Gallium-doped Nano-Engineered Zirconium Dental Implants

Nantes University

Name of the hosting institution in France: Nantes University
Name of the host laboratory / research team: CNRS UMR 6230
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Internship offer

Topic of the internship (title): Gallium-doped Nano-Engineered Zirconium Dental Implants
Proposed dates of the internship: Start 05/09/2022, End 05/12/2022

Scientific and academic objectives of the internship:

Background and research challenges:
Biocompatible and chemical/corrosion resistant zirconium (Zr) has gained popularity as the material choice for dental implants.

Further, when compared to other metals like stainless steel, CoCr alloys and Ti, Zr has lower magnetic susceptibility, which means it does not interfere with standard diagnostic techniques like MRI (magnetic resonance imaging). Clinically, Zr-based implants in dentistry have shown promising outcomes with low ion release, lower cytotoxicity, favourable biocompatibility and aesthetics.

Notwithstanding such favourable outcomes, in compromised patient conditions (poor bone quality/quantity, aged and diabetic patients), early establishment and long-term maintenance of osseointegration (at the bone-implant interface) and soft-tissue integration (at the transmucosal region of dental implants) results may be less than ideal. Further, compromised conditions also increase the chances of bacterial infection, leading to complete implant failure, requiring thorough decontamination and revision surgery. This is a significant oral health and economic challenge, especially considering the ageing nature of populations worldwide.

To achieve enhanced bioactivity, various surface modifications of zirconia implants have been proposed. Surface topographical modifications for implants can be undertaken at the macro-, micro- and nano-scales. Among these, nano-engineering offers unique control over pore size and roughness, which dictates the interaction of cells with implant surfaces. It is also established that nano-scale engineering can be used to tailor cell responses, attributed to natural cell behaviour and growth on the nanostructured extracellular-mimicking surfaces. More recently, electrochemical anodization (EA) has emerged as a promising strategy to nano-engineer Zr-based implants. EA also offers cost-effective fabrication, ease of clinical translation and great control over the characteristics of the fabricated nanostructures. In this pioneering attempt, we aim to further enhance the bioactivity and therapeutic potential of nano-engineered Zr implants by doping it with Gallium (Ga) ions to enable soft-tissue integration and antibacterial functions. This collaborative project will benefit from the complementary expertise of the Australian partner to design nano-engineered Zr implants [1-2] and of the French partner to perform Ga-modification (and its characterization and bioactivity evaluation) [3].

The project aims to:
1. Fabricate controlled zirconia (ZrO2) nanostructures on zirconium implants via electrochemical anodization
2. Perform modification of ZrO2 implants via chemical functionalization with Ga
3. Characterize the surface topography/chemistry of the modified implants and quantify release of Ga from implants
4. Evaluate the functions of gingival fibroblasts towards soft-tissue integration and oral biofilm towards antibacterial efficacy

Clinical relevance and project outcomes:
Aimed at achieving enhanced soft-tissue integration, our Ga-doped nano-engineered Zirconia implants can alleviate challenges associated with compromised healing conditions in dental implantology, representing a major health and economic burden worldwide. The project outcomes will be disseminated in high-impact publications and reputed national and international conferences, which will further strengthen collaboration between France and Australia. Currently, the teams at Australia and France are working together to optimize implant bioactivity and have published a review together [4].

References
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<th>Australian partner</th>
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<tr>
<td><strong>Name of the Australian partner institution</strong></td>
<td>The University of Queensland</td>
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<td><strong>Lab/department/team involved in the collaboration</strong></td>
<td>School of Dentistry</td>
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<tr>
<td><strong>Main contact in the Australian partner institution</strong></td>
<td>Sašo Ivanovski</td>
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<tr>
<td><strong>Function</strong></td>
<td>Professor</td>
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<tr>
<td><strong>Email</strong></td>
<td>s.ivanovski @uq.edu.au</td>
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<td><strong>Outside of this ongoing collaboration, will students from other Australian universities be considered by the hosting institution in France?</strong></td>
<td>No</td>
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<th>Expected profile of applicant</th>
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<tr>
<td><strong>Level of study</strong></td>
<td>Bachelors and Masters in Nanotechnology or Materials Science</td>
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<td><strong>Discipline</strong></td>
<td>Nanotechnology, Biomedical Engineering</td>
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<td><strong>Prerequisite knowledge, qualities and skills</strong></td>
<td>Surface modification of implants, materials science, nano-engineering, surface characterisation</td>
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<td><strong>Other specific eligibility criteria</strong></td>
<td>Students studying in Australia who are Australian citizens/permanent residents or international students doing PhD</td>
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Je soussigné(e) [Prénom / Nom / Fonction] atteste par la présente que [nom de l’université XXX / de l’Ecole XXX / du laboratoire XXX, du partenaire industriel XXX] s’engage, en cas de sélection d’un candidat pour le stage [sujet du stage proposé] proposé dans le cadre de l’initiative Stages en France du programme d’aide à la mobilité Nicolas Baudin :

- à assurer la mise place de la convention (convention de stage ou convention d’accueil d’un chercheur doctorant), et le suivi administratif (circuit de signature, validation par les autorités préfectorales) et ;
- à couvrir, le cas échéant, le financement de la gratification de stage obligatoire selon le montant minium en vigueur au moment de la tenue du stage en France.

Fait à [Ville]

Le samedi 27 mars 2021

Signature, cachet