DEVELOPMENT OF NEW DAMAGE-TOLERANT TITANIUM ALLOYS

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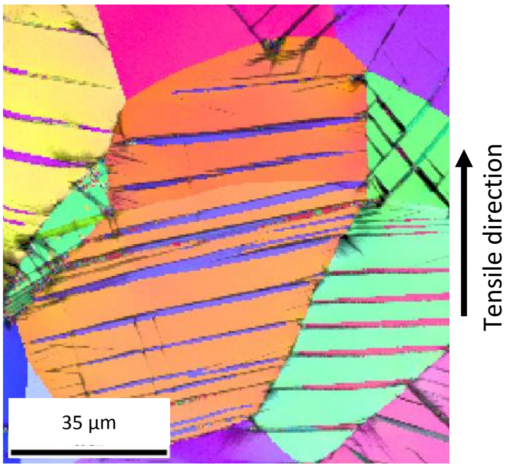

EBSD map of Ti-7Cr-1Al-1Fe (% wt.) during SEM in-situ tensile test

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- Hot rolling and heating treatments on raw material to obtain a controlled grain size
- Mechanical tests under various loading conditions
- Detailed analysis of fracture mechanisms by SEM on an microstructure strongly evolving during deformation
- New tests to confirm the assumptions about physical mechanisms, still unclear
- After identification of physical mechanisms, development of an advanced damage and ductile fracture model

Abstract:

TRIP/TWIP (transformation-induced plasticity and twinning-induced plasticity) titanium alloys are amongst most advanced and promising structural materials because of their exceptional stability against strain localization, due to the unusual combination of mechanical properties (high fracture elongation around 40 % and exceptional strain hardening ability, TS/YS > 2).

This enables opening potential applications of titanium alloys to new kinds of requirements, in order to address the high industrial demand in lightweight components (40 % lower density than austenitic stainless steels). Moreover, in contrast to the wide family of titanium alloys, these new alloys additionally possess a high damage resistance (Charpy impact toughness of 194 $J.cm^{-2}$ and fracture toughness (CT specimens) of 145 $MPa.m^{1/2}$). The first stages of the

alloy design have been successfully achieved and these alloys have been patented for aircraft applications in collaboration with TIMET and SAFRAN companies.

This PhD project deals with highly-hardenable and ductile β titanium alloys, which deformation mechanisms and microstructure evolution remain unclear. Indeed, the deformation occurs by dislocation slip, twinning and phase transformation, and a synergy between them seems to be existing.
Considering this, the resistance to crack propagation is investigated after optimizing the grain size by hot rolling and heat treatments on the raw material. Various mechanical tests, such as uniaxial tensile tests, fracture toughness tests and fatigue tests, are processed in order to study the crack propagation in this constantly-evolving complex microstructure and microstructural evolutions due to strain. The effect of loading conditions on microstructural evolutions during tests and on corresponding mechanical response is investigated by SEM.