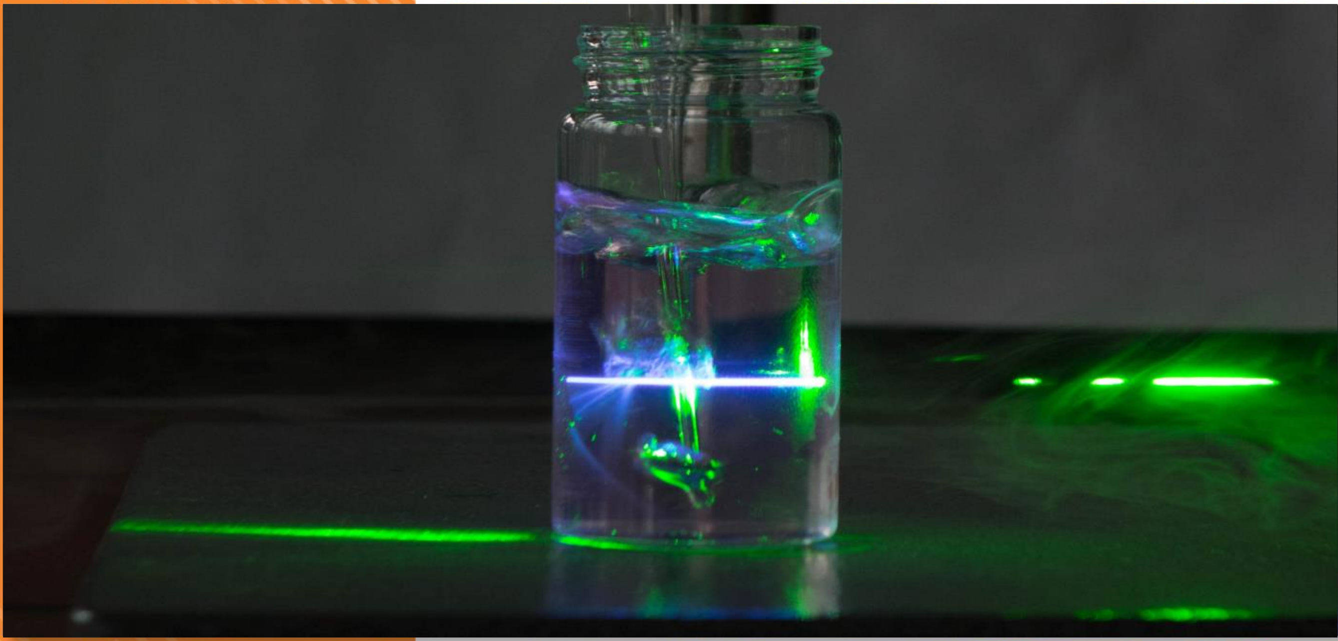

Quantitative analysis of crystal structure, microstructure and texture using electron backscatter diffraction (EBSD) and electron channeling contrast imaging (ECCI)

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Structural and functional properties of crystalline materials are significantly determined by the presence of extended lattice defects including one-dimensional line defects (dislocations), two-dimensional planar defects (stacking faults, anti-phase boundaries, grain and phase boundaries) and three-dimensional volume defects (elastic strain fields, precipitations). Extended defects are traditionally observed and quantitatively characterized by transmission electron microscopy (TEM) techniques. While TEM allows spatial resolution down to subatomic scales and offers established techniques for crystallographic and chemical analysis of defects, it often lacks statistical relevance, has challenging sample preparation and in-situ observations are generally difficult to do. Here is where scanning electron microscopy (SEM)-based diffraction techniques come into play. The long-established electron backscatter diffraction (EBSD) technique allows comprehensive characterization of grain and phase structure, including the crystallographic nature of interfaces. Using 3D-EBSD techniques, even grain and phase boundary planes can be determined in statistically relevant numbers. Using EBSD pattern cross correlation it is also possible to measure elastic strain fields and dislocation-based crystal rotations with a resolution down to about 50.

Besides EBSD, the electron channelling contrast (ECC) technique now allows additionally the direct observation of dislocations, stacking faults and other features, with a contrast mechanism that resembles that of TEM, but with the advantage that it works on bulk and potentially very large samples. This also facilitates to perform in-situ experiments, e.g. deformation or annealing processes. The combination of both techniques, ECC imaging and EBSD mapping allows materials observations that enable bridging between microstructure and macroscopic properties.

In the presentation I will briefly introduce the ECC and EBSD techniques and point out a couple of particular features (cross correlation EBSD, 3D EBSD, basics and practice of ECC imaging) and then present some examples where the combination of both lead to interesting new materials understanding. These examples will concern hydrogen embrittlement of steels, fatigue deformation of high Mn-steels, dislocation stimulated precipitation in high-strength Al alloys and dislocation evolution in 3D printed Ti-based implant materials during fatigue loading.

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Campus Freudenberg

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