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Neutron diffraction supporting mechanical metallurgy

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Reducing weight or increase operating temperature are possible ways to reduce energy consumption. For metals this usually means developing stronger microstructures so that less material has to be used or creep resistant alloys that can operate longer and at a higher temperature. The playground to optimize the mechanical properties is vast and that is why even after a long-standing mature research history in metallurgy, new microstructures with advanced properties are continuously emerging. The structure-mechanics relation in metals is truly multiscale: the atomic to the macro scale are connected by a series of reactions that determine the resulting microstructural evolution under load. The ability to use physics-based computational models at all lengthscales for the understanding and the prediction of the mechanical behavior has revolutionized engineering and contributed to new innovations.
Neutron diffraction has contributed to a great extend to the science and engineering of metals. A neutron powder diffraction pattern is a static footprint of a microstructure providing information on all constituent phases. When performed insitu this footprint can be followed during deformation and give information on phase transformation mechanisms, degradation phenomena in fatigue and creep processes, or the dynamics of the development of microstresses in a Bauschinger tests. In recent years in-situ neutron diffraction has proven to be a very useful tool to validate and further develop computational models.
This will be illustrated using examples of neutron diffraction studies performed at the time-of-flight strain scanner POLDI at SINQ which is equipped with an insitu tensile rig and soon also a biaxial tension/torsion deformation rig. The examples include research on superalloys, MAX phases, Al alloys and high-temperature bainitic steels.

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