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Evolution of the high temperature γ/γ′ lattice misfit of highly alloyed single crystalline Ni-base superalloys

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The lattice misfit between γ and γ' phase is a key parameter in Ni-base superalloys. Resulting internal coherency stresses govern the microstructure, its evolution and mechanical properties. Here, the lattice misfit evolution of highly alloyed Mo, Re- and Ru-containing single crystalline Ni-base superalloys up to 1100 °C is investigated by in-situ X-ray diffraction experiments. Due to their preferred partitioning to γ, the addition of Mo, Re and Ru leads to a stronger increase of the lattice parameter of γ than of γ' and thus to a more negative misfit. The overall content of these elements influences significantly the evolution of the misfit with temperature. Alloys with high contents show an atypical behavior, where the magnitude of the negative misfit gets smaller at high temperatures. Alloys with a medium content exhibit a rather constant misfit and alloys with a low content or without Re and Ru follow the typical trend of a more negative misfit with increasing temperature. The observed differences are ascribed to different thermal expansion coefficients and particularly to the changing chemical composition of γ due to the dissolution of γ' precipitates. Another factor affecting the γ/γ' lattice misfit is the formation of TCP phases in some of the alloys, as they consume the solid solution strengthening elements Mo, Re and Ru. This causes an even stronger reduction of the γ/γ' lattice misfit at high temperatures. Finally, qualitative guidelines for an optimum lattice misfit are presented by comparing the lattice misfit values with previously determined creep properties.

Keywords: Ni-base superalloys, lattice misfit, Rhenium, Ruthenium, X-ray diffraction

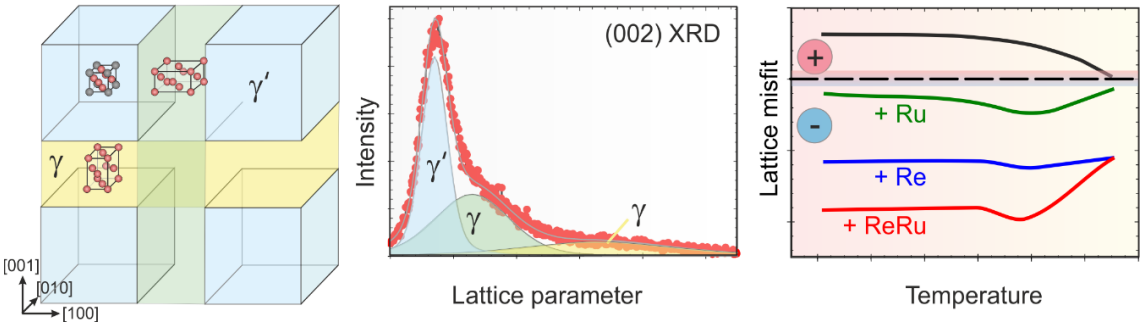

Fig.1: The γ/γ' lattice misfit leads to coherency stresses and a tetragonal distortion of the γ unit cell, which can be evaluated by X-ray diffraction. Depending on composition and formation of TCP phases the misfit changes with temperature and time.

References:

[1] S. Neumeier, F. Pyczak, M. Göken, The temperature dependent lattice misfit of rhenium and ruthenium containing nickel-base superalloys – Experiment and modelling, Materials and Design 198 (2021) 109362.