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 Double degree program, 2018 – 2021
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Elaboration and characterization of new titanium alloys for biomedical applications

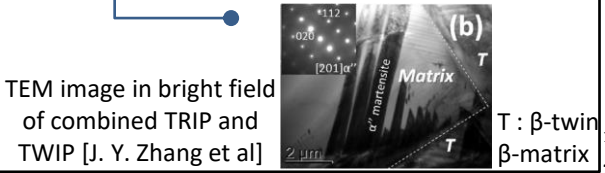
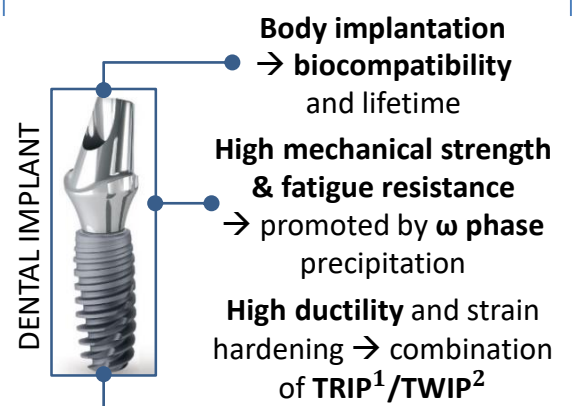
PhD Thesis

Context

Titanium alloys for implantology → **limits**

- **Toxicity** of alloying elements (Al, V)
- **Plateau** of mechanical properties
- **Sheer shielding** effect

Design of metastable β titanium alloys by « d-electron » method



Method and tools

Alloys design using « d-electron » method

- **New quaternary alloys** of Ti-Mo with Zr, Sn, Hf, Ta
- **New design approach** → Stacking Fault Energy, e/a ratio

Elaboration and characterization of the alloys

- Cold crucible melting, electric arc melting
- Microscopy and analysis (MO, SEM, EBSD, XRD, EDX, EPMA, TMA, TEM)

Microstructure optimization

- **Thermal treatments** (flash Low Temperature Aging)
- **Thermomechanical treatments** (GLEEBLE, MAXStrain)

Testing

- Tension, compression, fatigue (tension/compression, rotative bending), corrosion
- **In situ** experiments (XRD synchrotron, EBSD)

Biocompatibility and lifetime

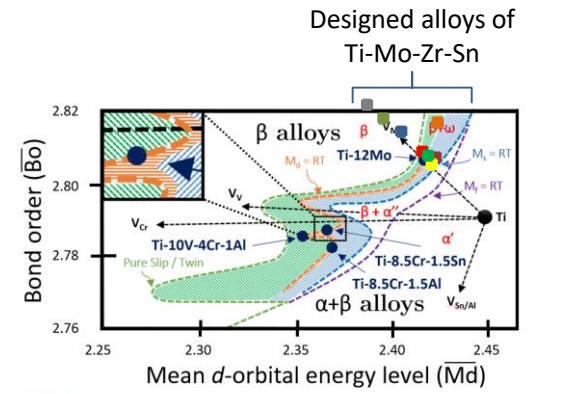
- **Cytotoxicity**
- Surface treatments by **Cold Spray**

¹ Transformation Induced Plasticity

² Twinning Induced Plasticity

Results

- **7 new Ti-Mo-Zr-Sn alloys** designed in and nearby TWIP/TRIP narrow domain
- **Melting** of the alloys (cold crucible levitation, electric arc furnace)
- **Initial microstructure** after thermomechanical treatments: full β grains of [35; 250] μm average size → **basis for optimization**



Legend:
 - Green: Main deformation mechanism : Twinning
 - Blue: Main deformation mechanism : SIM
 - Red: Combined deformation zone : TWIP+TRIP
 - Dashed line: Transition lines
 - Orange: $\beta/\alpha'/\alpha''$ As-quenched microstructure

Bond order Bo vs. Mean d orbital energy Md from « d-electron » method [C. Brozek et al.]