Metal-semiconductor phase transition in nanoscale vanadium dioxide precipitates formed in silica and sapphire by ion implantation.

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The effects of particle size on semiconductor-to-metal structural phase transitions have been investigated in VO_2 nanocomposites. Nanophase precipitates of VO_2 were formed by the stoichiometric ion implantation of V and O into silica and sapphire substrates. By varying the annealing time in the subsequent thermal-processing step, the VO_2 nanoparticle size was controlled. The effects of nanocrystal size and particle morphology on the optical properties of the nanocomposite material are described. VO_2 nanoparticles in silica exhibit a sharp transition with a hysteresis width that is enhanced up to 50 K as particle size decreases – one of the largest values reported for this transition. In addition, the surface plasmon resonance that is induced by dielectric confinement when the particles reach the metallic state amplifies the optical contrast in the near-IR, optical communications band. Fiber-optic and “smart-coating” applications are demonstrated. By doping the particles with tungsten or titanium, the transition temperatures and hysteresis-loop properties can be varied over a wide range.

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