Grain boundary stability governs hardening and softening in extremely-fine nanograined metals

Subject Code: E01

Conventional polycrystalline materials become harder with decreasing grain size, following the classical Hall—Petch relationship, i. e., strength increases reversely proportional to the square root of the grain size. Strengthening occurs due to dislocation pileups at grain boundaries that prevent the dislocations from moving. Plastic deformation therefore becomes more difficult at smaller grains as the density of the grain boundaries increases. The situation can be different in certain nanograined materials, however, and researchers have already observed softening, rather than hardening, when grain sizes are smaller than 10 to 30 nm in size.

With a financial support from the National Natural Science Foundation of China, a team led by Prof. Lu Ke (**卢柯**) from Shenyang National Laboratory for Materials Science, Institute of Metal Research in the Chinese Academy of Sciences in collaboration with UNIROUEN (France) and Nanjing University of Science and Technology found that hardening and softening are governed by grain boundary stability in extremely-fine nanograined metals, as published in *Science* (2017, 355: 1292—1296). Their experimental results showed that the mechanical behaviour and plastic deformation mechanisms can fundamentally differ in extremely-fine nanograined metals with the same grain size. The nature of their grain boundaries becomes more important instead. The electro-deposited nano-grained Ni-Mo samples become softened for grain sizes below 10 nm due to GB-mediated processes. With GB stabilization through relaxation and Mo segregation, ultrahigh hardness (> 11 GPa) is achieved in the nano-grained samples with a plastic deformation mechanism dominated by generation of extended partial dislocations. The hardness variation of nano-grained Ni-Mo alloys can be as large as over 100% without a change in grain size. The finding is of significance since it provides us with an alternative way to tailor the properties and performance of nanograined metals along with grain size. Novel nanostructured materials with extraordinary properties such as ultrahigh hardness could be synthesized by manipulating both characteristic size and interface stability.

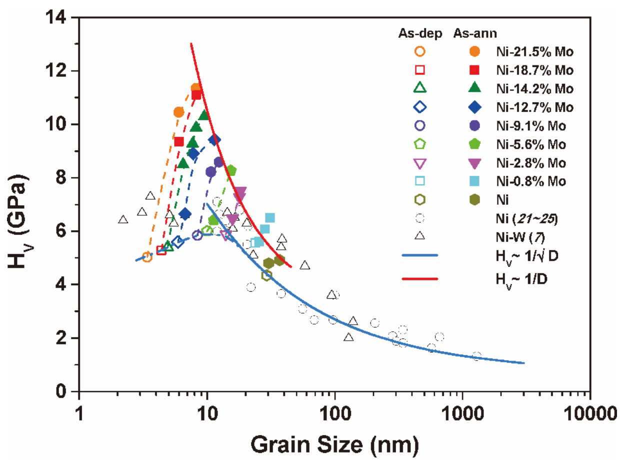

Figure Hardening and softening in extremely-fine nano-grained Ni-Mo alloys: Variations of microhardness (Hv) with grain size for the as-deposited and the as-annealed Ni and Ni-Mo samples.