

MS15-P11 A crystallographic characterization of pseudo single crystal Ni-base superalloy - thermal expansion and lattice misfit

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Today composite pseudo-single crystals of nickel-base superalloys are widely used for turbine blades in gas turbines and jet engines. These critical components have to operate in the creep range, where they have to withstand mechanical loads at temperatures exceeding by far half of the melting point in K. The favorable mechanical properties of these superalloys are related to their characteristic microstructure [1] which consists of cuboid-like γ' -precipitates with ordered Ni₃Al-structure embedded in a fcc-type γ -matrix [2,3]. The evolution of this microstructure during alloy processing and high temperature deformation, however, depends on the alloy composition, the temperature and the thermo mechanical history of the material. In order to study the evolution of the microstructure at high temperatures under high mechanical loads, a superalloy of type ERBO/1 [4] was investigated. The distributions of γ/γ' lattice constants of as-cast, thermally treated and mechanically treated (creep parameters: 1320 K / 36 h / 160 MPa, $\epsilon \approx 1\%$) samples were measured using X-ray diffraction techniques. Moreover, atomic force microscopy, optical microscopy, electron microprobe analysis and scanning electron microscopy were applied to characterize the microstructure. Our results indicate that the lattice constant measurements cannot be directly interpreted merely on the basis of a lattice misfit between the two phases, because the dislocation density in the γ -channels clearly affects the results. Moreover, creep experiments with an uniaxial mechanical load lead not only to the well-known directional coarsening of the γ' -precipitates (rafting), but also to an anisotropic distribution of the dislocations in the γ -channels. An effort was made to determine the temperature dependence of elastic constants [5] as well as the thermal expansion coefficient of ERBO/1 using dilatometry. Anomalies were observed above about 900 K. These anomalies are probably related to the gradual dissolution of γ' -particles at higher temperatures.

References:

- [1] S. Kaciulis *et al.*, *Surf. Interface Anal.*, **2012**, 44, 982-985
- [2] R. C. Reed, *The Superalloys*, 2006.
- [3] T. M. Pollock, *et al.*, *Acta Metall. Mater.*, **1992**, 40, 1-30.
- [4] A. B. Parsa *et al.*, *Advanced Eng. Materials*, **2015**, 17, 216-230
- [5] K. Demtröder *et al.*, Influence of microstructure on macroscopic elastic properties and thermal expansion of nickel-base superalloys ERBO/1 and LEK94, accepted for publication in *Matwiss. & Werkstofftechn.*

Keywords: Superalloys, single-crystal X-ray diffraction, thermal expansion, microstructure

MS15-P12 Combining X-ray diffraction and pyroelectric measurements for phase transition investigations

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Near morphotropic phase boundaries differences in structures may be too subtle to be resolved via single crystal diffraction. In semi-crystalline polymers structural and thermodynamic parameters may be broadly distributed, thus limiting access to these parameters. Therefore, additional information from the symmetry constraints of pyroelectricity provides otherwise unavailable insight into the nature of these phase transitions.

As cases in point we present combined X-ray diffraction and pyroelectric studies on SrTiO₃ and P(VDF₇₀-TrFE₃₀). Studying the migration-induced field-stabilised polar phase (MFP-phase) of SrTiO₃ yields not only the pyroelectric coefficient but allows a space group prediction *P4mm* for the MFP-phase. Besides, the electric signature of the forming process corroborates the hypothesis of oxygen migration. The temperature-dependent pyroelectric characterisation of the polyvinylidene fluoride copolymer with trifluoroethylene P(VDF₇₀-TrFE₃₀) shows pyroelectricity also in the phase assumed paraelectric in literature. Combined with the field reversibility of the pyroelectric effect we postulate a phase transition from ferroelectric to ferroelectric. Implicitly, these data contradict the established orthorhombic to hexagonal cell change in the transition and help to construct an improved structure model.

Keywords: pyroelectricity, polymer, perovskite, phase transition, symmetry breaking, SrTiO₃, PVDF