Cian Lomax - Rokos Award Internship Report

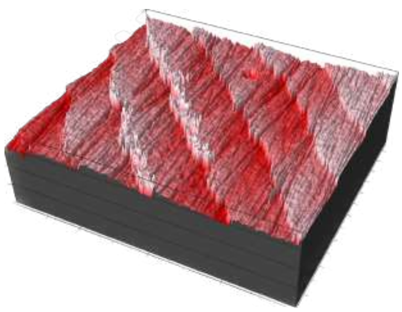
Over the summer vacation I spent 8 weeks working in the Surface Engineering Lab at the Manchester Fuel Cell Innovation Centre. I had a fantastic time, gaining experience of what a life in academia is like, as well as the skills required to carry out experiments and analysis.

The projects I was fortunate enough to be introduced into used a method of PVD (physical vapour deposition) called magnetron sputtering. This involves using small amounts of a positively charged gas to hit a negatively charged target plate - this being made of a chosen metal or ceramic. This physical contact results in a momentum exchange, causing particles of the target to be 'sputtered' into the chamber. Magnetrons channel these particles towards the substrate and depending on time, temperature and pressure (factors of mean free path) we can manage the surface topography of the coating as well as thickness.

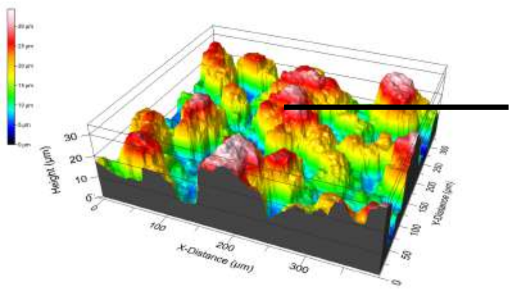
Techniques such as this are used wide-scale in industry, some examples being: coating drill bits with titanium aluminium nitride, which can increase durability by over 5x; zinc sulfide coatings are used for holograms on security devices such as cash and passports; tin, silicone and titanium oxides are used in windows for antiglare and U.V protection; and many more applications to increase lifetime of machinery by using chemically and physically resistant coatings.

The project I worked on involved the deposition of chromium yttrium nitride (CrYN) developed for use in high temperature and high pressure environments. The work I took part in involved applying coatings with the use of transition metal dopants in differing amounts, which was controlled by the amount of power used to create the negative charge on the target plates. Then the coatings were subjected to corrosion in air at 800 degrees Celsius for various amounts of time, followed by subsequent characterisation of the coatings using a white light profilometer. An example of the physical changes can be seen below:

This is CrYN as deposited, wave like structures can be seen from the unrolling of the steel sheets this layer is deposited on. The run had a very nice, dense growth necessary for protective layers.



CrYN with 150W Vanadium as deposited, height about 3 microns



CrYN with 150W Vanadium after 100h annealing, height about 30 microns

Tall growth of vanadium (n) oxide can be seen here, and has adhered to the surface remarkably well.

I was also given the opportunity to use a analytical technique called XPS (X-ray photoelectron spectroscopy) which uses x-rays to scatter electrons from atoms in a crystal, and by their energetic states we can determine properties such as charge and the environment these atoms are in. In this case it was used to determine the oxidation states of vanadium present in a solid oxide hydrogen fuel cell membrane, which had been deposited using magnetron sputtering and even found consequences of the quantum mechanics taught in my course present in the fine structure of the spectra. Hydrogen being such a viable option for the future of energy storage, this y of research is undoubtably important for the future and sustainability of humans. Following this, the project leader has recently worked on approving a £300m green hydrogen production facility in the North West which is another big step forward in sustainability.

Overall, I had a great time during my summer internship. I was exposed many aspects of the industry and research, insight which I could not have learnt in a textbook - too much to include here. I would like to give a big thanks to Dr Justyna Kulczyk-Malecka and everyone in the Surface Engineering Lab at Manchester Metropolitan University for welcoming me into their labs, and the Rokos Award grant which made this experience financially possible.