In this project, an effective technique for site-selective, multicomponent assembly at the nano- and micro-scale has been created and quantitatively modeled. This approach offers great promise for assembling arbitrary (not necessarily periodic) systems of multiple different types of nanoscale components, such as electronics (memory, logic, interconnects, displays) and sensor systems.

The key elements of the approach follow. 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, and 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 600 nm and 2 µm diameter silica microspheres into designated sites on the substrate. Figure 2 shows how measured assembly yield of spheres into holes of slightly different sizes increases with the contact area between spheres 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. This allows the organizing information to be stored in the template initially, and permits components that may not be compatible with top-down manufacturing techniques to be added to the system later, with high positional precision. Work is underway to demonstrate this approach at smaller size scales and to create practical systems using this technology.

▲ Figure 1: Optical micrograph of 600 nm and 2 µm spheres assembled into designated sites on a surfaces.

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