CFEL SCIENCE SEMINAR

September 23rd, 2010, 02.30 p.m. – DESY Bldg. 28c, Seminar Room

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Super-dense bcc-Al formed by ultrafast laser microexplosion

Under extreme pressures and temperatures, such as those existing inside planets and stars, common materials form new dense phases which, having compacted atomic arrangement, have new unusual physical properties. In practice, the extreme conditions are achieved using large presses, diamond-anvil cells, explosively-triggered shock-waves, which have allowed synthesis of new phases of super-hard oxides Ti_2O_3, SiO_2, nitrides (b-Si_3N_4), metals Li, Al, Cu, etc. While many new material phases were produced this way, others like bcc-Al were predicted theoretically, but have not yet been confirmed in experiments.

Here we present a new body-centred-cube aluminium (bcc-Al) phase synthesized in ultrafast laser induced microexplosion. With ultra-short laser pulses tightly focused in the bulk of transparent material, we create unique non-equilibrium plasma conditions, with up to 10 TBar pressure and temperature of 10^5 K in tabletop experiments. Generation of such plasma in sapphire (Al_2O_3) unexpectedly leads to spatial separation of constituent aluminium and oxygen ions in short-lived plasma, with the resulting synthesis of a new previously unobserved dense bcc-Al phase. The record high 10^{15} K/s cooling rate in ultrafast laser experiments allows preservation of this exotic material in a shell surrounding the laser focus within otherwise pristine sapphire. We suggest the physical mechanism responsible for spatial separation of O- and Al-ions in conditions of complete confinement and preserved stoichiometry.

The novel ultrafast laser induced microexplosion technique offers new routes for synthesis of super-dense and unusual forms of materials and study warm dense matter in tabletop experiments.

Host: Henry Chapman, CFEL Coherent Imaging Group