Three-dimensional real-space analysis of colloidal dispersions under shear flow

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We studied the microstructure of concentrated colloidal dispersions undergoing shear flow in a cone-plate shear cell using confocal fluorescence microscopy. The cone and plate of the cell are counter-rotating so that a plane of zero velocity is formed in the dispersion, in which individual particles can be held stationary. Variation of the relative rotational velocities of the cone and plate allows one to move the zero velocity plane through the dispersion. This way, shear-induced structures can be observed in real-space and in three dimensions and flow profiles can be observed directly. Our technique thus provides a welcome supplement to scattering studies, which provide information in reciprocal space and produce an average over many particles.

This microrheology technique was applied to concentrated colloidal dispersions of monodisperse, fluorescent pmma spheres. Depending on the volume fraction and shear rate we observe shear-induced melting and shear-induced crystallization. Since individual particles can be tracked during shear flow it is now possible to follow the dynamics of these phenomena on a single particle level. The evolution of order within crystal planes as well as among crystal planes is investigated. Crystal planes are further observed to perform a zig-zag motion while sliding over each other. This, as well as the statistics of random particle motions are measured on approach of the shear melting transition.