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Self-Limiting Growth of Magnetic Nanoparticles in a Glassy Matrix SERGIO PICOZZI, MARK LAURENZI III, IAN PEGG, Department of Physics and Vitreous State Laboratory, The Catholic University of America, Washington, DC — Nanoparticles of magnetite can be grown by heat treatment of suitable glass compositions slightly above the glass transition temperature. We have investigated the transformation kinetics and magnetic properties, including the size dependence of the Verwey transition, in such systems. The initially rapid growth is quickly arrested leading to tight size distributions that become essentially independent of time. The mean size (a few nm) is dependent on the glass composition and temperature. In this paper, we investigate a simple model in which the self-limiting nature of this process is ascribed to the experimentally observed strong dependence of the glass transition temperature of the matrix on the concentration of one of the diffusing species, which in turn gives rise to a concentration-dependent diffusivity. In addition, the relationship between the equilibrium concentration of the diffusing species and the curvature of the particle-matrix interface (the Gibbs-Thomson effect) is shown to play a prominent role. The model reproduces the essential features of the transformation kinetics, predicting an initial power law growth that becomes nearly logarithmic at long times, and identifies the key physical parameters that determine the self-limited particle size.

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