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Development of novel Co-base superalloys for turbine applications by advanced characterization techniques

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Superalloys are key materials for energy conversion in jet engines, rockets or power plants. For more than 60 years, Ni-based superalloys are in use. Due to their unique two-phase microstructure, they retain their strength up to 70% of their melting temperature. In 2006, a new, ternary Co3(Al,W) compound was discovered that enabled the development of Co-based superalloys with similar microstructures than the conventional Ni-based superalloys.
In the following years, we developed compositionally complex Co-based superalloys with significantly improved properties starting from the simple ternary Co-Al-W alloys. In this talk, it will be shown how various advanced characterization techniques, such as in-situ high temperature neutron scattering with neutron diffraction at the beamline SPODI and Small-Angle Neutron Scattering at SANS-1 Together with Transmission Electron Microscopy and Atom Probe Tomography helped to understand the observed microstructures and the resulting mechanical properties. It was found that the matrix is under tension and the precipitates under compression due to a positive lattice misfit between both phases of up to 0.8%, which is larger compared to conventional Ni-based superalloys. Additionally, the volume fraction of the intermetallic precipitate phase is exceptionally high (up to 70%). These findings were essential to develop polycrystalline Co-based wrought alloys that show enhanced creep properties compared to conventional Ni-based wrought alloys.

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