Phase stability in Nanostructures: a physicist's perspective.

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Nanotechnology is a new, fascinating branch of Materials Science, which deals with unique structural states and physical properties of materials that appear as a result of confinement. There is a big gap between the scale of an individual molecule made by a chemist and the sub-microscopic scale of materials used in different engineering fields. That gap, which spans from about one nanometer to several hundred nanometers, is where fundamental properties of materials, including electrical conductivity, optical properties, and mechanical strength, are defined. Given practical importance of thin films and nanoparticles in microelectronics, they became a popular subject of experimental research in materials science during the past decades. There is, however, a lack of the theoretical understanding of the problem of phase stability in materials with dimensions on the order of nanometers.

In my talk I will discuss two different types of situations in nanomaterials. At first, I will discuss a phase diagram of small one-component particles. In very fine particles (50-100 nm in diameter) under conditions of conservation of energy the equilibrium is achieved on homogeneous phases, which can never be obtained in the bulk because of their absolute instability. This fact can be used to compose a refrigeration cycle that employs magnetocaloric effect in nanoscale ferromagnetic composites. Then I will discuss the case of a binary metallic alloy where spinodal decomposition takes place in a bulk system. However, if thickness of such film is below certain critical value, the decomposition does not go. The thermodynamic and dynamic explanations of stabilization of unusual phases and composition will be presented.