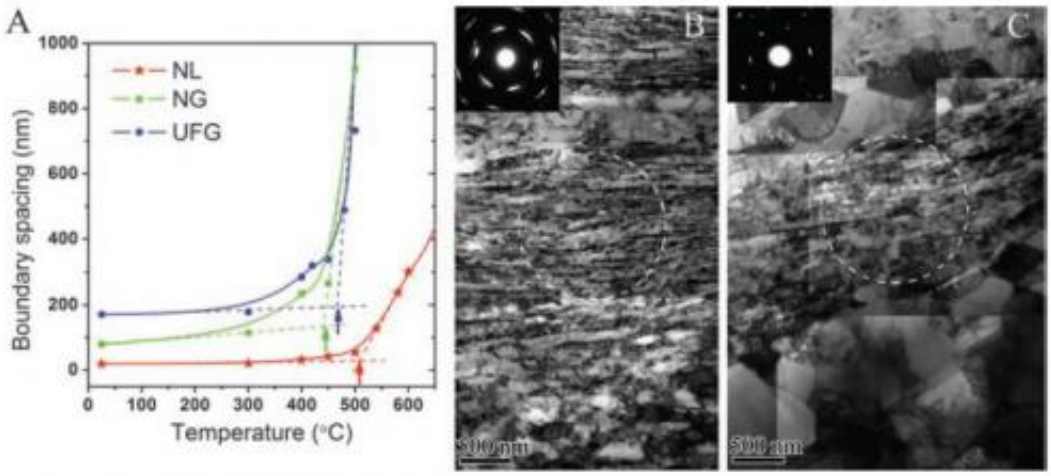
Researchers develop method for creating much stronger nickel

October 18 2013, by Bob Yirka



Thermal stability of the NL structure. Credit: *Science* 18 October 2013: Vol. 342 no. 6156 pp. 337-340 DOI: 10.1126/science.1242578

(Phys.org) —A team of researchers at the Chinese Academy of Sciences and Nanjing University of Science and Technology has found a way to create an ultra fine grain (UFG) nickel with a nanolaminated structure. As the team describes in their paper published in the journal *Science*, the result is a new process that allows for the creation of a form of nickel that is both harder and stronger than the metal is in its native form.

Ever since human beings first began using various metals they have been trying to modify them to conform to our wishes. Such efforts have resulted in an amazing array of metals ranging from the small amounts

used in electronics to the mammoth steel girders that keep our skyscrapers upright. Research continues as scientists look for ever more advanced ways to treat metals to allow for ever more exotic applications. In this new effort, the team in China has developed a way to create a UFG from ordinary nickel. Such metals offer more resistance to corrosion and wear and have higher fracture strength.

UFG's advantages over other metals come about by causing a reduction in grain size—generally by a factor of ten or more. The smaller grain size means smaller grain boundaries which impede dislocation movement—it's dislocation that results in fractures or localized deformations.

To create a nickel UFG, the researchers subjected a rod made of 99.88 percent pure nickel to grinding on its surface—a process that tears away portions of the metal allowing for it to be shaped. In this case, the researchers noted that as nickel grains were being pulled by the mechanical grinder, the metal that remained was subjected to intense shearing causing what's known as plastic deformation. Upon closer inspection of the ground surface, the researchers discovered that two-dimensional nanometer-thick laminated structures had been created by the process. Further testing indicated that grain size had been dramatically reduced meaning that a nickel UFG had been created.

It's not yet clear if the simple process can be used to manufacture a nickel UFG on a scale large enough to be used in real world applications. What is clear, however, is that the process is very likely applicable to other metals, which means a whole new area of metal science might just be in the making.

More information: Strain-Induced Ultrahard and Ultrastable Nanolaminated Structure in Nickel, *Science* 18 October 2013: Vol. 342 no. 6156 pp. 337-340 DOI: 10.1126/science.1242578

ABSTRACT
Heavy plastic deformation may refine grains of metals and make them very strong. But the strain-induced refinement saturates at large strains, forming three-dimensional ultrafine-grained (3D UFG) structures with random orientations. Further refinement of this microstructure is limited because of the enhanced mobility of grain boundaries. Very-high-rate shear deformation with high strain gradients was applied in the top surface layer of bulk nickel, where a 2D nanometer-scale laminated structure was induced. The strongly textured nanolaminated structure (average lamellar thickness of 20 nanometers) with low-angle boundaries among the lamellae is ultrahard and ultrastable: It exhibits a hardness of 6.4 gigapascal—which is higher than any reported hardness of the UFG nickel—and a coarsening temperature of 40 kelvin above that in UFG nickel.

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