# Discussion on Structure-Property Relationship in Advanced High Strength Steels

Nanograined (NG) materials exhibiting "high strength-high ductility combination" are excellent vehicles to obtain an unambiguous understanding of deformation mechanisms. Toward this end, the concept of phase reversion-induced NG structure enabled high strength-high ductility combination to be obtained. Utilizing this concept, our aim is to fundamentally understand grain size dependence on deformation mechanisms.

During the visit, a presentation was made to obtain "high strength-high ductility" combination in nanograined (NG) austenitic stainless steel. using the concept of phase reversion involving severe cold deformation of austenite at room temperature to generate strain-induced martensite, followed by annealing when martensite reverts to austenite via diffusional mechanism. The objective of the presentation was to stimulate discussion on dependence of grain size on deformation mechanisms in nanostructured steels. We also discussed the application of depth-sensing nanoindentation experiments and post-mortem analyses of the deformed region using transmission electron microscopy (TEM) in the understanding of deformation mechanisms. It was emphasized that strain rate sensitivity of the nanograined (NG) austenitic steel as obtained by nanoindentation experiments was (0.13), which is about twice the coarse-grained counterpart (0.06) and the activation volume was about one-third (16 $b^3$) of the coarse-grained structure (48 $b^3$), where b is the magnitude of the Burgers vector. In the high strength nanograined steel, deformation twinning contributed to excellent ductility, while in the low strength coarse-grained (CG) steel, ductility was also good, but due to strain-induced martensite, implying clear distinction and fundamental transition in the deformation behavior of NG and CG Fe-17Cr-7Ni austenitic stainless steels. In the NG structure, there was marked increase in stacking faults and twin density at high strain rates, which led to decrease in the average spacing between adjacent stacking faults, converting stacking faults into twins. The plastic zone in the NG structure resembled a network knitted by the intersecting twins and stacking faults. The observed change in the deformation mechanism with change in grain size is attributed to increased stability of austenite with decrease in grain size, and is explained in terms of austenite stability-strain energy relationship [1].

The fracture surface of the CG alloy that experienced strain-induced martensitic transformation during tensile deformation was microvoid coalescence-type, which is typically observed in ductile metals and alloys. In contrast, the fracture surface of the NG alloy though appeared relatively flat but at higher ma s that were nearly parallel to one another were observed with line-up of voids along the striations (Figure 1).

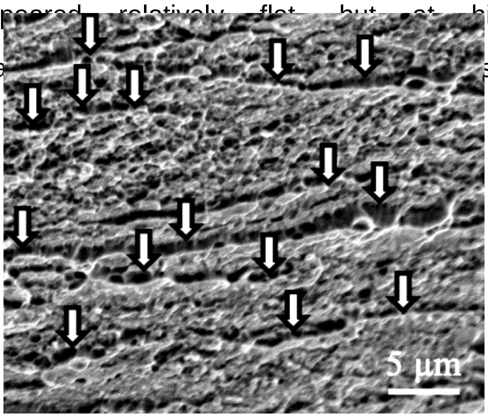

Figure 1. Striated fractured induced by twinning in nanograined austentic stainless steel.

A strong discussion took place on the ongoing research being conducted by the members of Professor Furuhara’s group.

[1] R.D.K. Misra, V.S.Y. Injeti and M.C. Somani, “The Significance of Deformation Mechanisms on the Fracture Behavior of Phase Reversion-induced Nanostructured Austenitic Stainless Steel,” Scientific Reports – Nature, 8:7908 (2018) 1-13.

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Full Name: Devesh Misra
E-mail: dmisra2@utep.edu
http://engineering.utep.edu/materials/