Particle Deposition from Evaporating Drops

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Evaporating drops are used as highly parallelizable means of depositing and organizing small particles and solutes, including the organization of nanoparticles and the deposition of solutes on microarrays for rapid throughput analysis. Two means of influencing this process are explored.

First, surfactants at the liquid-gas interface are used to influence the stresses there. An evaporating sessile drop has a flow field within it. Submicron particles suspended within the drop are convected and deposit on the substrate in patterns dictated by the flow. Surfactants change the flow field dramatically, and hence alter the deposition patterns of the particles. In this talk, experiments on evaporating sessile drop with surfactant in various states of aggregation on the interface are presented. The particles deposit in a variety of patterns as a function of surfactant surface state. In particular, conditions are identified in which surfactants cause the drop to enter Marangoni Benard convection with spontaneous deposition of particles in polygonal patterns beneath the drop.

Then, surfaces of patterned wettability are used as substrates, with small wet features on a continuous, poorly-wet surface. Evaporating drops with diameters large compared to the dimensions of the patterns are studied. As the 3 phase contact line of the drop recedes, spontaneous dewetting of the hydrophobic domains and flow into the hydrophilic domains creates discrete fluid elements with peripheries that mimic the underlying surface topography. Suspended particles are carried with the fluid into the wetted regions, and deposit there in a variety of patterns as the discrete fluid domains evaporate, including ‘coffee ring’ patterns at the feature boundaries, incomplete monolayers, and ordered multilayers. Simple criteria for inclusion of particles within the wetted features are developed, based on particle dimension, contact angle and feature size.