Advanced Solidification

Incentive Homework 3

Quar-ternary or higher eutectic system

Lopes, Éder SN, et al.
"Crystallographic features of the Al_3Nb, Nb_2Al and $Nb(Ni_{1-X}Al_X)_2$ phases in a directionally solidified ternary eutectic microstructure." Materials Characterization 147 (2019) 303-310.

- Objective
  - Apply electron microscopy and X-ray diffraction techniques to investigate chemical composition and crystallographic features of the Al_3Nb, Nb_2Al and $Nb(Ni_{1-x}Al_x)_2$ phases in a directionally solidified ternary eutectic microstructure.

- Experimental Procedure
  - Al-Nb-Ni system with eutectic composition
    - Arc melted using a water-cooled Cu hearth and a non-consumable W electrode.
    - Under an inert atmosphere of high purity Ar.
  - Homogenization
    - Inverting and re-melting them at least 5 times.
  - Directional solidification using a Bridgman furnace (high purity Al_2O_3 crucible)
    - Under an inert atmosphere.
    - Solidification rate of 10 mm/h.

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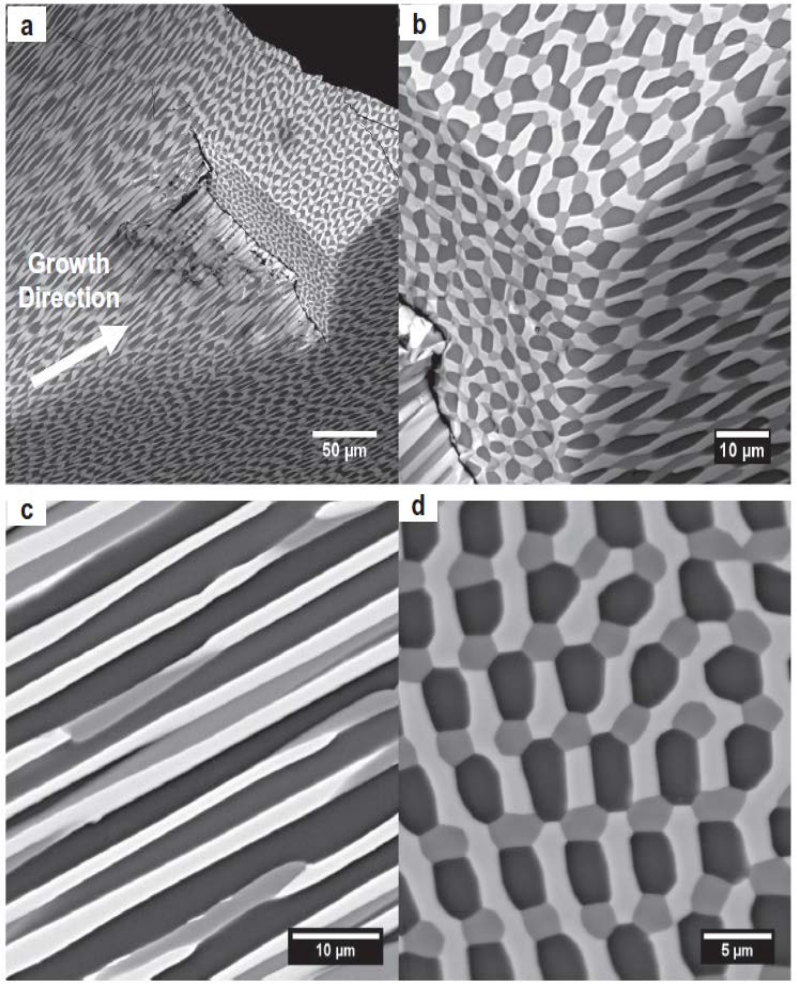
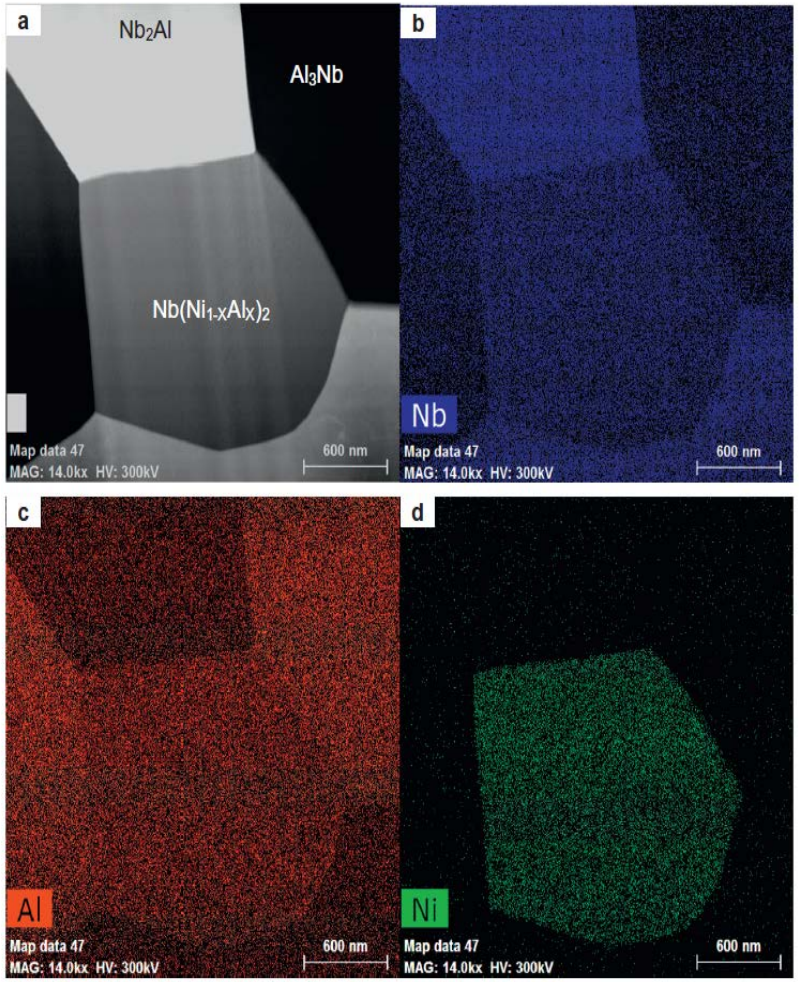
- Analysis
  - Conventional metallographic preparation procedures
  - Microstructure and chemical composition were examined using SEM
  - Interplanar spacings (d) of the diffraction maxima were calculated using TEM
  - Lattice parameters were determined using XRD

- Conclusion
  - A directionally solidified ternary eutectic in the Al-Nb-Ni system made up of Al_3Nb, Nb_2Al
  - $Nb(Ni_{1-x}Al_x)_2$ intermetallic phases was investigated using SEM, TEM and XRD.

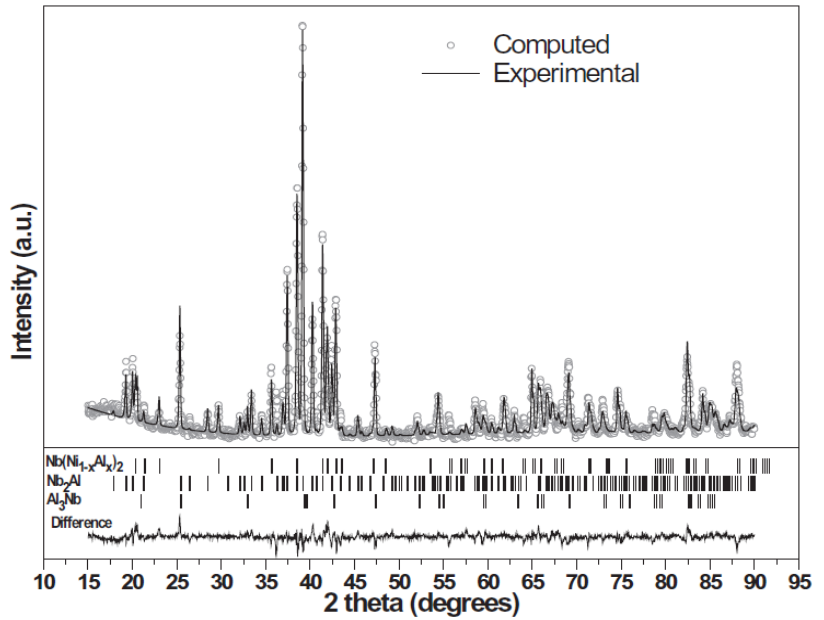
  - Eutectic growth resulted in a well-organized rod-like three-phase arrangement.
  - $Nb(Ni_{1-x}Al_x)2$ intermetallic phase possesses the MnZn2 type structure.
    - Composition 56.91 ± 0.43 at.% Al / 10.11 ± 0.12 at.% Ni / 32.98 ± 0.53 at.% Nb, (which corresponds to x=0.85).
    - Lattice parameters of the $Nb(Ni_{1-x}Al_x)_2$ (x=0.85) are a=5.031 Å and c=8.298 Å (c/a=1.649), which is close to the ideal hcp lattice ratio.



SEM backscattered electron images: (a) simultaneous longitudinal and transverse views; (b) magnification of (a); (c) longitudinal view, and (d) transverse view.



STEM-EDS images showing Nb, Al and Ni distribution in the three-phase microstructure.



The experimental, computed, and difference values of the X-ray diffraction pattern of the ternary eutectic sample after Rietveld refinement.

Result of TEM/SADP observations is omitted

Chemical composition of the three phases in the directionally solidified ternary eutectic determined by EDS

Phase	Al (at.%)	Nb (at.%)	Ni (at.%)
Al_3Nb	75.52 ± 0.31	24.02 ± 0.29	0.46 ± 0.06
Nb_2Al	42.70 ± 0.49	56.39 ± 0.83	0.90 ± 0.34
$Nb(Ni_{1-x}Al_x)_2$	56.91 ± 0.43	32.98 ± 0.53	10.11 ± 0.12