High-density hydrogen gas in hollow silica nanospheres

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Various deuterium-containing microspheres were proposed as fuel targets in laser-initiated thermonuclear reactions. In addition, accommodation of hydrogen in the hollow silica glass microspheres was previously proposed as one of the possible ways for hydrogen storage. Opal matrices consisting of silica hollow spheres with an outer diameter of 300 nm and a shell thickness of 30 nm, were hydrogenated to $X = 0.93$ mol H_2 per mole of SiO_2 at an H_2 pressure of $P = 7.5$ GPa and temperature $T = 140$ °C. This is the highest hydrogen solubility ever achieved in silicates. After keeping the sample at normal pressure in liquid nitrogen for three days, the hydrogen concentration decreased to $X = 0.8$ and then stopped changing. Subsequent scanning electron microscopy showed that the hydrogenation did not change the shape of the nanospheres. Raman spectroscopy showed that at 80 K and normal pressure, hydrogen molecules form a gas in the cavities inside the spherical SiO_2 shells and a solid solution in these shells. The density of the H_2 gas inside the cavities estimated from the measured Raman spectra was about $\rho \approx 0.02$ g/cm^3, which is 100 times greater than its density at the same temperature and normal pressure. This work was supported by the Russian Science Foundation (project No. 23-23-00426).