Research Topic for the ParisTech/CSC PhD Program

Field: 8. Materials Science; 7. Life and Health Science and Technology; 2. Chemistry

Subfield: Physical metallurgy; Biomaterials; Corrosion science

Title:High-performance bioresorbable alloys for cardiovascular implants

ParisTech School:Chimie-paristech, ENSCP, PSL university

Advisor(s) Name: Dr. Philippe VERMAUT; Dr. Fan SUN
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(Lab, website): *Equipe de Métallurgie Structurale*

Short description of possible research topics for a PhD:

Metallic stents are commonly used to promote revascularization and maintain patency of plaqued arteries. To mitigate chronic inflammation and late stage thrombosis associated with stainless steel and Co-Cr stents, a new generation of bioresorbable stents is currently being expected. The bioresorbable stents will corrode and be absorbed by the artery after completing their task as vascular scaffolding. However, the outcomes from current biodegradable materials (polymeric, Fe-based, Zn-based and Mg-based) are still far from clinical requirements due to their poor mechanical performances. New insights from metallurgical development on this special type of materials are planned to explore the potentials for an absorbable metallic stent with balanced mechanical and biodegradation characteristics for optimal clinical performance. The host lab has invented the strain-transformable (TRIP/TWIP) conceptual alloys by tailoring the chemistry-microstructure-property relationship in Ti alloys. Its extension to bioresorbable alloying systems will be the key point and of great challenge to this PhD project.During the thesis, experimental works based on our preliminary results are intended to develop and assess systematically new alloy systems forTRIP/TWIP effects and suitablecorrosion behaviors. The thesis will be an important part of the fundamental research of the lab to answer specific scientific questions fromproof-of-concept to mechanism. TRL 5-6 (Technology readiness levels) is expected at the end of the 36/48-month thesis. The work will be directed mainly by Dr. Fan SUN, permanent lecturer-researcher of Chimie-paristech, for the experimental works (alloy design, elaboration, thermo-mechanical processing, metallurgical preparations, electronic microscopes SEM/TEM, in-situ mechanical testing, electrochemical testing), for supervision of scientific quality and for high-impact publications and communications.

Required background of the student:Master ofmetallurgy and metallic materials, experienced in biomaterial characterizations and electronic microscopies SEM/TEM, basic in electrochemistry, excellent English communication and writing, motivated in team-working and project-running.

A list of 5(max.) representative publications of the group: (Related to the research topic)

1. Sun, F; Hao, YL; Nowak, S; Gloriant, T; Laheurte, P; Prima, F*; *A thermo-mechanical treatment to improve the superelastic performances of biomedical Ti–26Nb and Ti–20Nb–6Zr (at.%) alloys*, **Journal of the mechanical behavior of biomedical materials**, 4,1864-1872, 2011.
2. Sun, F*; Zhang, JY; Marteleur, M; Gloriant, T; Vermaut, P; Laillé, D; Castany, P; Curfs, C; Jacques, PJ; Prima, F; *Investigation of early stage deformation mechanisms in a metastable β titanium alloy showing combined twinning-induced plasticity and transformation-induced plasticity effects*, **ActaMaterialia**, 61, 6406-6417, 2013.
3. Sun, F; Zhang, JY; Marteleur, M; Brozek, C; Rauch, EF; Veron, M; Vermaut, P; Jacques, PJ; Prima, F*; *A new titanium alloy with a combination of high strength, high strain hardening and improved ductility*, **ScriptaMaterialia**, 94, 17-20, 2015.
4. Sun, F;Vermaut, P;Choudhuri, D;Alam, T;Mantri, SA;Svec, P;Gloriant, T; Jacques, PJ; Banerjee, R*; Prima, F*;*Strengthening strategy for a ductile metastable β-titanium alloy using low-temperature aging*; **Materials Research Letters**, 5, 547-553, 2017.
5. Lilensten, L;Danard, Y;Brozek, C;Mantri; S, Castany; P, Gloriant; T, Vermaut; P, Sun, F*; Banerjee R, Prima F; *On the heterogeneous nature of deformation in a strain-transformable beta metastable Ti-V-Cr-Al alloy*; **ActaMaterialia**, 162, 268-276, 2019