Microstructural characterization and micromechanical modelling of internal lengths effects on the plastic behavior of ferritic steels

Layal Chamma\textsuperscript{a,b}, Jean-Marc Pipard\textsuperscript{a}, Artem Arlazarov\textsuperscript{a}, Thiebaud Richeton\textsuperscript{b}, Jean-Sébastien Lecomte\textsuperscript{b} and Stéphane Berbenni\textsuperscript{a}

\textsuperscript{a}ArcelorMittal Maizières Research SA, Voie Romaine - BP30320, 57283 Maizières-lès-Metz, France
\textsuperscript{b}University of Lorraine, Arts et Métiers Paris Tech, CNRS, LEM3, F-57000 Metz, France

\texttt{layal.chamma@arcelormittal.com}

Microstructural internal lengths play an important role on the local and macroscopic mechanical behaviors of steels. The dislocation density gradients near grain boundaries in a ferritic steel are investigated using SEM/EBSD together with instrumented nanoindentation \cite{1} on the pre-deformed Al-k steels at 0\%, 3\%, 5\%, 10\% and 20\% tensile strains. The effect of distances to grain boundaries on Geometrically Necessary Dislocations (GND) densities is, first, determined by analyzing orientation gradients from 2D-EBSD \cite{2}. Then, nanohardness measurements are performed in the vicinity of grain boundaries. Data analyses show a clear correlation between the spatial gradients of GND density and the ones of nanohardness. Using a mechanistic model, the total dislocation densities are estimated from the measured nanohardness values. From both GND and total dislocation density profiles, the value of an internal length, denoted $\lambda$, is estimated from the analysis of dislocation density gradients near grain boundaries. This description of the internal length $\lambda$ with plastic deformation due to GND hotspots near GBs extracted from both EBSD and nanohardness measurements is introduced in a micromechanical mean-field approach with internal lengths \cite{3}, in order to improve the description of the grain size dependent plastic behavior of Alk steels.

Keywords: Internal lengths, Grain boundaries, Dislocation densities, Micromechanics, Steels.

References: