Electron Backscatter Diffraction study of recovery and recrystallization in Oxide Dispersed Strengthened Steels

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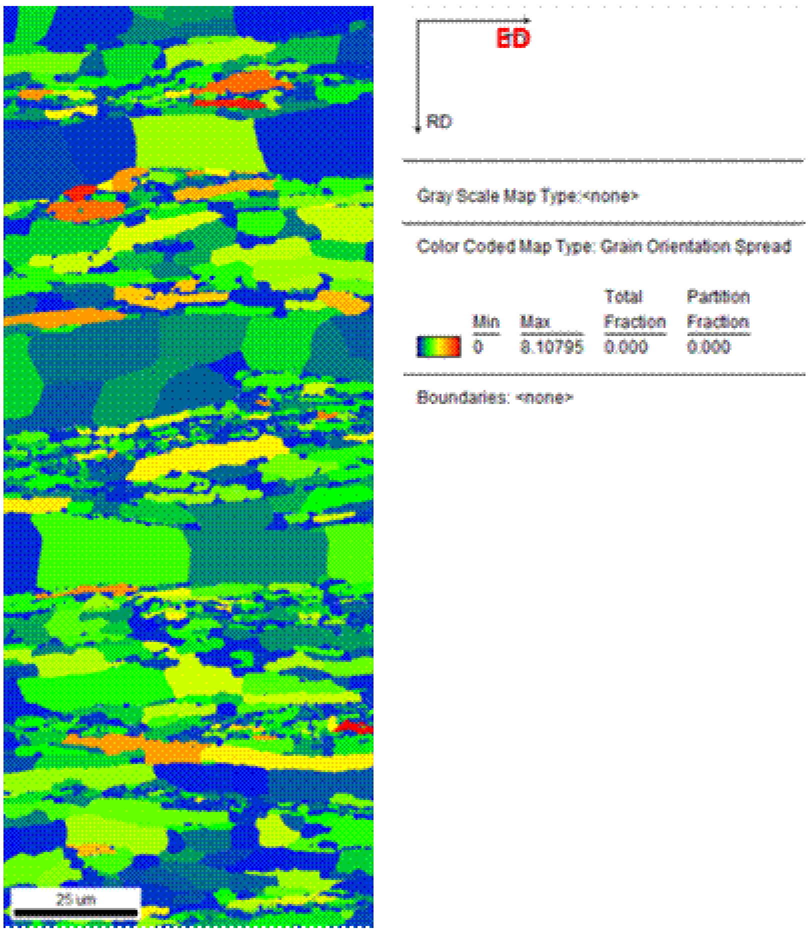
Electron Backscatter Diffraction (EBSD) is a versatile tool for the study of microstructure in crystalline materials. EBSD is often used for determination of the crystallographic orientation of grains in a polycrystalline material, and for measurement of grain size. Basically, what is measured is the set of Euler's angles for each collected data point, using which several other parameters can be extracted, notably the grain boundary character distribution.

Strengthening of a ductile matrix with the precipitation (or addition) of second phase particles is an established mechanism. Recent focus has been in oxide dispersed strengthening (ODS) and it is known that dispersion of oxide particles in the lengthscale 1-10 nm in different types of steels not only enhances the strength but also increases resistance to creep. Mechanical milling is usually the method of choice for oxide dispersion. During the course of milling with ductile (alloy) and brittle (oxide) constituents, the alloy particles are flattened; the oxide particles get fragmented and are eventually trapped in the ductile particles so that upon completion of the process, they get dispersed uniformly in the matrix with reduction in size of both the alloy and oxide particles.

We have studied the dispersion of Y-Ti-O based oxide particles in 18Cr and 9Cr steels, as also in pure iron. In this talk, we focus mostly on 18Cr ferritic steel. The steel and oxide powders were subjected to high energy ball milling for 1, 3, 5 and 6 hrs, followed by upsetting the powder in a can, extrusion, and subjecting the rods to a solutionizing heat treatment. The mechanical alloying and consolidation both led to a complex yttrium-titanium-oxide being formed. EBSD data were collected on the powder and on bulk samples after the different processing steps to monitor microstructural evolution. Transmission electron microscopy was used to study the crystal structure and morphology of the dispersoids, while small angle x-ray scattering (SAXS) measurements provided complementary information on their size distribution.

After the cold work that takes place during milling, it is expected that there will be recovery in the materials to a certain extent, and during the further processing steps of upsetting, extrusion and solutionization, all at elevated temperatures, recrystallization is bound to occur. Recrystallization imparts a stable microstructure so that the alloy can be used to high temperatures with consistent performance. EBSD was used effectively to study recovery and recrystallization at different stages of the processing. High energy milling introduces large strains and the observed microstructures are as reported in the literature. However, the presence of intentionally created ultrafine dispersoids is expected to have a significant effect on recovery and recrystallization, which would be different compared to the case of larger precipitates. Among other parameters derived from EBSD measurements, we have monitored the grain orientation spread, which can be used as a measure of the recrystallized fraction. The combined results from EBSD and other studies have been used for optimization of the microstructure in 18Cr steels and will be presented.



Grain orientation spread in the sample milled for 1 hr.