element modelling techniques at the micro-scale and compact modelling at the macro-scale. The project will involve the use of advanced computational techniques to solve real power flow problems in converters. There is a very high probability that the project will lead to a PhD project.