Templated Assembly by Selective Removal

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In this project, an effective technique for site-selective, multicomponent assembly on the nano- and microscale has been developed. Creation of practical nanosystems using this technique is underway. This approach offers great promise for assembling arbitrary (not necessarily periodic) systems of different types of nanoscale components, such as electronics (memory, logic, interconnects, displays) and sensor systems.

The key elements of the approach are as follows. First, the topography of the substrate is modified to match the components’ 3D shapes. Then, the substrate and components are coated with an adhesion promoter, such as a hydrophobic SAM, for adhesion in a water-based environment. The components and substrate are placed in a fluid environment for the assembly process then megahertz-frequency ultrasound is applied to the fluid bath. Components contact the substrate randomly and adhere wherever they land; however, components that are not in shape-matched sites are removed by fluid forces initiated by the high-frequency ultrasound. Components in shape-matched sites are selectively retained because their adhesive force is stronger than the removal forces. Figure 1 is an optical micrograph showing the successful assembly of 1.6 µm diameter microparticles into designated sites on the substrate. Figure 2 shows how measured assembly yield of microparticles into holes of slightly different sizes increases with the contact area between particles and substrate.

This approach to assembly is inherently selective. Since each component will adhere only in a shape- and size-matched site, geometrically distinct components will assemble only into their designated assembly sites. Therefore, the organizing information is allowed to be stored in the template initially, and components that may not be compatible with top-down manufacturing techniques can be added to the system later, with high positional precision. Work is in progress to demonstrate this approach in smaller-size scales and to create practical nanosystems using this technology.

Figure 1: Optical micrograph showing four particle-filled holes and one empty hole.

Figure 2: Plot of assembly yield (number of particle-filled holes/total number of holes) vs. contact area between particle and hole. Assembly yield increases from 0% to 100% as quality of the shape match improves.