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Investigation of the microstructural evolution during hot deformation and cooling in VDM® Alloy 780 by in-situ high-energy X-ray diffraction

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Ni-based superalloys are essential for applications in demanding environments, such as jet engines or the heavily stressed rotating discs in the hot sections of modern gas turbines. Such environments typically challenge the material with a combination of high temperatures, high tensile loads, and oxidizing atmospheres. In this study, the polycrystalline Ni-based superalloy VDM 780® Alloy 780 was investigated consisting of γ -matrix, γ' -hardening phase, δ and η high-temperature phases. High-energy X-ray diffraction experiments were performed in-situ during hot compression with synchrotron radiation to mimic the forging process in this study. In the first part of the experiments, i.e. the hot forming, the formation, and development of the crystallographic texture were investigated. During plastic deformation, subgrain formation, rotation of the grains into preferred orientations, and dynamic recrystallization were observed. In the second part, directly after the hot forming at 1000 °C, the microstructural evolution at cooling rates of 10 °C/min, 100 °C/min, and 1000 °C/min were investigated in situ. Post dynamic recrystallization, grain growth, and precipitation of γ' can be observed, and their magnitude is strongly influenced by the cooling rate. Advanced microscopy techniques confirmed the diffraction results and showed that the recrystallized fraction is highest at the slowest cooling rate and vice versa.

Primary author: Dr FRITTON, Massimo (Technische Universität München)

Co-authors: Mr KIRCHMAYER, Andreas (FAU); Dr STARK, Andreas (Helmholtz-Zentrum hereon GmbH); Dr GEHRMANN, Bodo (VDM Metals International GmbH); Dr KÜMMEL, Frank (TUM/FRMII); Dr HAGHIGHAT, Masood Hafez (VDM Metals International GmbH); Dr GILLES, Ralph (Technische Universität München); Dr NEUMEIER, Steffen (Friedrich-Alexander-Universität (FAU) Erlangen-Nürnberg)

Presenter: Dr FRITTON, Massimo (Technische Universität München)

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