NANO-MECHANICAL BEHAVIOR OF BCC IRONS CHARACTERIZED THROUGH NANOINDENTATION AND TEM IN-SITU STRAINING

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Local mechanical behaviors were investigated through nanoindentation and TEM in-situ straining techniques for bcc irons. Pop-in phenomenon that corresponds presumably to local plasticity initiation was detected on load-displacement curves with major parameters of critical load *Pc* and corresponding excursion depth *Dh* [1]. The *Pc* decreases significantly when indent are made on a grain boundary, which indicates a role of dislocation source of a grain boundary. Alloying elements including interstitial or substitutional atoms have an effect on increasing *Pc*. Since the maximum shear stress underneath the indenter is estimated in an order of a theoretical strength, the event can be understood as dislocation nucleation from defect-free region in a crystal. Dislocation structures underneath the indenter were observed through TEM before and after a pop-in event [2]. No dislocations were observed before initiation while considerable dislocations were generated right after the event. These results suggest that dislocation nucleation and multiplication occur drastically upon plasticity initiation based on collective dislocation motion. In-situ TEM compression tests were performed for interstitial-free (IF) steel to get the relationship between an evolution of dislocation structure and flow stress [3]. Figure 1 shows stress-strain curves (a) and TEM images (b, c) of dislocation structures of the sample. The initial dislocation density was quite low, then after the yielding, the dislocation density increased gradually with strain and the corresponding flow stress decreased edgingly, indicating a significant strain softening. The flow stress was plotted as a function of the dislocation density and the stress exponent *m* was evaluated based on the combination of Johnston and Gilman model and Orowan model. The *m* value is lower than that in the case of edge dislocation dominant condition that is previously shown in literatures. This is reasonable because the stress exponent *m* goes down with the much lower mobility of screw dislocation than that of the edge dislocation in bcc structure.

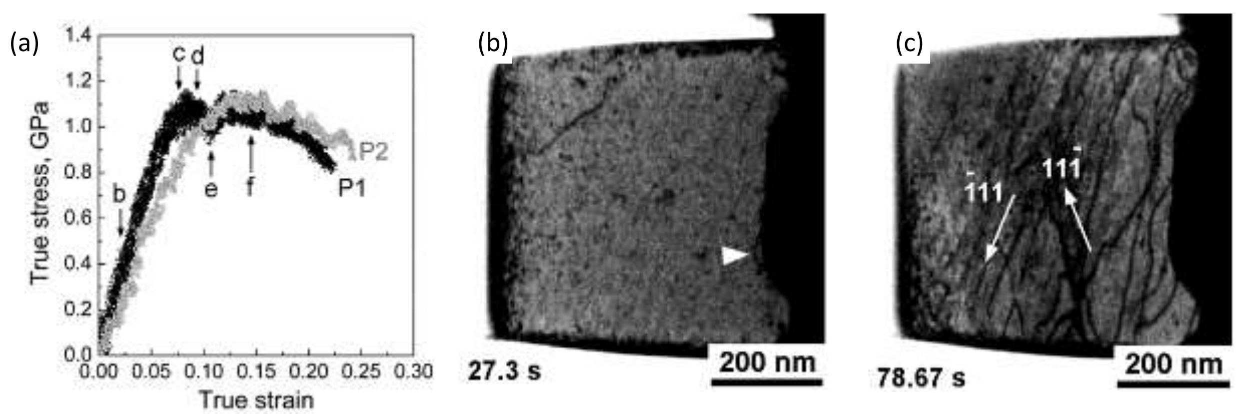

Figure 1 – (a): Stress-strain curves of IF steel obtained through micro-compression test in a TEM. TEM images of the sample before (b) and after (c) yielding showing an evolution of screw dislocations during deformation. The sample showed remarkable strain softening with increasing screw dislocation density.

References

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