cbecimat26
26° Congresso Brasileiro de Engenharia e Ciência dos Materiais
22 a 26 de novembro de 2026
Costão do Santinho
Florianópolis-SC

Influence of Cr/Nb Ratio and Ti Additions on the Early Stage Oxidation in Nb-Cr-Ti Alloys

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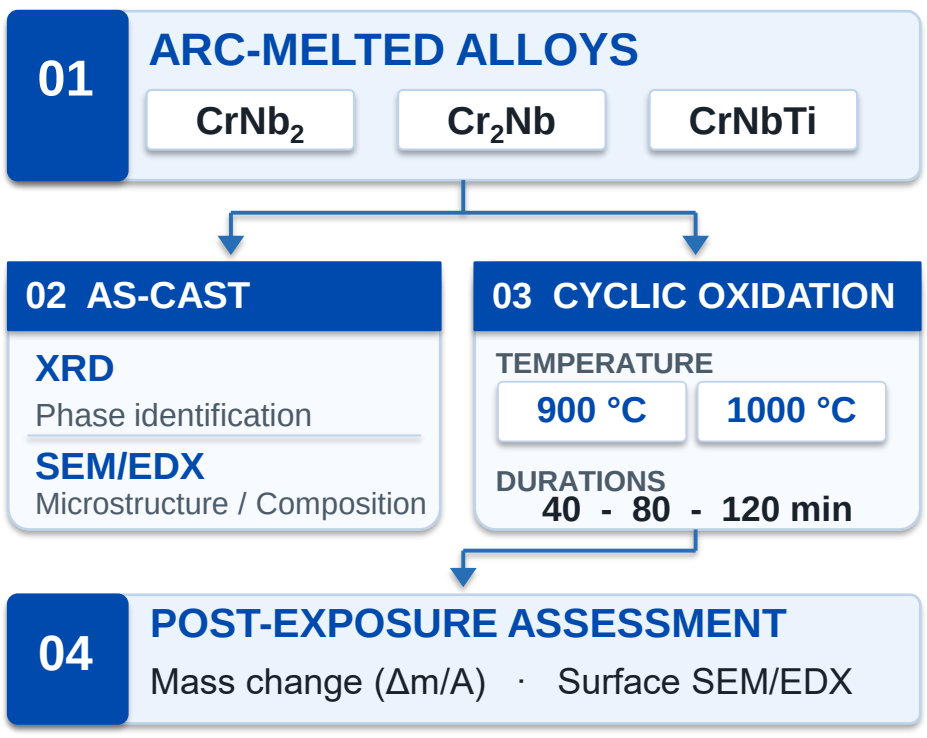
Introduction

Refractory Cr–Nb-based alloys are promising for high-temperature applications, but their oxidation resistance remains a major limitation. CrNb and CrNbTi form complex oxide scales at 1200 °C [1], while cyclic testing has revealed nonprotective oxidation despite the formation of Cr-rich oxides [2]. Recent studies also associate Cr–Nb complex oxides with improved oxidation resistance [3]. This work investigates the effects of Cr/Nb ratio and Ti-containing compositions on the early-stage cyclic oxidation of $CrNb_2$, Cr_2Nb, and CrNbTi at 900 and 1000 °C.

Objectives

Evaluate the influence of the Cr/Nb ratio and Ti addition on the early-stage cyclic oxidation behavior of $CrNb_2$, Cr_2Nb, and CrNbTi alloys at 900 and 1000 °C, correlating mass changes and surface oxide morphology with alloy composition and as-cast microstructure.

Methodology



Results and Discussion

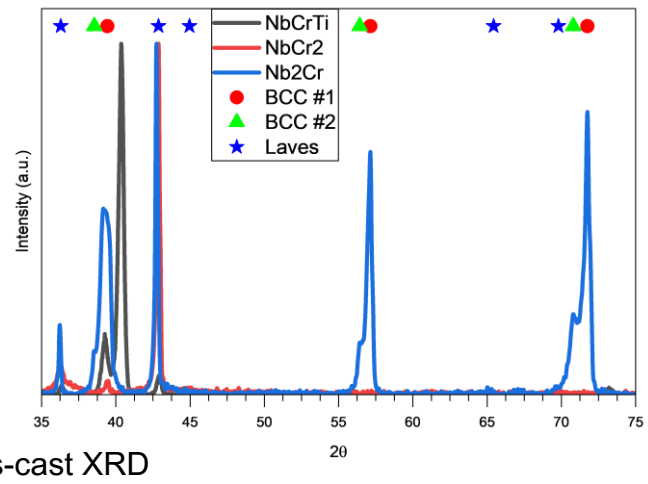


Figure 1. As-cast XRD

Laves phase → $CrNb_2$, BCC#1 → solid solution, BCC#2 → Nb-enriched (homogenization).

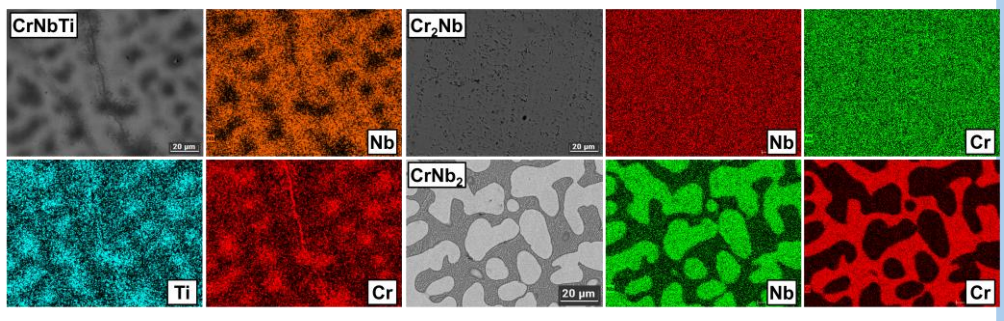


Figure 2. SEM(BSE)/EDX of as-cast samples.

Oxidation kinetics analysis shows better behavior of Cr_2Nb over the other two alloys

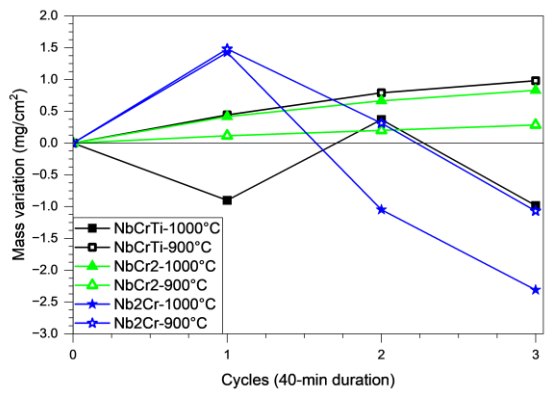


Figure 3. Mass variation data of samples exposed at 900 and 1000 °C

Post-exposure SEM reveals catastrophic behavior of $CrNb_2$, Cr oxide protection of Cr_2Nb and a convoluted scale on CrNbTi.

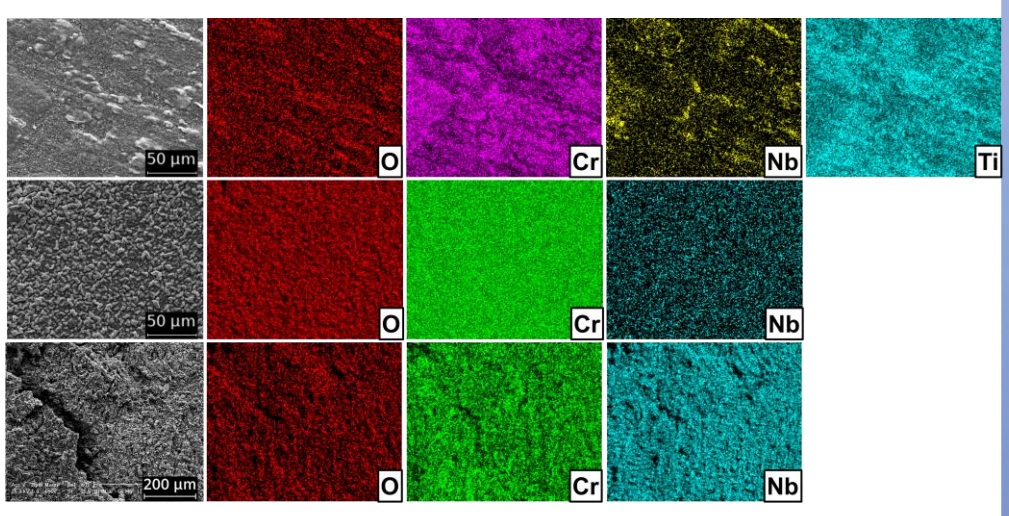


Figure 3. SEM (SE)/EDX of samples exposed for 120 min at 1000 °C.

Conclusions

Although the aim of this investigation was to find possible routes of developing alloys protected by a Cr-Nb rutile, it seems that Nb is severely detrimental to oxidation resistance, most possible due to the formation of voluminous pure Nb oxides, as indicated by the severe spallation in the Nb-rich alloy. The study indicates the best route for medium-to-high temperatures could still be chromia, but this still would limit the alloys to relatively low temperatures. Investigations will be undertaken on intermediate compositions and different test conditions.

References and Acknowledgment

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This study was financed by the São Paulo Research Foundation (FAPESP), Brazil, process number 2025/04108-8.