Effects of Surface Heterogeneity and Roughness on Colloidal Interactions

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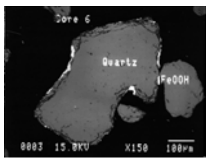
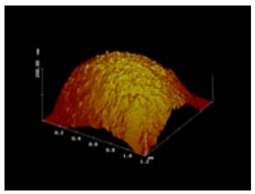
Significance

Solid phases in engineered and natural systems exhibit both physical (roughness) and chemical (charge) heterogeneities. Knowing the extent and distribution of surface heterogeneities is essential for understanding the interaction between colloidal particles and surfaces.



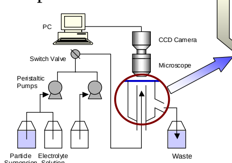
Chemically heterogeneous quartz grains from a sandy aquifer (Cape Cod, MA)

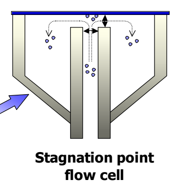


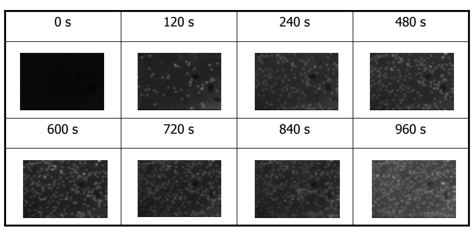
AFM scan of the top of a 2.5 micron diameter TiO_2 particle showing the roughness.

Direct Observation of Colloid Deposition onto Solid Surfaces

Stagnation Point Flow Setup





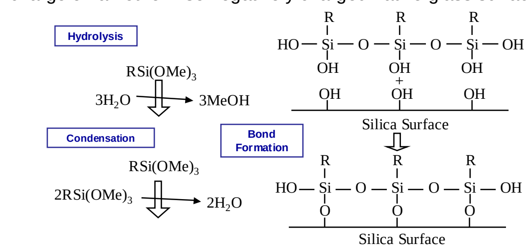


Snapshots of deposited particles from which particle deposition and release rate constants can be determined

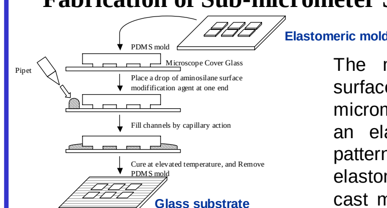
Studying Microscopic Chemical Heterogeneity

Surface Charge Modification

Surface charge of glass surfaces can be modified by silanization. When using aminosilanes, the silanized regions acquire a positive charge on an otherwise negatively charged native glass surface.

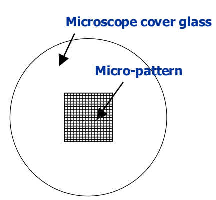


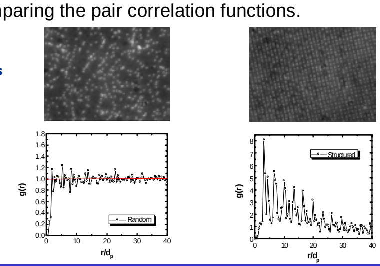
Fabrication of Sub-micrometer Scale Heterogeneity



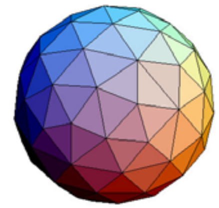
The micropatterns of silanized surfaces are fabricated by micromolding in capillaries with an elastomeric mold having a patterned relief surface. The elastomeric mold is prepared by cast molding over a master chip having the desired relief structure.

A stagnation point flow system is then used to study the influence of microscopic charge heterogeneity on deposition kinetics of colloidal particles. The marked difference in the distribution of deposited particles on homogeneous and micropatterned glass surfaces can be further quantified by comparing the pair correlation functions.



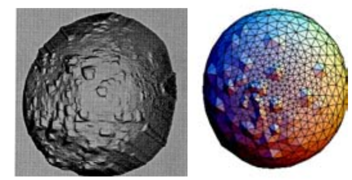


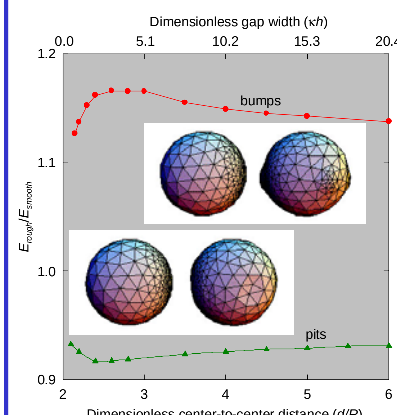
Modeling Surface Roughness Effects



A boundary element model was developed to calculate the electrostatic interaction between particles. Here, the surface of each particle is represented via a set of triangular elements. The size of the elements in each region is adjusted to better match the local curvature and the relative contribution of the region to the electrostatic interaction.

One of the of the major advantages of this approach is that essentially any surface topology can be represented. For example, shown at far right is a discretized representation of a *Cryptosporidium parvum* oocyst, a water-borne pathogen. The schematic at near right is an AFM scan of an oocyst.





Shown at left is a graph demonstrating the effect of roughness on the electrostatic interaction energy between two particles. The graph plots the ratio of the energy with roughness relative to that without roughness versus the center-to-center distance. Two specific types of roughness, bumps (positive asperities) and pits (negative asperities) are shown.