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Age-hardening of Beta-III metastable Ti-alloy

H.P. Ng, C.J. Bettles and B.C. Muddle

Background:

This study focuses on the age-hardening mechanisms of Ti-11.5Mo-6Zr-4.5Sn alloy (also known as β-III), which possesses outstanding deep-hardening capability. Effects of the solute elements in β-III are investigated, particularly with respect to their influences on the formation and microstructures of omega (?) phases that serve as the precursors for hard α-phase nucleation.

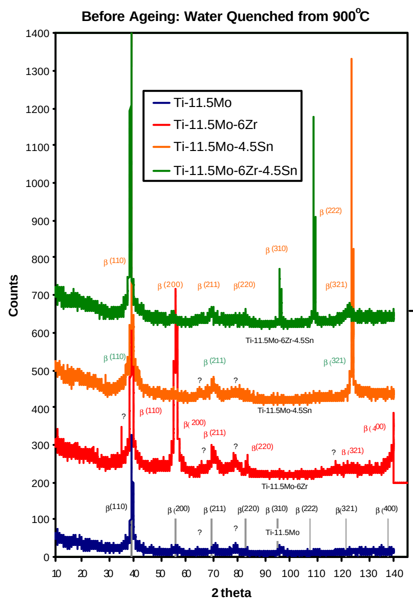
Materials & Processes:

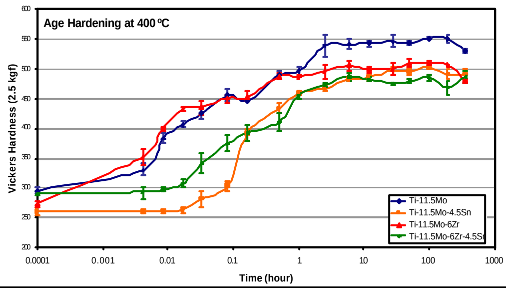
Ti-11.5Mo-6Zr-4.5Sn(β-III) (argon arc-melted)

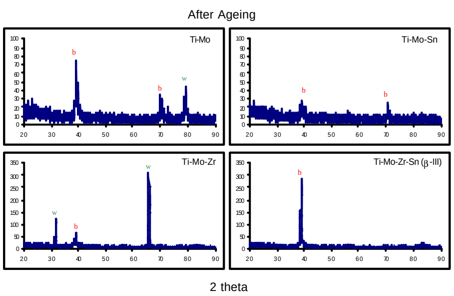
Ti-11.5Mo | Ti-11.5Mo-6Zr | Ti-11.5Mo-4.5Sn

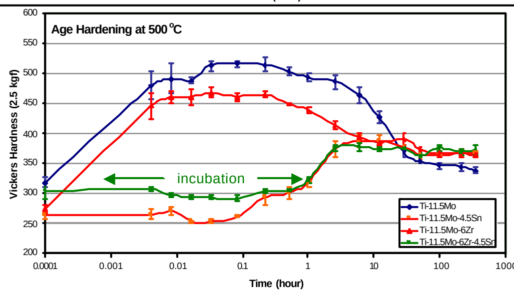
Solution-treated at 900°C 50hrs in quartz tube
\+ Water Quench
\+ Age Hardening at 400 & 500°C in Salt Bath

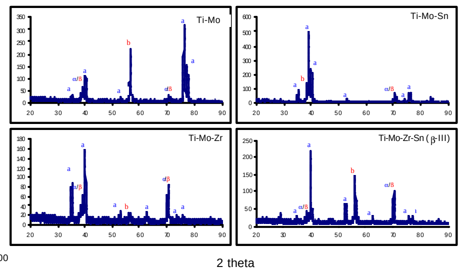
Age Hardening







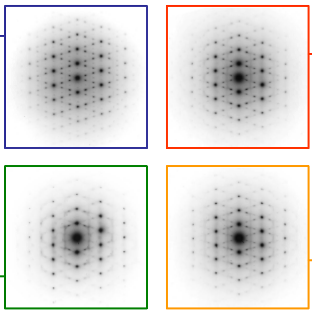




? -phase

Ti-Mo: *Strong* and *sharp* reflection spots from ?

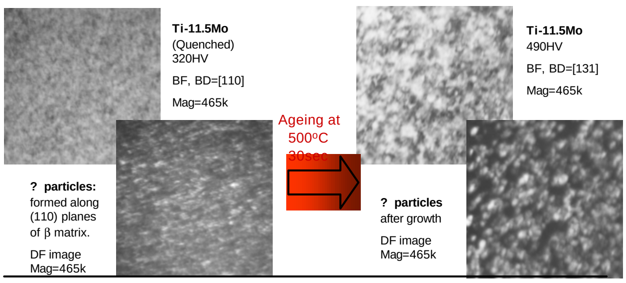
b-III: *Weak* and *diffuse* diffraction pattern of ?



Ti-Mo-Zr & Ti-Mo-Sn: Intermediate between Ti-Mo and β-III. Both spots and curvi-linear diffuse patterns.

Electron SAD patterns BD=[131]: Quenched ?-phases

Morphology of ?



Observations:

- fine dispersion of ? particles (size ≈ 20-30 Å) occurs in quenched alloys.
- β and ω phases prevail at 400°C, whereas the desired α-phase emerges at 500°C
- β-III exhibited the highest hardness among the different compositions at 500°C after an incubation-like period.
- formation of quenched (athermal) ω phase seems to be suppressed in β-III alloy through the addition of Zr and Sn.

Discussions and Conclusions:

- quenched ? precipitates are responsible for the high strength associated with the initial ageing stage. However, ? phase is generally regarded as undesirable for its embrittling effect on Ti-base alloys. This is implied by the incorporation of Zn and Sn into β-III, presumably as a means to suppress quenched ?.
- the intermediate rise in hardness of β-III (at 500°C) could be attributed to the formation of isothermal ?, which eventually gives rise to α phase. The potential role of isothermal ? in the deep-hardenabilty of β-III requires further investigation.

Reference:

E.W. Collings, *The Physical Metallurgy of Titanium Alloys*, American Society for Metals, Metals Park, Ohio, USA, 1984.