E&I Research Studentship project proposal 2019

Project title: Enhanced biocompatibility of medical grade titanium alloy surfaces

Supervisory team:
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Project Highlights:

- Thermal oxidation of titanium alloys yields anatase and rutile surface coatings.
- Covalent functionalisation depends on chemical moieties presented at the surface.
- Peptide coatings will improve biocompatibility and *in vivo* attachment to native tissue.

Project Description:

The global market value for prosthetics was estimated at $1.6 billion in 2015, with an estimated growth of 5% per year until 2026. Areas of activity include cochlear implants, artificial organs, and retinal implants. Titanium alloys are widely used for orthopaedic prosthetics. They exhibit strong potential for use in the above-mentioned areas.

Recently performed studies on titanium alloy TiAlV have revealed a complex surface heterogeneity which evolves as a function of thermal oxidation (TO) conditions. The titanium oxides anatase and rutile can develop on the surface, as well as oxides of vanadium and aluminium. The newly created surfaces displayed pH responsive behaviour, and promoted the electrostatic attachment of amphiphilic peptide coatings from aqueous solutions of pH 5-7. The robustness of the coating was compromised by large changes in environmental pH.

This project will firstly explore the influence of TO conditions at temperatures in excess of 400 °C. The effect of treatment time and temperature will be explored in detail, to generate a systematic understanding of the relationship between (i) surface chemical composition, (ii) the increase in surface roughness, and (iii) pH response.

Secondly, the covalent attachment of peptide coatings will be investigated. Synthetic strategies will include (i) direct attachment of peptide-containing polymers, and (ii) the use of an intermediate bridging layer between alloy surface and peptide.

A variety of alloys will be investigated, such as TiAlV and TiAlNb, which are both employed for biomedical applications. The results of these studies will have direct impact for orthopaedics and dentistry, as well as in the field of regenerative medicine.

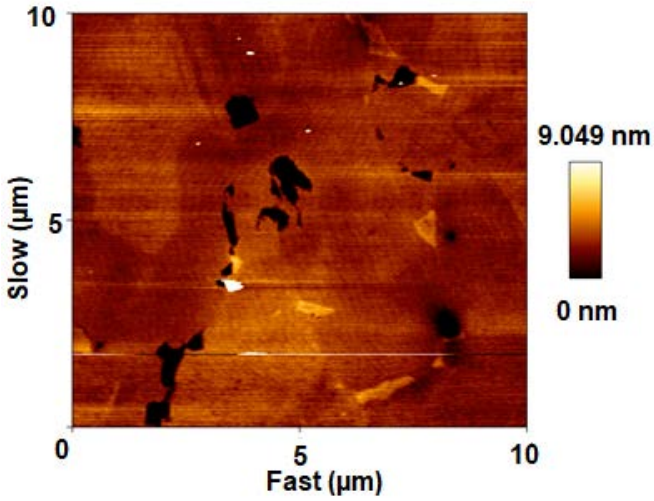

Figure 1. Topography of TiAlV surface with mirror-like finish.

Research Methods:

Mirror polished titanium alloys will be subjected to thermal oxidation; variables include duration, temperature, and vapour phase composition. The change in surface physicochemical properties will be assessed using state-of-the-art interrogation techniques including X-ray spectroscopies and sub-optical microscopies.

Functionalisation of the alloy surfaces will be attempted using suitable reaction conditions; the efficacy of the transformation will be quantified. The newly-created surfaces will present covalently bound peptide aptamers, suitable for enhancing biocompatibility and mammalian cell attachment, including osseointegration.

The results of these studies will be of use to researchers in a range of fields. Specific interest is expected in the fields of tissue engineering and regenerative medicine.

Indication of project timeline:
Year 1: Effect of oxidation conditions.
Year 2: Peptide attachment.
Year 3: *In vitro* response of surfaces. Complete thesis write-up.

References

Rodriguez et al.; *Colloid. Surface. B*, **2017**, *160*, 154-160.
Chen and Thouas; *Mater. Sci. Eng. R*, **2015**, *87*, 1-57.
MacDonald et al.; *Coll. Surf. B*, **2011**, *82*, 173-181.
Liu et al.; *Mater. Sci. Eng. R*, **2004**, *47*, 49-121.

Candidate Applications

- 1000 word cover letter outlining how they are equipped in their educational background and expertise to conduct the research project,
- a CV including contact details of two academic references
- An Open University application form, downloadable from: http://www.open.ac.uk/postgraduate/research-degrees/how-to-apply/mphil-and-phd-application-process (Note: This is an Advertised studentship and you do not need to submit a proposal).
- IELTs English Language test scores on application. An average of 6.5 and no less than 6 in anyone of the four components. Applicant should have these results when applying.

Applications should be sent to **STEM-EI-Research@open.ac.uk** by 28 February 2019