**Role of nanoscale metastable phases in strengthening advanced Ti alloys**

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**Introduction**

Due to their outstanding property profile including very high strength-to-weight, toughness and excellent corrosion resistance, titanium (Ti) alloys are widely adopted for biomedical and aerospace applications. There is considerable focus on β-type Ti alloys with body-centred cubic structure stabilised though alloying. This is largely due to their greater capacity to undergo deformation, in comparison to α-type hexagonal structured Ti alloys with more limited slip systems, and their amenability to precipitation strengthening. Precipitation of α phase is typically employed to strengthen the β matrix, though other metastable phases including hexagonal ω may also contribute to strengthening or control formation of α. The mechanism through which these metastable precipitate phases participate in precipitation is controversial. This presentation will present recent advances in understanding the role of metastable ω phase in precipitation strengthening of β-type Ti alloys. It aims to elucidate the role of nanoscale ω phase in precipitation hardening of metastable β-titanium alloys.

**Methods**

A near-β Ti alloy, Ti-6Cr-5Mo-5V-4Al (wt.%) (Ti-6554), was solution treated under vacuum at 1103K and aged at 573K for 2, 4, 8, 12, 16, 24, 48 and 192 h. In some cases, additional ageing was performed at 773K for 10min. Transmission electron microscopy (TEM) samples were prepared by twin-jet electro-polishing (Tenupol-3, struers). TEM was conducted in a JEOL-3000F at 300kV and scanning transmission electron microscopy (STEM) with a probe-corrected JEOL-ARM200F with cold field emission gun. 3D atom probe tomography (APT) samples were electropolished and sharpened in a Zeiss Auriga FIB. APT experiments were conducted in a Cameca LEAP 4000X SI instrument at 50K with a laser energy of 80pJ and target evaporation rate of 5 ions per 1000 pulses.

**Results and Discussion**

Three phase transformation processes were detected; β🡪(1) β+embryonic ω 🡪 (2) β+isothermal ω 🡪 (3) β+isothermal ω+α [1]. Formation of ω exhibits two distinct stages, a displacive structural reconstruction in the embryonic stage (1) proceeded by diffusional chemical changes (2). Embryonic ω form within regions lean in β phase stabilising solute from spinodal decomposition of the β matrix, inheriting the local chemistry. A pseudo-equilibrium composition of isothermal ω, lean in all solutes, is reached (2). A diffusional and displacive process occurs in (3) with α forming after the coherent embryonic ω transform to isothermal ω associated with formation of semi-coherent isothermal ω/β interfaces. Interfacial ledges and oxygen enrichment at the semi-coherent interfaces provide potent nucleation sites for α. Formation of α involves rapid consumption of ω through displacive reconstruction at the α/ω interface and slower diffusion mediated reconstruction at α/β interfaces.

**Conclusion**

The coupling of advanced high-resolution TEM with 3D APT has provided novel insight into the structural and chemical processes during formation of nanoscale metastable ω phase and subsequent ω-controlled formation of the strengthening α phase in advanced β-type Ti alloys.

**References**

1. Li, T. et al. (2016) New insights into the phase transformations to isothermal ω and ω-assisted α in near β-Ti alloys, Acta Materialia, 106, 353-366.

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