Elasto-Plastic Deformation Behavior of Polycrystalline Steels

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Grain refinement [1] and Si addition [2] to ferritic steels increase strength without losing toughness. It is however unclear why such a good balance can be achieved in these steels. Hence, IF steels with different concentrations of Si and a Mn-Si-C steel with various grain sizes were prepared and their tensile deformation behavior was studied using *in situ* neutron diffraction with an engineering diffractometer, *Takumi*, at MLF/J-PARC.

First, it should be noted that bcc iron shows strong elastic anisotropy resulting in elastic inhomogeneity under the external stress. Therefore, the onset of plastic flow is dependent not only Schmid factor but also stresses in individual grains. Such elastic inhomogeneity is described by so-called diffraction <hkl> elastic moduli which can be determined by *in situ* neutron diffraction during tensile test showing good agreements with the calculated values by Kroner model. Second, "grain to grain yielding" occurs in the beginning of plastic deformation accompanying the generation of intergranular stresses due to the misfit plastic strains among differently oriented <hkl> grains, which can be monitored during tensile deformation by *in situ* neutron diffraction. The effect of Si addition and grain size on the intergranular stresses will be reported. Third, the evolution of dislocation structure and density are influenced by <hkl> orientations of individual grains, accompanying different work-hardening behavior. The addition of Si has been found to increase dislocation density and to change substructure, leading to higher work-hardening [2]. Combined with the neutron diffraction results with TEM and EBSD observations, work hardening mechanisms of polycrystalline steels will be discussed. Finally, similar analyses for plastic deformation behavior at elevated temperatures will be shortly reported, which is needed for thermo-mechanically controlled processing for microstructure control in steel production.

References

[1] For example, Special Issue on Strength of Fine Grained Materials -60 Years of Hall-Petch-, Materials Transaction, 55(2014), pp.1-120.

[2] For example, Y.Kawasaki et al., Proc. of the 2nd Int. Sympo. on Steel Science, (ISSS 2009), pp. 241-244.