BAPVC Annual Project Report

Project Title: Large-Area, Fast, and Electric-Field Assisted Continuous Coating for Nanostructured Photon Management

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Summary:
The group has investigated three individual key components in the proposed coating process, i.e., the electric field, the convective flow, and the interfacial assembly. The electric field has been successfully utilized to generate uniform arrays of colloidal tetrahedrons, demonstrating a potential path to make arrays of plasmonic and photonic clusters for photon management. Both interfacial assembly and convective flow can generate periodic patterns of micro- and nanoparticles with tunable spacings too.

Key Accomplishments:
The application of low-power AC electric fields could modulate the interactions between colloidal particles in solution in a precise fashion. A number of attractive and repulsive forces can be tailored in different directions. During the past year, we have discovered the method for building colloidal clusters and arrays of colloidal clusters from particles that are isotropic in both geometric and interfacial properties. As shown in **Fig. 1**, a large array of colloidal tetramers with high monodispersity has been fabricated.[1] These tetramers could potentially be fixed using several reported methods. Colloidal tetramers are of special interest because they could potentially form diamond-like lattices for photonic crystals. The clusters of metallic particles could also possess superior plasmonic properties than individual spheres. Moreover, the group has demonstrated that this method is based on physical principles that can be applied to a variety of particles with different materials properties.

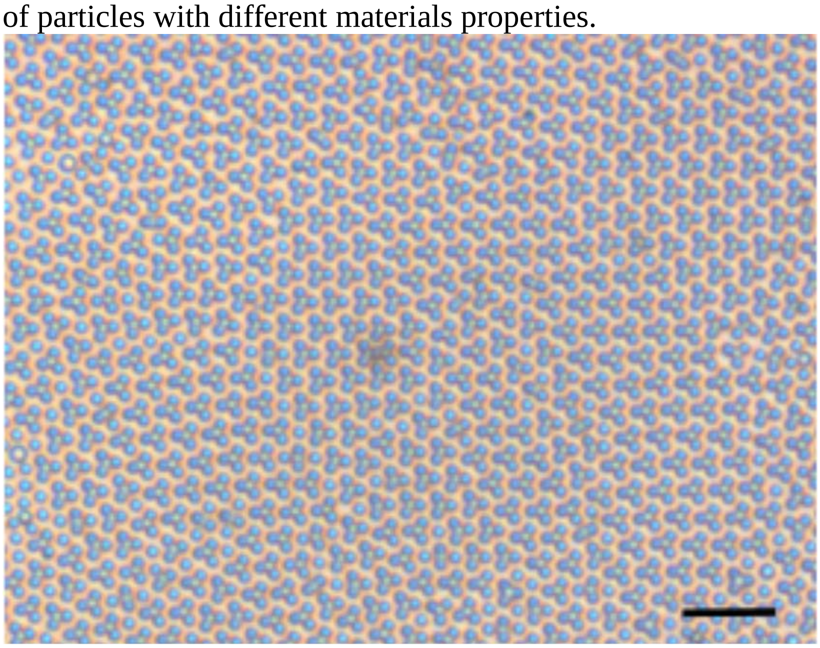

Fig. 1 Large array of colloidal tetramers with high monodispersity. Scale bars: 10 μm.

The convective and interfacial assembly have also been explored. In particular, the particles (silica or polystyrene) are dispersed at the interface between air and alcohols. Although periodic arrays have been found at all three interfaces, the methanol-air interface generates the arrays with the best qualities. Moreover, the inter-particle spacings can be conveniently tuned by the initial particle concentrations, as shown in **Fig. 2**.

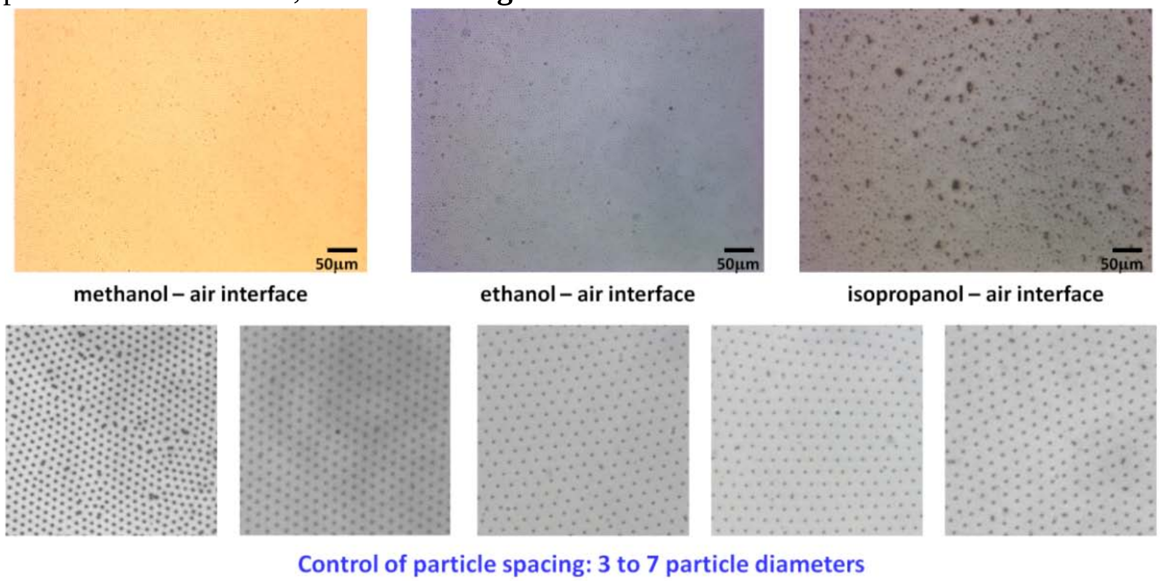

Fig. 2 The interfacial assembly of colloidal particles (silica and polystyrene) with tunable particle-particle spacings.

Future Work:

In this year, we plan to integrate the electric-field assembly with convective flow and/or interfacial assembly with a custom-built setup (**Fig. 3**). Our goal is to fabricate the periodic arrays with both dielectric (silica or polystyrene) and metallic (silver or gold) particles on ITO glass and silicon wafer. The parameters that could impact the quality of coating such as humidity, field strength, solvent evaporation rate, and coating speed will be investigated. The optical properties will also be measured.

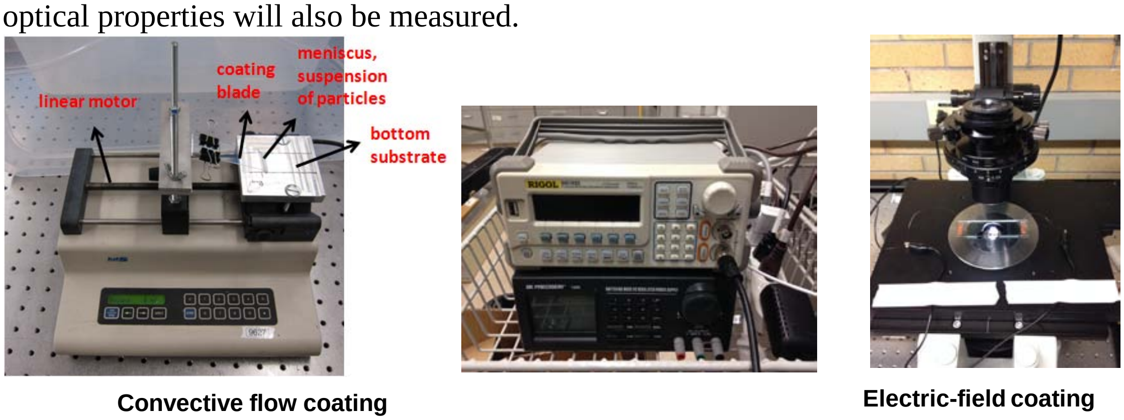

Fig. 3. Custom-built flow-coating setup combined with electric fields.

Reference

1. Ma, F., Wu, D. T., and Wu, N. Formation of Colloidal Molecules Induced by AC Electric Fields, J. Amer. Chem. Soc. 2013, 135, 7839-7842