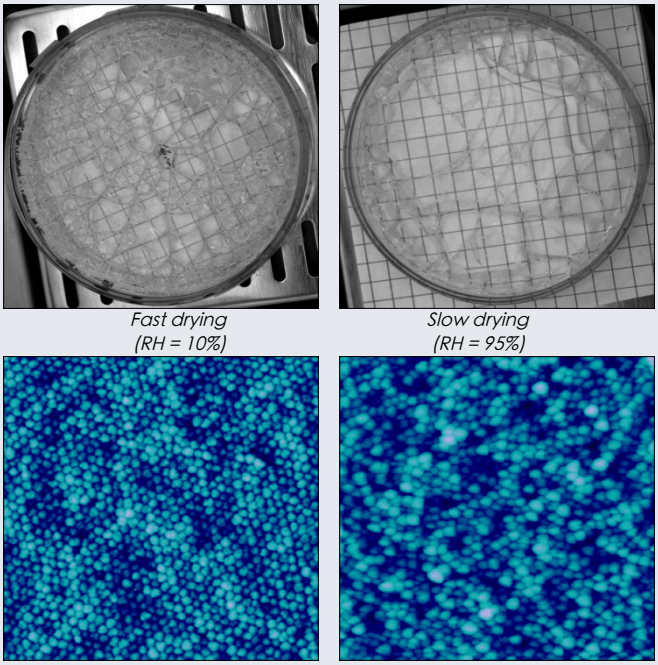
How to understand fracture and self-organization in dried colloidal suspensions?

C. L. Rountree, A. Lesaine, D. Bonamy (SPEC, CEA (SPEC), G. Gauthier, V. Lazarus (FAST).

Drying a colloidal suspension results in the formation of a porous solid layer. This procedure is central to many applications such as sol-gel processes, the design of paints and lacquers... Evaporation of the solvent induces shrinkage of the material, subsequently leading to large stresses developing in these layers, making them prone to fracture. A crucial challenge is thus to understand the role of the control parameters, such as drying rate, film thickness and particle size, on the structural and mechanical properties of the final layer.

Using Ludox HS-40 (colloidal silica) as a model system, we show the effect of the drying rate on the elastic and structural properties of the resulting solid. Counterintuitively, faster drying leads to a denser, more ordered layer with higher crack density, whereas slow drying yields an amorphous solid with larger morsels. The observed dependence of elastic properties on porosity was contrasted with the predictions of homogenization models and was found to agree well with the self-consistent scheme.



Fast drying (RH = 10%) *Slow drying (RH = 95%)*

Surface of dry layers (AFM images, 500nm x 500nm)

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A. Lesaine, D. Bonamy, G. Gauthier, C. L. Rountree and V. Lazarus, *Highly porous layers of silica nanospheres sintered by drying: Scaling up of the elastic properties from the beads to the macroscopic mechanical properties,* (2017)

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