Templated Assembly by Selective Removal

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Templated assembly by selective removal (TASR) is an effective technique for site-selective multi-component assembly at the nano- and micro-scales. In this project, the TASR approach has been created and quantitatively modeled; work to expand the technology and demonstrate practical applications is now underway. The TASR approach offers great promise for assembling arbitrary (not necessarily periodic) systems of multiple different types of nanoscale components, such as electronics and biological or chemical sensing devices. It also offers a path to a new kind of shape and size selective chromatography.

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 force, which is initiated by the high-frequency ultrasound. The fluid forces create a moment that rolls components from mismatched holes. Components in shape-matched sites are selectively retained because the adhesive forces create a stronger moment that retains components in matching holes. Figure 1 is an optical micrograph showing the successful assembly of 600-nm- and 2-mm-diameter silica microspheres into designated sites on the substrate. The TASR approach has been demonstrated for component sizes down to about 400 nm and with a variety of excitation and interaction strengths. Figure 2 shows how the assembly yield (the ratio of the number of filled sites to the total number of sites) varies with the ratio of the retention moment to the removal moment.

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. The TASR method 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. Present work is focused on the creation of improved models based on molecular dynamics simulations, extension of TASR to smaller size scales and a diverse set of component shapes and materials, and improved template fabrication techniques, with the goal of demonstrating practical applications enabled by the TASR approach.

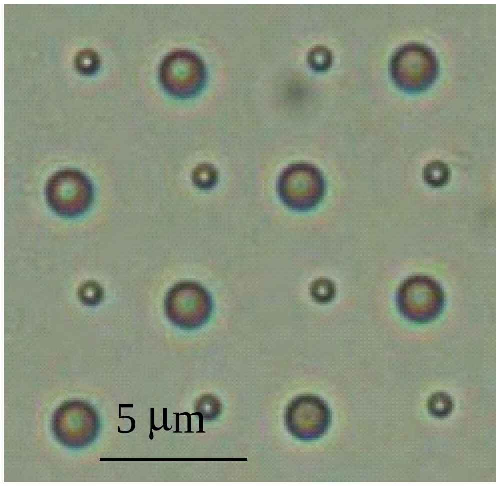

Figure 1: Optical micrograph of a template with assembled spheres of two different sizes.

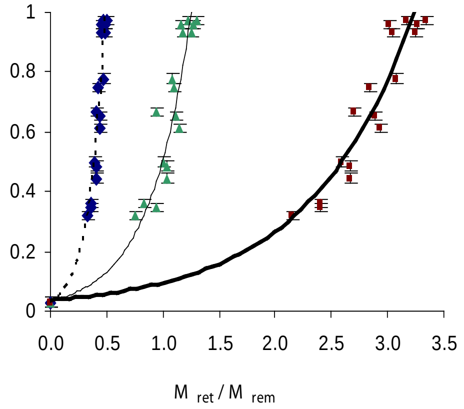

Figure 2: Plot of yield versus retention to removal moment ratio for the simultaneous assembly of 636-nm- and 2-µm-diameter spheres with various excitation and interaction strengths. The plot shows the actual data points and the fitted curves for the cases of minimum, nominal, and maximum moment ratios.

REFERENCES

[1] S. Jung and C. Livermore, "Achieving selective assembly with tem-plate topography and ultrasonically induced fluid forces," *Nano Letters*, vol. 5, no. 11, pp. 2188-2194, Nov. 2005.