

DFD08-2008-000860

Abstract for an Invited Paper
for the DFD08 Meeting of
the American Physical Society

Slip, droplets, complex fluids and other small things investigated with microfluidic technology

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Microfluidics is about flows of liquids and gases in miniaturized systems fabricated by MEMS (i.e. Micro ElectroMechanical Systems) technology, using hard (silicon or glass) or soft (polymers) materials. The domain is fostered by exciting applications representing important industrial challenges. It also embraces a number of fundamental issues interesting in their own right. The talk will concentrate on some of them through a presentation of a number of experiments we have been carrying out at ESPCI over the last three years. The first topics is about slip phenomena in liquids which benefit from the excellent flow control provided by the microfluidic environment. Measurements of flow velocities down to 30 nm from the wall, with and without applied electric fields, over smooth and superhydrophobic surfaces allow to reveal spectacular effects induced by the existence of slippage however small the related slip lengths can be. The second topics is about droplets. Controlling interface dynamics in immiscible fluids is a general challenge that microfluidic technology is facing. Experiments repeatedly recall that even in the simplest situations, droplet may develop complex dynamical behaviors. Nonetheless, low Reynolds number conditions and the complete control of the flow geometry offers the possibility to produce complex structures under outstanding control, such as multiple emulsions, capsules, opening the route towards the synthesis of new particles. The third topics is about rheology of complex fluids. Operating in miniaturized formats allows to obtain both large shear rates and low Reynolds numbes. Experiments carried out in straight microchannels show how this possibility can be exploited to resolve for the first time the rheology of surfactant solutions at high shear rates along with analyzing non newtonian flow instabilities.