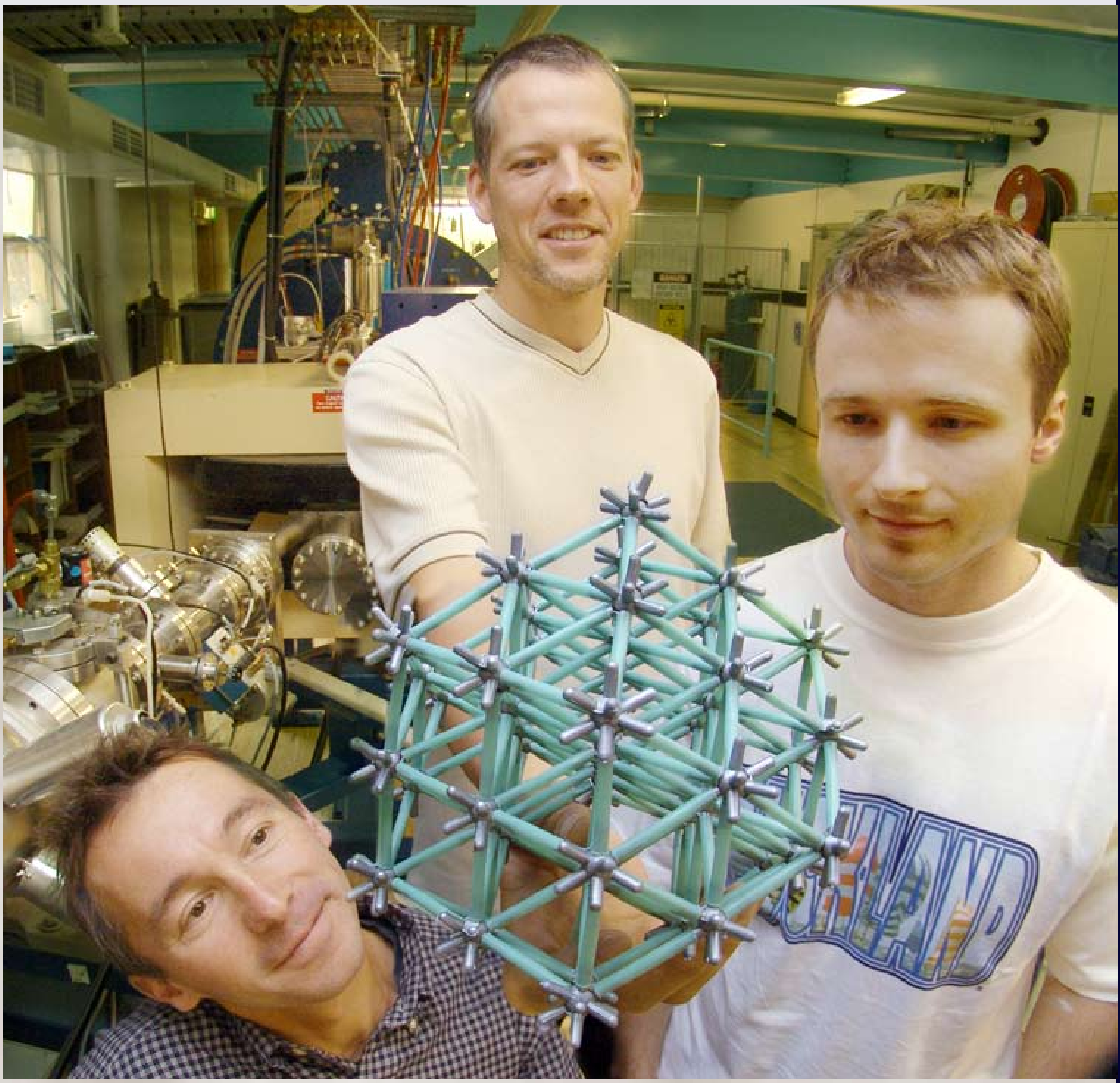
THE AUSTRALIAN NATIONAL UNIVERSITY

Ion Irradiation to form Amorphous Mono-Elementa

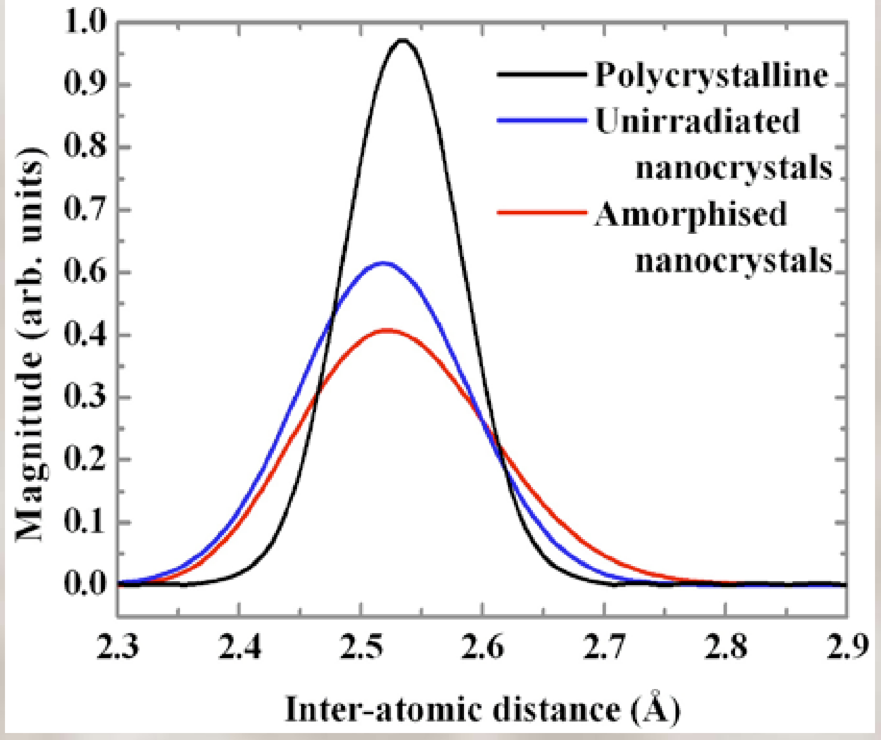
B. Johannessen, P. Kluth, D.J. Llewellyn and M.C. Ridgway



The physical properties of metals depend critically on their crystalline structure. Surprisingly amorphous metals with a highly disordered structure can sometimes greatly outperform more perfect polycrystalline versions of the same material. For example, golf club heads fabricated from amorphous "Vitreloy" are twice as hard and four times as elastic as those made from polycrystalline Ti and consequently 99% of the impact energy is transferred to the ball compared to only 70% for Ti.

To form an amorphous metal, one tries to "quench in" the disordered structure by rapid cooling from the molten state. Alloys such as Vitreloy have a very high viscosity and can freeze into amorphous states even at quite modest cooling rates. But for pure metals it's impossible to cool castings fast enough to yield the desired amorphous structure. To get around this, scientists have long experimented with ion implantation - accelerating ions to high velocity and smashing them into the material with the aim of displacing atoms and transforming the metal structure from a polycrystalline to amorphous state. However, to date, this has only yielded amorphous metals when using foreign ions whose inherent chemical properties inhibit the undesired recrystallisation. The trouble is that this also introduces undesirable impurities which themselves alter the properties of the metal.

Scientists at the ANU may soon have a way round this problem. They employ nanotechnology to generate metal nanocrystals with modified microscopic structure, then implant these materials with high-energy ions that pass straight through the nanocrystals to minimise impurity effects. The ANU group has recently demonstrated that for pure copper, their nano-preparation technique creates an amorphous structure that is unachievable when implanting bulk polycrystalline material yet is consistent with theoretical predicitons for a pure amorphous metal. The ANU scientists were able to fine tune their process such that the implantation disrupted all trace of the normal face centred cubic crystalline structure whilst leaving the particle size intact. The group is hopeful that this technology could soon find applications throughout the electronic, photonic and metallurgical industries.



The key to success has been developing a thorough understanding of the implantation process on the nanoscale. This has been made possible by collaborative interactions with some of the world's most advanced and brightest x-ray facilities such as the Photon Factory in Japan and the Advanced Photon Source in the USA. However, by 2007 these measurements will be possible for the first time in this country when the Australian Synchrotron opens in Melbourne. These same ANU scientists are also actively contributing to the design and construction of this new, state-of-the-art national facility.