Group for Microscopy and Diffraction

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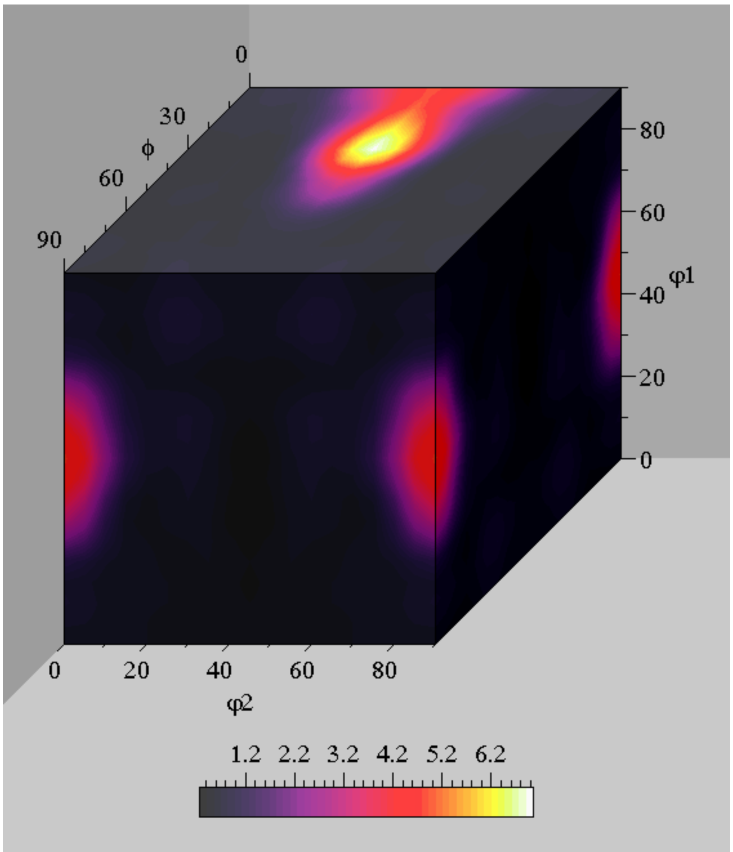
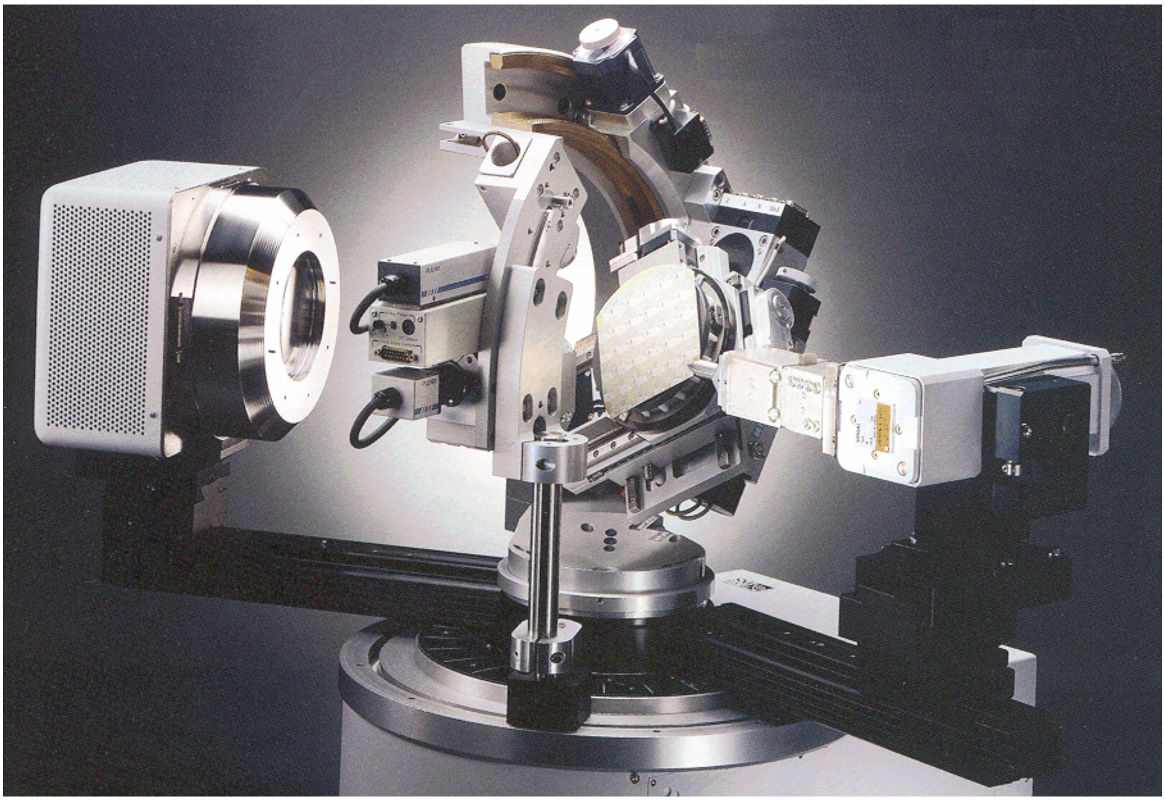
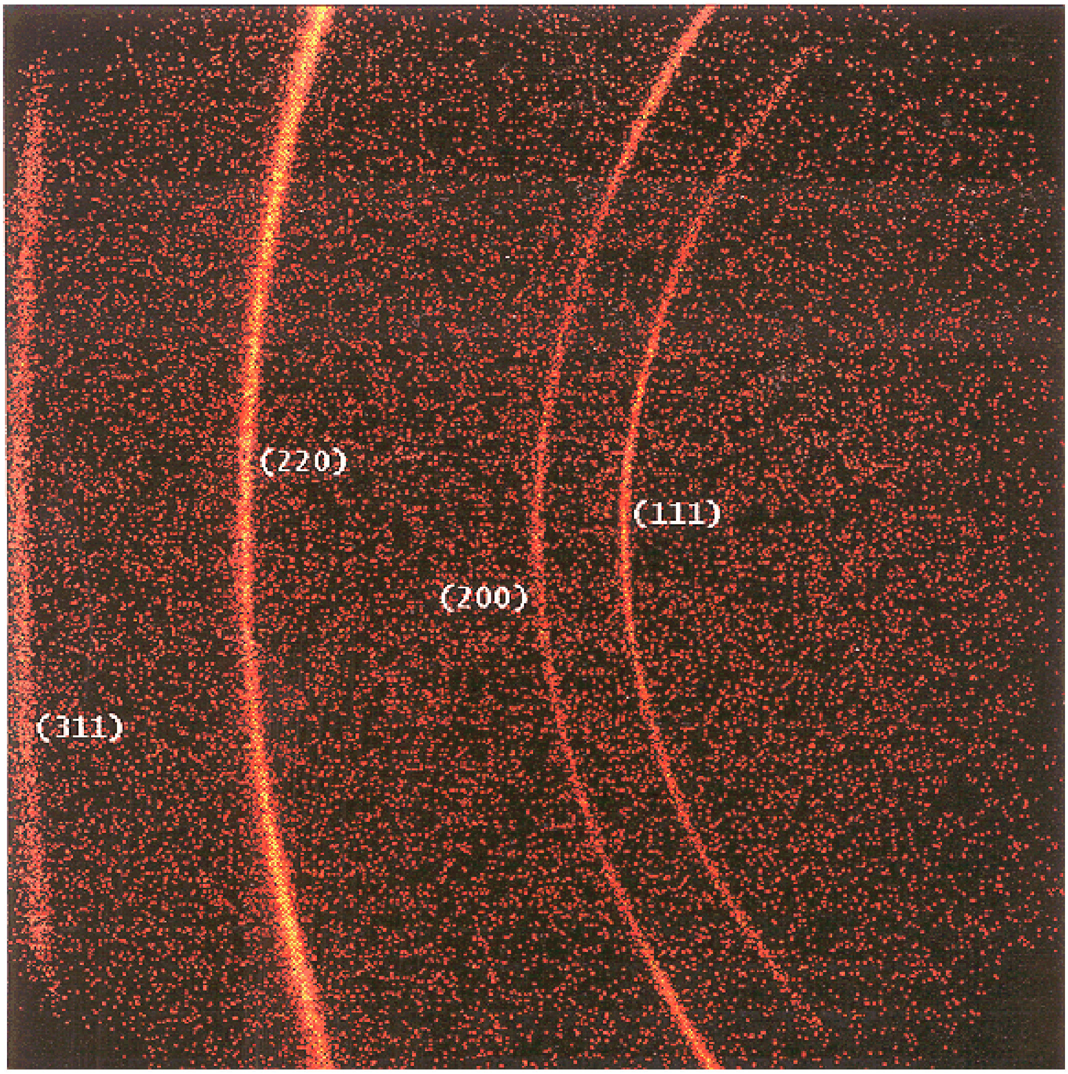
Task of the group "Microscopy and Diffraction" is the experimental investigation of the microstructure and crystallographic texture in materials and their evolution during different materials processes. The focus lies on the investigation of local processes. Therefore, the experimental methods mainly comprise transmission and scanning electron microscopy (TEM and SEM) and the appropriate diffraction techniques (transmission Kikuchi and spot diffraction in the TEM and backscatter electron diffraction (EBSD) in the SEM). Additionally, X-ray diffraction is used to measure textures, single grain orientations and residual stresses on a macroscopic and microscopic scale.



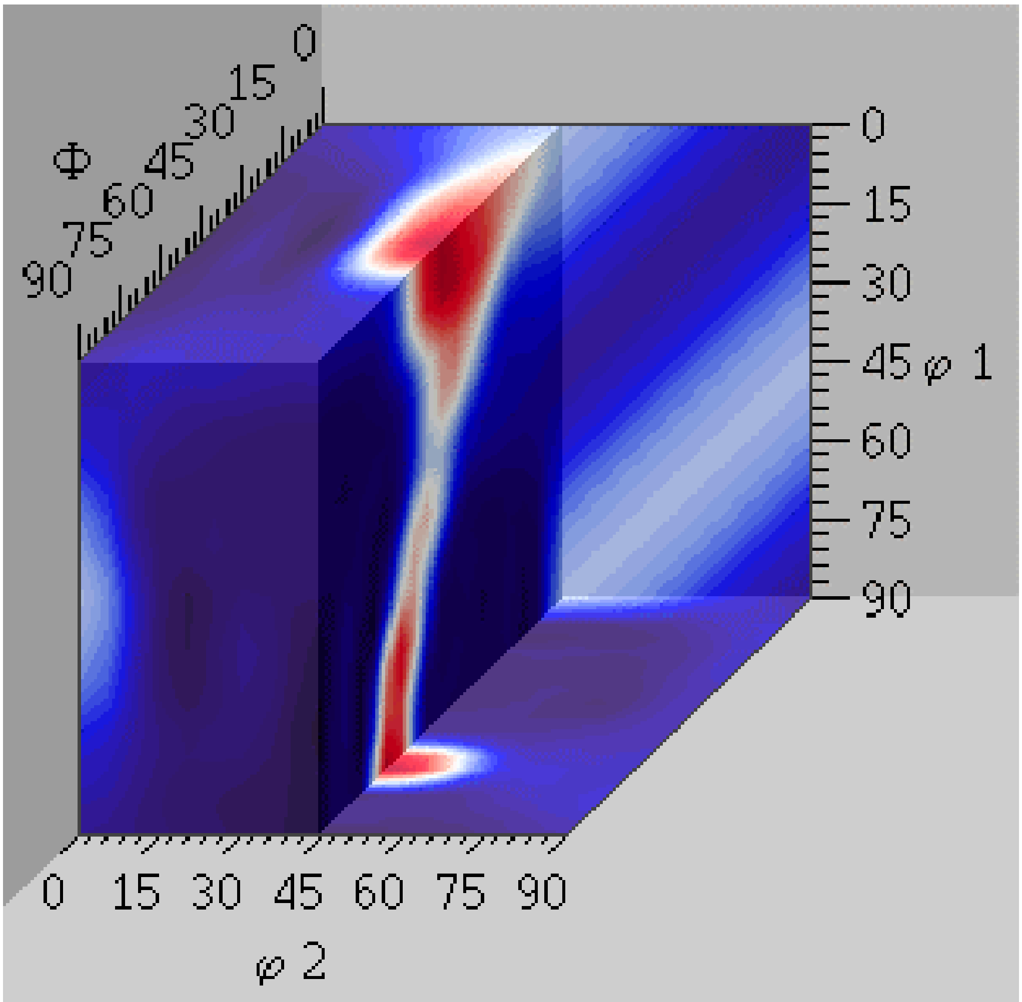
The group is equipped with a variety of instruments: for EBSD investigations, a high-resolution, high-beam SEM (JEOL JSM 6500 F) with a TSL EBSD system (with DigiView CCD camera) as well as a standard tungsten filament SEM (JEOL JSM 840A) with an HKL Technology EBSD system is available. The latter SEM also has the possibility of inserting a micro tension machine (Kammrath & Weiss) for in-situ deformation tests. For TEM a Philipps CM 20, available in the department of materials technology, is used. This instrument is equipped with the software TOCA (*S. Zaefferer*) for on-line crystallographic analysis. Furthermore, the latest X-ray goniometer of Bruker Axs, equipped with capillary beam guide for high X-ray intensity and an area detector (GADDS, Bruker Axs) is available. Alternatively, this instrument can be used with a monochromator set-up for high-precision residual stress measurements.



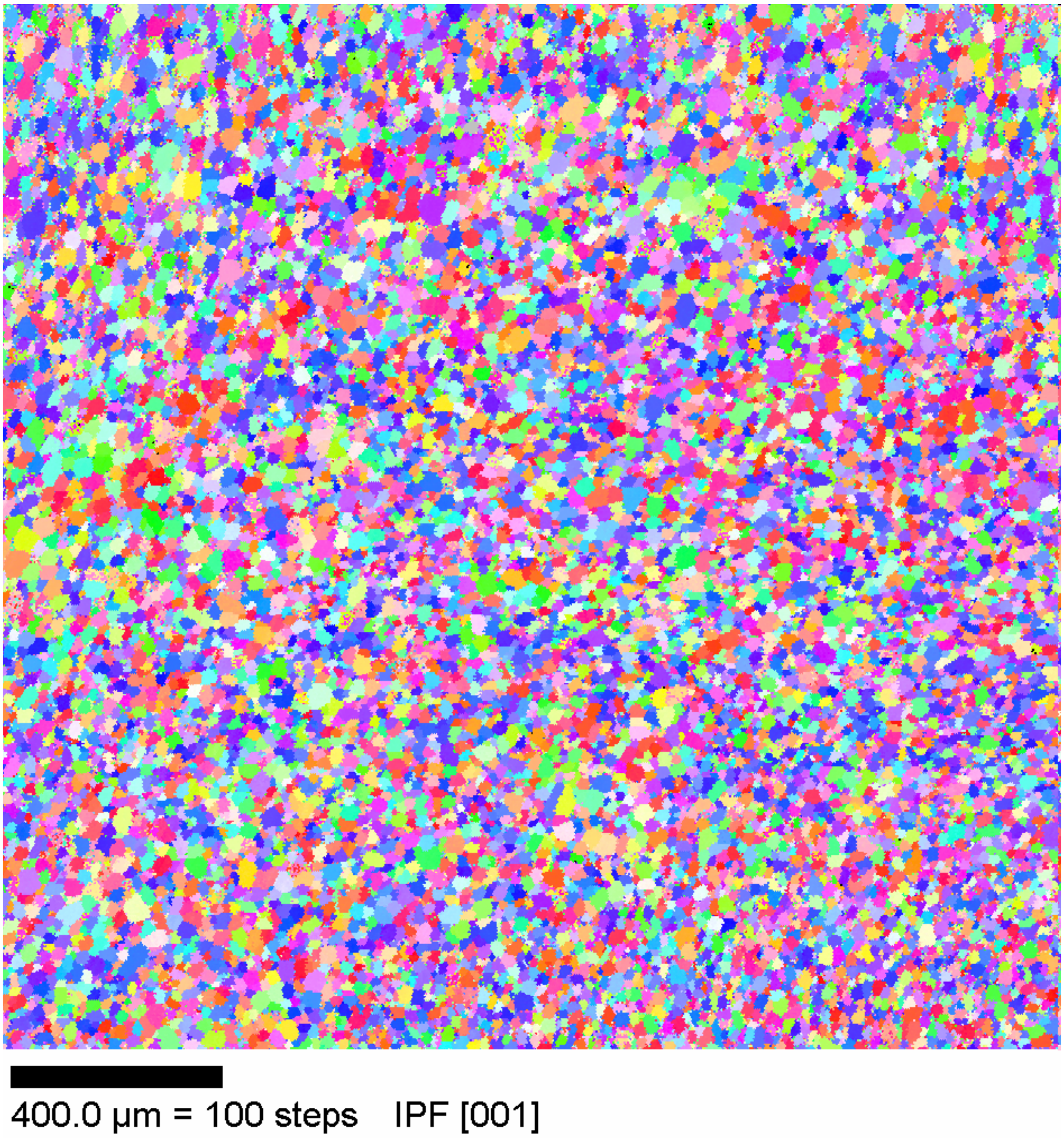
The *origin of the sharp Goss texture (110)<001>* developing during secondary recrystallization of Si steel sheets is a subject of research since more than 60 years. Nevertheless, no really satisfying solution for the problem has been given until now. Particularly, no experimental proofs of the models which have been developed on the basis of statistical observations have been given. In collaboration with Thyssen-Krupp Electrical Steel (TKES) (*N. Chen, S. Zaefferer, D. Raabe, K. Günther*) this problem has been taken up again. The new SEM and X-ray devices acquired in the group, make a more detailed and spatially resolved re-investigation of the origin of the Goss texture possible and large advances could be made. By large area crystal orientation maps the influence of grain topology (grain size and number of next neighbours) on nucleation of abnormally growing Goss grains was tested and some promising results have been obtained.



In particular, a "finger-print" graph showing the relationship between topology and Goss-orientation has been developed. The search for a topological reason of nucleation has lead to the discovery of Goss clusters (clusters of slightly misoriented Goss grains) which might act as nuclei for secondary recrystallization. In order to check their growth behaviour currently an x-ray orientation scanning technique is developed which will allow to detect Goss grains even if they are below the sheet surface.



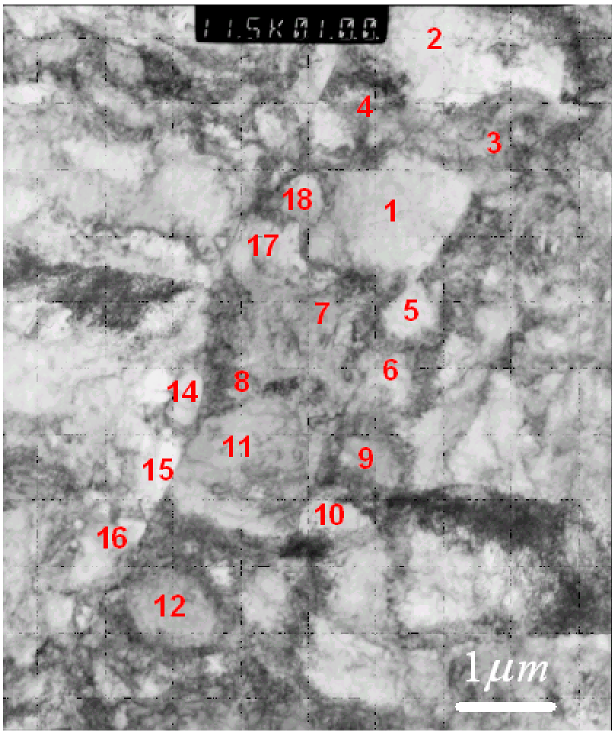
Various research projects deal with aspects of primary recrystallization in different materials, including IF steels, NiAl and Fe_3Al intermetallics, and aluminium. A study on *the origin of the heterogeneous recrystallization of IF steels* is conducted in collaboration with Thyssen-Krupp Steel (TKS) (*I. Thomas, S. Zaefferer, D. Raabe, F. Friedel*). Using EBSD in the SEM it is tried to understand the nucleation phenomena in differently oriented crystals in commercial material. This investigations have lead to the discovery of several nucleation sites inside of characteristic orientation gradients. Furthermore, the combination of SEM and TEM investigations has shown large amounts of Ti(N,C) precipitations on grain boundaries. The importance of this particles for the growth behaviour during recrystallization is currently investigated.



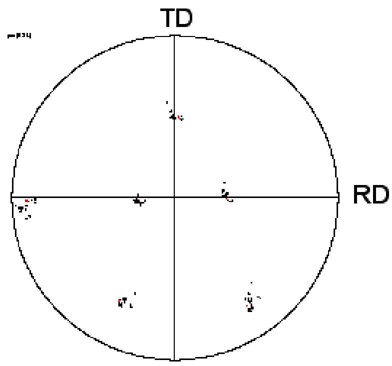
In collaboration with Dr. Hirano, NIMS, Japan, an investigation on *the recrystallization mechanisms of heavily deformed NiAl single crystals* is carried out. Here, it seems that preferred growth or secondary recrystallization plays an important role. Furthermore a study on *the origin of the cube texture in aluminium* (*S. Zaefferer*) is conducted. In this case, start material is prepared by equal channel angular extrusion (ECAE) and subsequent recrystallization in order to obtain fine grains and unusual start textures.

Goal of this project (*J.-C. Kuo, D. Raabe, S. Zaefferer, M. Winning*) is to understand the influence of well defined, symmetric <112> tilt boundaries with various misorientations on the *microscopic and macroscopic deformation behaviour of bicrystals*. To this end a variety of measurement techniques are used: the macroscopic deformation pattern is measured by photogrammetry, mesoscopic and microscopic crystal rotation distributions are determined by EBSD measurements on different scales. It has been found that only very close to the grain boundary (some 10 µm) a change of the bulk deformation behaviour can be detected. In this area, however, a clear difference between large angle and small angle boundaries is visible.

TEM observation of deformed microstructures



alpha-fiber, cold rolled



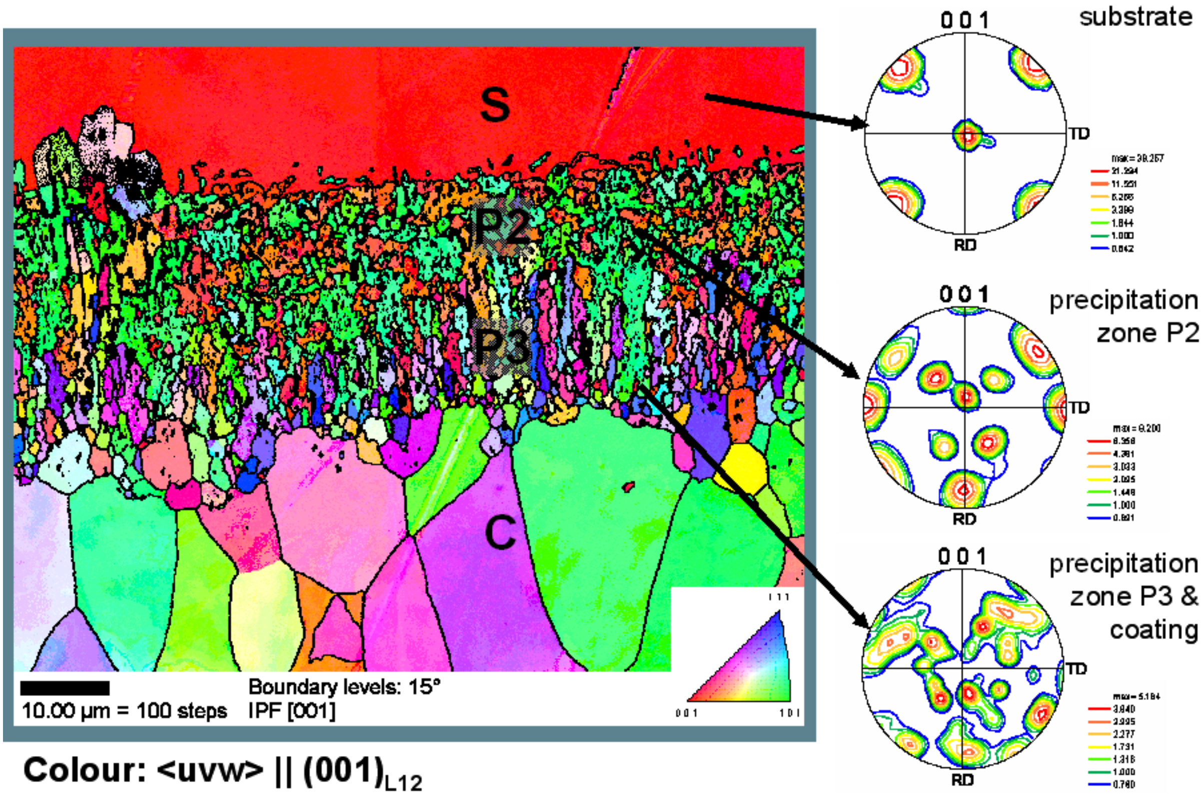
pole figure (011)

misorientations of adjacent subgrains:

2/3 :	2.8°
3/1 :	1.2°
1/5 :	4.4°
5/6 :	1.9°
9/10:	1.5°
14/15:	1.3°

In collaboration with U. Glatzel, Universität Jena, *the phase transformation mechanisms leading to the formation of oxidation protection coatings on Ni-based superalloys* are studied. A crystallographic model for the $L1_2$ - B2 transformation from the Ni_3Al

superalloy substrate into the NiAl coating could be proposed based on EBSD measurements. Additional spatially resolved EDX measurements lead to the proposition of a precipitation and diffusion model.



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A project in collaboration with Prof. Bleck, Universität Aachen, (*J. Ohlert, S. Zaefferer, W. Bleck*) on *the transformation behaviour of TRIP steels* is currently in progress. Here, EBSD and TEM have been applied in order to distinguish the different bcc phases (ferrite, bainite and martensite) and the fcc phase (austenite). It has been found that the ferrite phase can be separated into two groups, one which does not transform at all and one which was created from the austenite during cooling. Bainite can be distinguished by its high content of dislocations, visible in TEM and leading to bad pattern quality in EBSD.