Breath figures under electrowetting

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We show that an electric field in an electrowetting (EW) configuration (Fig. 1(a)) can be used to actively control the pattern of drops condensing onto flat hydrophobic surfaces (breath figures). Understanding condensation of vapor on functionalized surfaces is scientifically challenging and simultaneously technologically relevant (heat transfer; fog harvesting). A quantitative description of the positional and size distribution of the drops, in conjunction with electrostatic energy calculations, reveals how EW strikingly modifies condensation patterns by aligning drops and enhancing coalescence (Fig. 1(b)). Such alignment results in a definite periodicity of the droplet pattern, which is determined by the electrode geometry. The EW-controlled evolution of drop condensation pattern significantly alters the statistical characteristics of the entire ensemble of droplets from those established for classical breath figures. A scaling analysis shows that under EW, the evolution of the drop size distribution displays self-similar characteristics that significantly deviate from classical breath figures on homogeneous surfaces once the electrically induced coalescence cascades set in beyond a certain critical drop size. We also show using preliminary heat transfer measurements that the droplet pattern characteristics under EW eventually lead to enhanced net heat transfer. We hope that this study will not only trigger a general theoretical analysis of drop condensation patterns in arbitrary energy landscapes but will be also useful for optimizing various applications involving dropwise condensation, like heat exchangers.

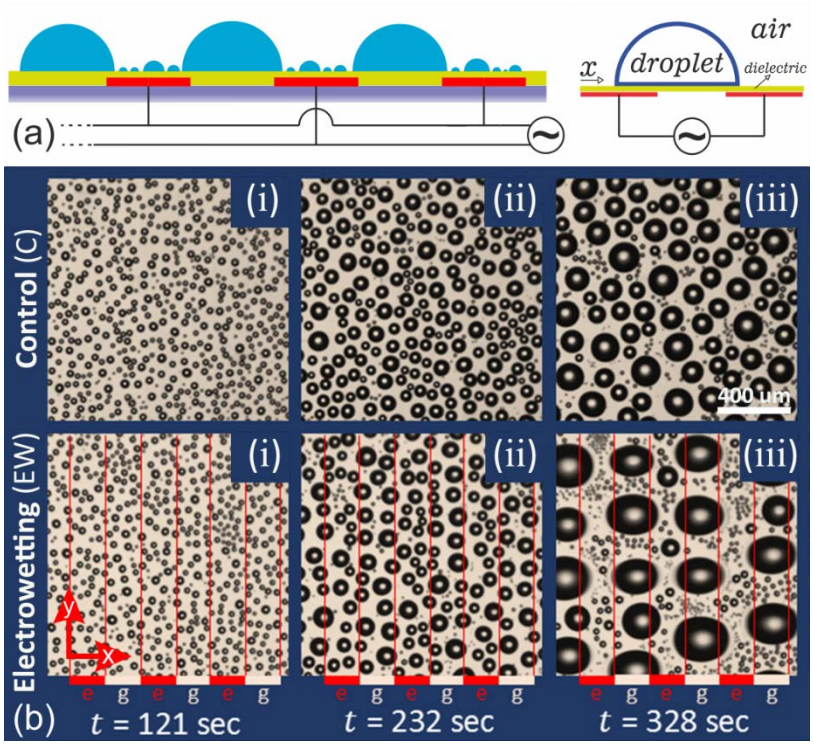

Fig 1(a) Schematic of the substrate used for the condensation experiments. Transparent interdigitated ITO electrodes are patterned on the glass substrate, which is then coated with a hydrophobic dielectric polymer film. A schematic of a condensate droplet under EW is also shown. (b) Comparison between breath figures without EW (control) (C-i to C-iii) and under EW (U_{rms} =150 V; f=1 kHz) (EW-i to EW-iii) at different time (t) instants. The (e)lectrode-(g)ap geometry underneath the dielectric film is indicated by the solid red and white lines. Gravity points from top-to-bottom i.e. along the negative y--direction.

REF:

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