Nanoscale manipulation of the properties of solids at high pressure with relativistic heavy ions

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Nature Materials 8 (2009) 793-797

High-pressure and high-temperature phases show unusual physical and chemical properties, but they are often difficult to 'quench' to ambient conditions[1]. Here, we present a new approach, using bombardment with very high-energy, heavy ions accelerated to relativistic velocities, to stabilize a high-pressure phase. In this case, $Gd_2Zr_2O_7$, pressurized in a diamond-anvil cell up to 40 GPa, was irradiated with 20 GeV xenon or 45 GeV uranium ions, and the (previously unquenchable) cubic high-pressure phase was recovered after release of pressure. Transmission electron microscopy revealed a radiation-induced, nanocrystalline texture. Quantum-mechanical calculations confirm that the surface energy at the nanoscale is the cause of the remarkable stabilization of the high-pressure phase. The combined use of high pressure and high-energy ion irradiation[2,3] provides a new means for manipulating and stabilizing new materials to ambient conditions that otherwise could not be recovered.