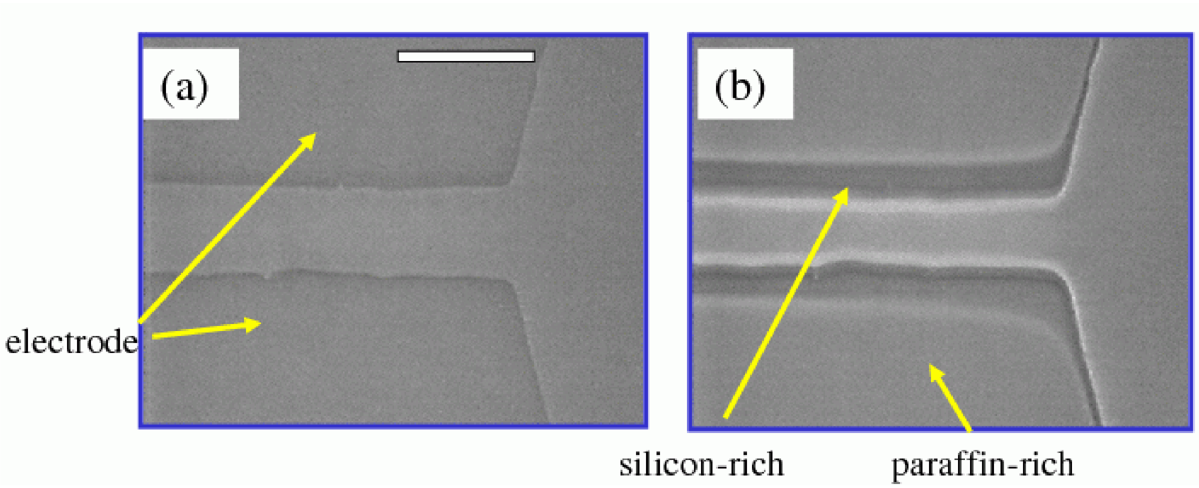
Research activity for Yoav Tsori:

The main aspect of the research in our group is a theoretical study of phase transitions in soft matter in electric fields.

Phase transitions in simple liquids in electric field gradients

When a mixture of two simple liquids, or a pure liquid in coexistence with its vapor, are under the influence of spatially uniform electric field, the critical temperature may change by a small amount, typically in the mK regime. Different scenario occurs when the external fields has gradients. In this case the change to the coexistence temperature is 2-100 larger than the change in uniform fields. The phase separation is reversible: when field gradients are turned off, the mixture becomes homogeneous again. We are investigating this new “electro prewetting” by pursuing analytical calculations and extensive computer simulations. In particular, we study the equilibrium properties of charged colloids in mixtures, the rich dynamical behavior (e.g. nucleation and migration of drops), and the role of critical fluctuations.



Field-induced phase transition in mixtures of simple liquids. (a) Field off. Two flat electrodes are covered with homogeneous mixture of silicon oil and paraffin. (b) Field on. Silicon-rich domains form close to the electrodes' edges, paraffin-rich phase is elsewhere. Bar is 50 μm [*Nature* **430**, 544 (2004)].

Preliminary experiments have revealed several interfacial instabilities, occurring as a competition between surface tension and electrostatic forces. In addition, as the size of the electrodes is reduced, surface tension becomes more dominant; at the scale of 50 μm we are able to achieve a large array of small drops of one liquid embedded in a matrix of the second liquid.
The phase transition may have various applications in the nanotechnological world, since it benefits from field gradients near small conducting objects. Some of the promising directions studied by us are demixing in microfluidics channels, MEMS, and electro lubrication.

Orientation methods and phase transitions in block-copolymers

Numerous applications of ordered mesophases in soft materials have emerged in recent years. Few examples are antireflection coatings, photonic band-gap materials and waveguides, and ordered arrays of thin metallic wires. In these systems it is crucial that the crystalline domains are oriented in a specific direction. We focus on the alignment mechanism and order-order phase transitions of block-copolymers in external fields. We have shown that the block-copolymer morphology is determined by the complex interplay between interfacial interactions with the substrates, film thickness, lamellar period and external electric field. In a related study we show that a simple surface corrugation can be used to control the orientation of a smectic phase. Here, the elastic penalty of having distortions of a ``perfect'' bulk phase competes against the preference for a wetting layer.

The existing theoretical models for polymers in electric fields are inadequate to most polymers since they do not allow for mobile dissociated ions. When these ions are taken into account, Joule heating takes place and the system is driven out of equilibrium by the ionic current. We have shown that in this case strong forces appear and that these forces can induce a phase transition or apply a torque on the system. Moreover, the strength of these forces can be tuned by controlling the ionic density, valency and mobility. Lastly, we study theoretically the effect of nonuniform electric fields on the phase and orientation of block-copolymers.