# Abstract for the General Public

In today's world, there is a continuous improvement of known engineering materials and the introduction of new materials. In today's materials, the micro- and increasingly often also the nano-structure has probably the greatest impact on the final properties of products. In the case of metallic materials such as steels and alloys, micro and nano-structure refers to the size and distribution of grains, i.e. elements of solids with the same crystal structure, as well as phases, i.e. elements of solids that are distinguished by the local location of atoms in their structure.

In order to harness the micro and nano-structure, it was necessary to invent imaging techniques and study the structure of materials. Historically, the most popular were light microscopy techniques, which allowed scientists and engineers to assess the size of grains of materials. Subsequently, with the discovery of X-ray radiation, X-ray diffraction techniques were popularized, which allowed, among others, to describe the position of atoms in phases, to determine the volume fraction of individual phases, to determine the grain size of individual phases or to determine the stresses present in the material, which are often the result of their treatment history. Often, however, even nowadays, these techniques do not allow for imaging the above-mentioned properties on a micro and nanometric scale. In order to describe the micro and nano-structure of materials, scanning and transmission electron microscopy techniques are most often used.

The technique of Electron Backscatter Diffraction (EBSD) in the scanning electron microscope allows to collect information on the size of microstructure elements by scanning with an electron beam point by point and collecting diffraction patterns assigned to these points. Diffraction patterns now allow to assess the crystallographic orientation, the crystal structure of a phase (with some limitations) and to determine the relative stresses occurring in single grain areas. Nevertheless, diffraction patterns also provide information on absolute stresses, lattice parameters - distances and types of atoms present in a given phase, or defects of crystal structures such as dislocations.

The aim of the project is to push the limits of possibilities for the EBSD technique towards those offered by X-ray diffraction techniques maintaining the assignment of measured properties to individual micro and nanostructure elements of the matter. New possibilities, i.e. measurements of the crystal axial ratios, absolute stresses and improved possibility of phase analysis including quasicrystals analysis are detailed objectives of the project.

Diffraction simulation techniques and multi-parameter matching of the simulation to the experiment will be used. Additionally, a special eucentric sample table will be adopted inside the microscope to collect diffraction patterns under controlled diffraction conditions with a known geometry of the electron beam, the sample, and the detector.

Obtaining the above mentioned objectives will allow for absolute stress measurements, analysis of single defects (dislocation), analysis of quasicrystalline orientation or local changes of crystal lattice parameters. This information on the local condition of the microstructure is of increasing engineering importance.

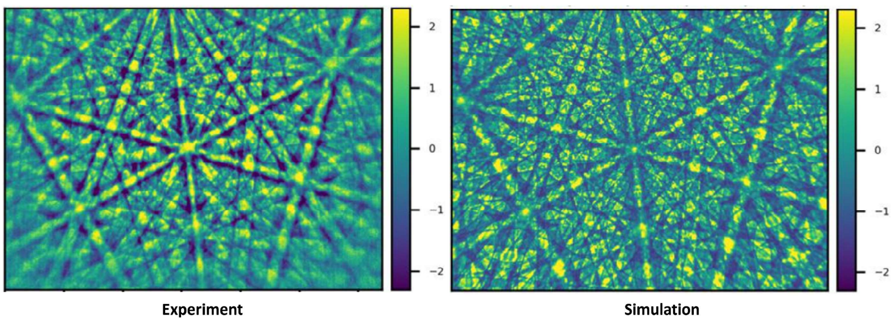


Figure 2: Quantitative Pattern Matching: Typical level of agreement which can be currently reached between an experimental Kikuchi pattern (left) and a simulated pattern (right) for high-precision orientation determination. Normalized Cross Correlation Coefficient $r = 0.69$ Tungsten Carbide hardmetal sample, SEM beam voltage 20kV (Winkelmann et al. Journal of Microscopy 277(2) (2020) 79-92).