ND*nano* Undergraduate Research Fellowship (NURF)
2014 Project Summary

1. Student name: Barry Reid

2. Faculty mentor name: Prof. Prashant Kamat

3. Project title: Material characterisation of hybrid organic/inorganic perovskites for solar cell applications.

4. Briefly describe any new skills you acquired during your summer research:
Learned how to use thermogravimetric analysis, differential scanning calorimetry and X-Ray diffraction instrumentation. This allowed characterisation of the crystal structure and thermal properties of the synthesised perovskite materials
Gained experience working in a glove-box environment.
Learned how to spin coat materials on to glass substrates.
Weekly group meetings and "chalk talk" classes provided opportunity to learn about the research being undertaken by the lab members.
The project also enabled me to practice my poster and oral presentation skills.

5. Briefly share a practical application/end use of your research:
Perovskites have the potential to be utilised in low-cost, efficient solar cells. Characterisation of the properties of the perovskite materials will allow for greater understanding and potential to increase the efficiency of the solar cells.

Project summary:

Perovskites are the general name given to compounds with a formula of AMX_3 with the atoms combining to form an octahedral network. Recently there has been growing interest in inorganic/organic hybrid perovskites consisting of an organic cation in the A position, divalent metal cation (M) and a halogen (X) to form three dimensional structures which have been identified as potentially useful due to their conductivity and photoactivity. These hybrid perovskites combine the attributes of the organic and inorganic components and have been identified for use as light harvesters in solar cells, with power conversion efficiencies now approaching 20%. In this project, the crystallographic and thermal properties of lead halide perovskites were investigated with the aim of determining the effect of different preparation methods on the properties of the final perovskite material.

The perovskite materials were synthesised by mixing different molar ratios of the pre-cursor materials methylammonium iodide (MAI) and lead iodide (PbI_2) in solid form (for mechanical synthesis) or in solution (for spin-coating). The mechanical synthesis method involved mixing the powder pre-cursor materials using a mortar and pestle, this resulted in the formation of a black powder perovskite. The solution synthesis required dissolution of pre-cursors in dimethylformamide (DMF) solvent, dropping the solution on to a glass slide and spin coating to form the perovskite. Following spin coating, the slides are heated to allow annealing of the synthesised perovskite films.

X-Ray diffraction (XRD) was utilised to determine the effect of annealing time on the final crystallographic structure of the perovskite. The results showed that preparation of a 1:1 pre-cursor (MAI:PbI_2) molar ratio will result in a fully formed perovskite film before annealing takes place whereas a 3:1 molar ratio required approximately 60 minutes of annealing at 150°C to allow the perovskite structure to form. The longer formation time allows for a more uniform perovskite structure.

Thermogravimetric analysis (TGA) and differential scanning calorimetry (DSC) were used to characterise the thermal properties of the powder perovskites. The characterisation method involved increasing of temperature and measuring the mass and heat flow in the cell. The aim of this characterisation was to determine whether the materials were suitable for melt-processing which could potentially produce more uniform perovskite films. The TGA/DSC results showed that increasing the molar ratio of MAI to PbI_2 resulted in increased mass loss (likely due to the excess MAI). There was no evidence of melting prior to decomposition.

Publications (papers/posters/presentations):

Poster and oral presentations were produced during this project.