Mechanics of self-assembly and applications

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A self-assembly process is characterized by the spontaneous and ordered aggregation of similar components. Magnetic microspheres and nanoparticles contained in fluids undergo magnetic field-assisted self-assembly to create low- or three-dimensional structures. Magnetic self-assembly can be implemented at different length scales for various applications, e.g. microfabrication, magnetic fluid based switches and valves, maskless wet etching, microfluidic mixing, biosensing and magnetic drug targeting. All these applications rely on proper magnetic micro- and nanoparticle aggregation by imposing a magnetic field. For devices to work, it is important that the structures maintain their integrity against the shear force exerted in either a steady or periodic flow. Previous research has generally focused on the magnetic field induced self-assembly of low dimensional (i.e., one- and two-dimensional patterns) rather than of complex three-dimensional architectures. New manufacturing techniques will have to integrate both the assembly and function (e.g., the ability to grow or pattern cells or carry a chemotherapeutic agent) of mesoscale components. Herein, we describe the transport of magnetic nanoparticles and microspheres so as to investigate novel self-assembly scenarios. Our purpose is to facilitate the formation of dynamic structures that are also capable of providing useful functions.