Charge patterns from water dewetting

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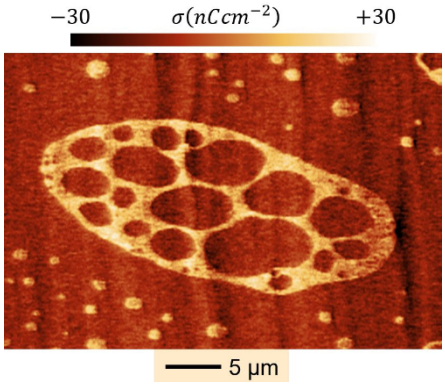
Dewetting of water from partially wetting surfaces is a ubiquitous phenomenon that leads to charge separation: charges are deposited on the dewetted solid surface, while the receding water acquires an equal net charge of opposite polarity. We employ high-resolution frequency-modulated Kelvin probe force microscopy (FM-KPFM) to investigate surface charge patterns generated by withdrawing polystyrene coated substrates from a pool of water. The 27-70 nm thick polystyrene films were deposited on an indium tin oxide electrode supported by a glass plate. We observe oval charge patches and polygonal charge features up to 100 μm in size, with no corresponding topography. These patterns form predominantly at higher withdrawal speeds (~10 mm/s) and under conditions of slow evaporation at high relative humidity near the receding contact line. We attribute these patterns to the dewetting dynamics of nanoscopically thin water films. Based on the observed charge distributions, we propose a three-step charging mechanism: (1) In water, the polymer–water interface typically becomes negatively charged, with positive counterions in the diffuse layer. (2) During bulk water dewetting, a thin water film is formed at the macroscopic receding contact line, in which the positive counterions are slightly depleted. (3) Subsequently, the thin film dewets and thereby concentrates the positive ions, leaving behind regions enriched in negative ions and forming distinct positive charge patterns.

Keywords:
water dewetting, thin film formation, thin film dewetting, dewetting electricity, charge patterns



A positively charged "puddlet" on a negatively charged background observed on a water-dewetted polystyrene thin film. The tessellated hole pattern within the puddlet indicates the transient formation of a thin water film during dewetting, induced by dipping the sample into a pool of pure water..