Balancing Capillary, Viscous, and Vibrational Mechanisms for making High Surface Energy Liquid Spread over a Solid Substrate

Gennady Altshuler and **Ofer Manor**

*Small Scale Transport Laboratory*

*Department of Chemical Engineering*

*Technion – Israel Institute of Technology, Haifa*

Substrate vibration is known to excite dynamic spreading of micron thick films of low surface energy liquids; this spreading mechanism is sometimes referred to as Acoustic Spreading. Previous work in this field has concentrated on low surface energy and high viscosity liquids such as silicon oil, where Acoustic Spreading is naturally excited under substrate vibration in the HF and VHF radio frequency range (i.e., 1-300 MHz). High surface energy and low viscosity liquids, such as water, were found however to resist spreading under similar excitation of low and medium power levels; applying high power levels of excitation in these systems, water was found to undergo weak and limited spreading but to further undergo capillary-acoustic instability that breaks the surface of the liquid film.

Water is the natural carrier of many chemical and biological agents on microfluidic platforms and other laboratory equipment so that governing the spreading of water films is vital for implementing this spreading mechanism as a viable technology. Here we present new results on the spreading of high surface energy liquids, and in particular water.

We use theory and experimental evidence to discuss the spreading of liquid films that possess arbitrary surface energy under the influence of substrate vibration. We show opposite contributions of capillary, viscous, and vibrational mechanisms are weighed within one non-dimensional number whose value governs the tendency of liquid to spread. We thus elucidate the discrepancy, observed in earlier studies, between the response of oil and water to high frequency vibrational excitation, and highlight a parametric region where precise manipulation of liquid spreading is achieved by carefully balancing the governing physical mechanisms. We further give evidence to explain the observed tendency of liquids to only spread under the influence of rather high frequency substrate vibration, highlighting additional physical mechanisms that dictate this requirement.