PhD position – Design of novel Ti-based superelastic and biocompatible alloy coatings by sputter-deposition

A 3-year PhD position (expected starting date: 2019, October 1st) is open at the “Institut des Sciences Chimiques de Rennes” (ISCR-CM) within the frame of an ANR-funded project (Super-Rev). The PhD research will be co-directed by two of the project partners: P’ institute at the University of Poitiers and ISCR-CM at INSA Rennes. The candidate will conduct its doctoral research in both partner institutes.

Research topic
Superelastic alloys are highly regarded for their unique ability to recover large deformations through reversible stress-induced phase transformations. Due to its unique superelastic performance, Nitinol (NiTi) is one of the most useful alloys suitable for a wide range of biomedical applications (guidewires for catheters, stents, orthopaedic fixation tools, orthodontic wires, chirurgical devices,…). Nevertheless, concerns exist with Nitinol for biomedical uses because of the high nickel content and the high prevalence of nickel allergy in the general population. The Super-Rev project aims at developing novel Ni-free Ti-based superelastic coatings which will fulfill specific and practical requirements for their applicability on biomedical implantable devices in order to circumvent the allergenic and possible toxic effects of Ni ions released from the Nitinol implant into the surrounding body fluids and tissues. While considerable attention has been paid to the superelasticity of new Ni-free β-metastable Ti alloys in their bulk form over the last fifteen years, much less work exists on the occurrence of a superelastic response of these alloys in their coating form.

Novel Ti-based quaternary coatings incorporating β-stabilizing and fully biocompatible elements (Nb, Zr, Mo, Hf, Sn) will be synthesized by magnetron sputtering on different substrates. The work aims at investigating a wide range of alloy compositions and deposition conditions (including Hipims) to provide new insight in the relationships between the alloy chemistry, the phase stability, the microstructure and the mechanical properties of new metastable β-rich Ti-based films. The first stage of the PhD work will focus on the optimization at the chemical and microstructural levels of the newly designed films and will be mainly realized in the DPMM group at P’ institute during the 1st-year. The stress evolution during growth will be monitored using in situ and real-time diagnostics, and the microstructure characterized by XRD, SEM and TEM. These novel coatings must satisfy excellent biomechanical requirements, in particular their ability to manifest similar mechanical properties to those of Nitinol, i.e., excellent superelastic recovery and low elastic modulus, in order to establish a mechanical continuum with Nitinol base system. The elastic modulus and superelastic performance of the coatings will be evaluated by nanoindentation. The different deformation regimes will be investigated using different indenter tip geometry. The adhesive properties, wear and fatigue resistance of coated Nitinol substrates will be also evaluated. These tasks will be addressed in a second stage and will be mainly conducted in the ISCR-CM group at INSA Rennes during the 2nd and 3rd-year thesis. The recruited PhD will also interact with the BMBI group at UTC (Compiègne) in charge of the assessment of biocompatibility and biological tests.

Keywords: coatings; titanium alloys; sputter-deposition; structural and mechanical properties; in situ stress
Candidate profile
Highly motivated candidates (master degree or equivalent) with a background in materials science and/or physics are strongly encouraged to apply. Previous laboratory experience in PVD process, metallic alloys, microstructural or mechanical characterization or any other field that could benefit the project would be appreciated. The interested candidate should have good written and oral communication skills as well as ability for team work.

Net salary around 1555€ per month.

Application procedure
For additional information about the project and/or the recruitment process, please contact Amélie Fillon (amelie.fillon@insa-rennes.fr).

Application has to be submitted online via the UBL job portal (https://theses.u-bretagneloire.fr/3m). The application should include a CV, a cover letter, contact information for at least two references, and academic transcripts and certificates. The deadline for application is 1st June 2019.

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1 https://iscr.univ-rennes1.fr/cm/anr-super-rev/project
2 https://www.pprime.fr/?q=fr/dynamique-de-la-croissance-de-films-mince
3 https://iscr.univ-rennes1.fr/cm/research/article/research-lab