

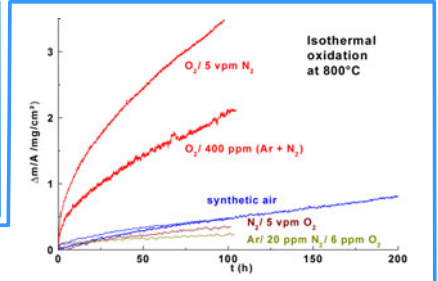
Oxidation Behaviour of Orthorhombic Alloys Based on Ti₂AlNb between 550°C and 800°C in Air, Oxygen and Nitrogen

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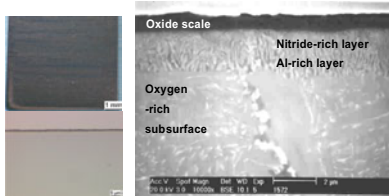
Orthorhombic Ti₂AlNb alloys

- ⇒ based on the phase Ti₂AlNb ($\alpha_2 + \beta + O$)
 - ⇒ attractive as lightweight structural materials for temperatures up to 700°C
 - ⇒ key potentials: good balance of thermomechanical processing capabilities and mechanical properties (strength, toughness, creep)
 - ⇒ key concern: environmental properties : oxidation resistance, fire resistance
 - ⇒ aim of this work is to provide evidences of the role of interstitial diffusion and nitride precipitation in the oxidation mechanism of the alloys at 800°C
- Ti-25Al section of the Ti-Al-Nb system [Gogia al. 1998]

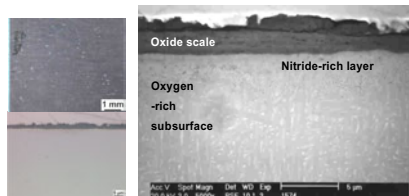
Ti23Al25Nb0.4Si at 800°C, 100 h Influence of O₂/N₂ ratio



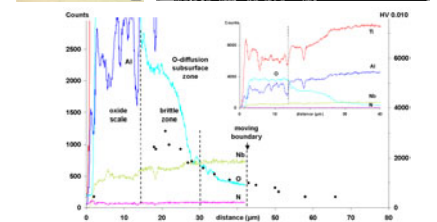
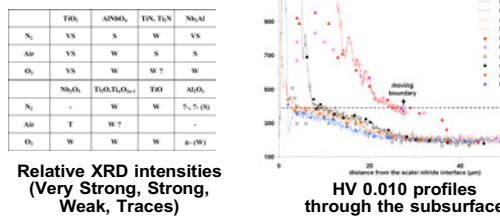
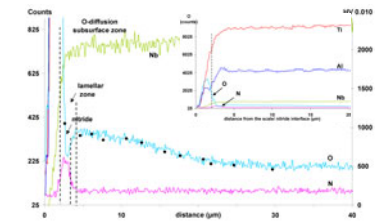
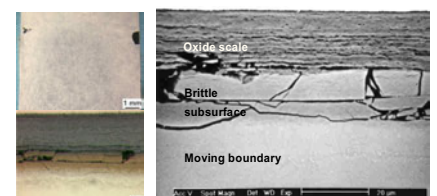
N₂ / 5 vpm O₂



80 % N₂ / 20 % O₂



O₂ / 5 vpm N₂



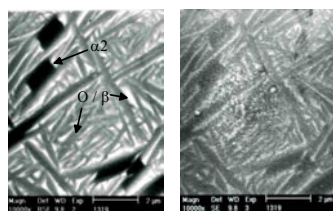
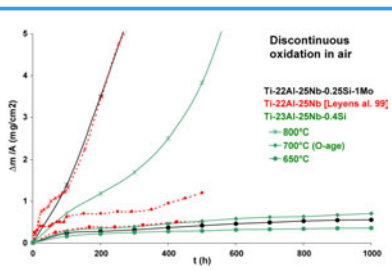
Relative XRD intensities (Very Strong, Strong, Weak, Traces)

Structure and role of the subsurface on the oxidation mechanism At low pO₂

- growth of TiO₂: outward transport via cations interstitials [Kofstad 88]
- dense precipitation of nitrides at the interface
- oxidation of nitrides is very slow in low pO₂
- this nitride-rich layer and the Al-enrichment underneath may act as barriers against diffusion of oxygen: both lowering amount of oxygen available at the interface and retarding oxygen diffusion in the subsurface
- oxygen diffusion is rate controlling, weight gain due to oxide formation

At high pO₂

- growth of TiO₂: inward mechanism as a p-type oxide via oxygen vacancies [Kofstad 88]
- laminated scale and defect structure of TiO₂: enhanced transport of interstitials to the interface, whereby oxygen plays the role of a precursor for further inward oxidation process in the subsurface
- high amount of oxygen available and high diffusion rate in the subsurface impede nitride precipitation
- oxygen diffusion and solution in the subsurface are mostly responsible for the weight gain, and oxide formation may become rate controlling. Non-protecting oxides, mainly TiO₂, AlNbO₄, Nb₂O₅
- cracking occurs in the saturated subsurface zone. Changes of the microstructure above the so-called



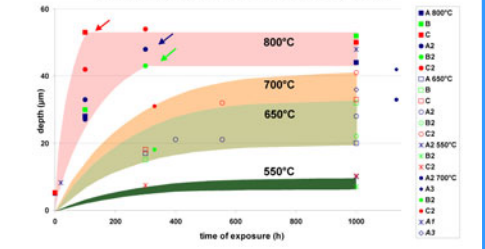
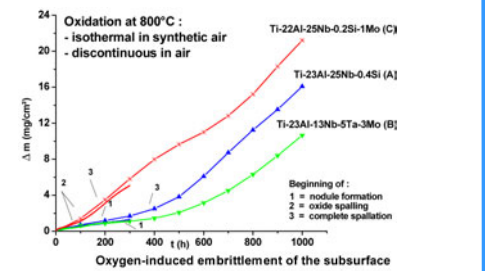
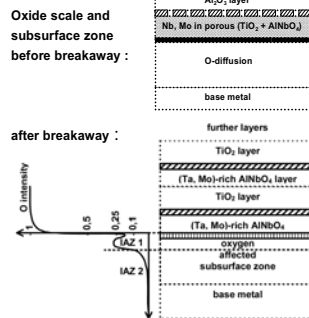
Oxidation of Ti-22Al-25Nb-0.25Si-1Mo (C) in air at 650°C, 1 h
 C: α2 Ti-27Al-14Nb-0.6Mo (~16Nb*), β Ti-23Al-29Nb-2.5Mo (~36Nb*)
 A: α2 Ti-28Al-14Nb, O Ti-25Al-29Nb, β Ti-21Al-35Nb (Nb* = Nb + 3Mo)

Scale structure and oxidation mechanism at 800°C:

- ⇒ lamellar microstructure in the oxygen-affected zone (IAZ): the β phase (low O solubility, high diffusivity) offers the most permeable path for penetration of oxygen, rapidly saturates and first oxidises to fast growing TiO₂ and (Ti,Nb)₂O₇. Nb₂Al precipitates and oxidises to non-protecting AlNbO₄
- ⇒ influence of the initial microstructure: as oxygen diffusion is rate controlling at this temperature, stabilisation of the α2 phase by oxygen (high O solubility, low diffusivity) enhances oxygen dissolution and embrittlement
- ⇒ the IAZ extends as long as the weight gain is parabolic. IAZ thickness remains constant after breakaway.
- Enrichment in Nb₂Al may favor external oxidation of Nb-oxides and scale cracking [Cerchiara 96]
- ⇒ engineering features: high sensitivity to interstitial-induced subsurface embrittlement; effect of alloying elements: deleterious Nb leads to formation of AlNbO₄ and Nb₂O₅, deleterious Mo [Meier 96], beneficial Ta lowers O diffusion

Dry air

Influence of T, t Influence of some alloying elements



Conclusion

- ⇒ at 800°C with low and intermediate pO₂: nitride precipitation slows the diffusion of oxygen, weight gain is due to oxide formation
- ⇒ at 800°C with high pO₂: weight gain is due to oxygen diffusion in the subsurface, oxide formation may become rate controlling
- ⇒ oxidation progress at 800°C in air is controlled by the diffusion of oxygen: decomposition and internal oxidation of β phase; slowing effect of the α phase; non-protecting oxides TiO₂ and AlNbO₄
- ⇒ onset of breakaway fits with constant thickness of the IAZ: external oxidation occurs with fast growing Nb-oxides
- ⇒ maximum application temperature in air < 650°C, due to a high O diffusion