Shear banding in films of drying colloids

Bin Yang[1], James S. Sharp[1] and Mike I. Smith[1]

[1] *School of Physics, University of Nottingham, UK*

Corresponding author: mike.i.smith@nottingham.ac.uk

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Suspensions of drying colloids exhibit a variety of interesting strain release mechanisms during the processes of film formation [1,2]. Although often undesirable in a coating, these failure processes (such as crack formation) are often periodic, revealing underlying lengthscales which aid fundamental understanding. In this paper we study the formation of intriguing bands which form at 45 degrees to the drying front (Fig. 1). We show [3] that these periodic patterns are shear bands, similar to those commonly observed in bulk metallic glasses subjected to an external stress and explain why they form.

Experimental measurements indicate that the ratio of the bandwidth to band spacing depends on particle size and salt concentration (which effect film yield stress), and the evaporation rate of the colloidal suspension. This ratio can be understood in terms of the drying rate of the film and a yield stress dependent critical strain rate. We show that below the critical drying rate, the ratio obeys a simple Lever rule.

To study the cause of shear band formation, we measured the local deformations in the early stages of drying films using fluorescent tracer particles. The measurements show that shear bands form due to the film compaction perpendicular to the drying front in the initial stages of film formation. The spacing of shear bands was also found to be strongly correlated with the characteristic length scale of the compaction process.

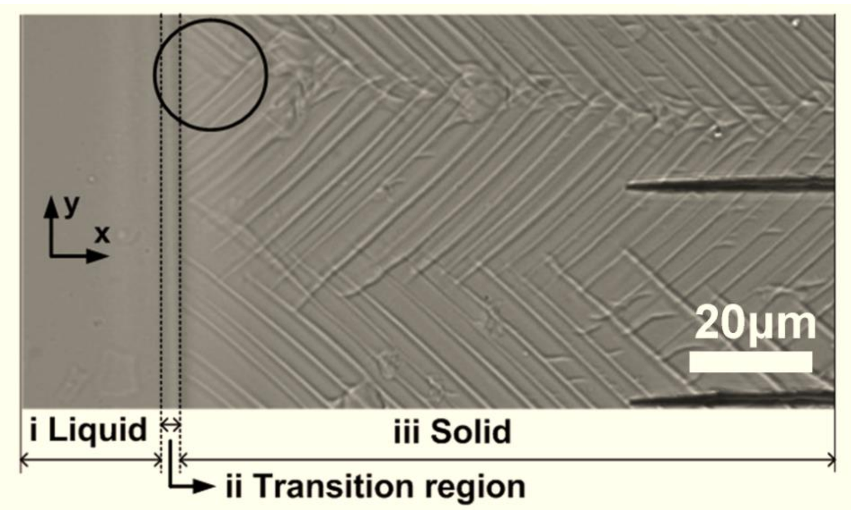

Fig. 1. Microscope image of a drying film of 50nm PS colloids showing shear bands at 45° to the direction of drying.

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References

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