Enhancing 'breath figures' using electric fields

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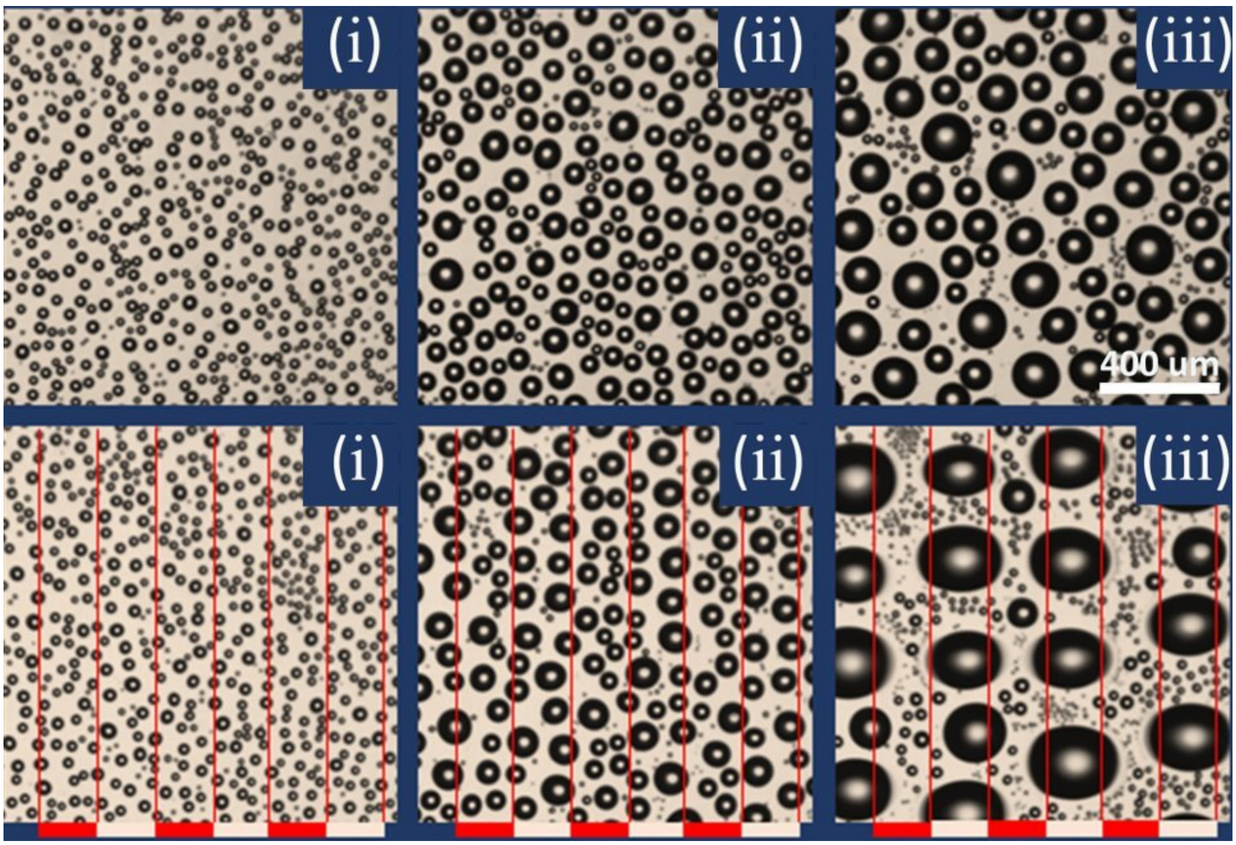

Development of droplet size and distribution in time, without electrowetting (upper images) and with electrowetting (lower images) . Credit: University of Twente

Breath figures are the typical condensation patterns we know from breathing on a cold surface. In physics, this term is used to describe dropwise condensation patterns. The evolution of these patterns and roll-off of droplets can be changed strongly under electric field effects 'electrowetting' - leading to higher heat transfer rates. Researchers of the University of Twente presented these findings in *Physical Review Letters*.

Dropwise condensation can be seen in many natural phenomena like dew formation; it is also the basis for technologies like heat exchangers, desalination units and water-harvesting systems. Optimizing these industrial applications requires thorough knowledge of the whole process of condensation, including droplet growth dynamics and mobility. It is possible to do this by modifying the surface characteristics, for example by applying a thin water-repellent coating that improves droplet mobility. The UT scientists now show it is also possible to actively influence the condensate droplets by embedding electrodes in the surface.

Applying electric fields changes the 'wetting state' of the surface. This is called electrowetting. The typical breath figure has randomly distributed drops, but under electrowetting, the evolution of condensation can be controlled. The electric field influences the distribution and the size of the droplets: they merge faster caused by the electric forces and form bigger droplets in shorter time. Furthermore they move to become aligned along each other.

Enhanced heat transfer

In this way, under electrowetting, the breath figure undergoes a major transformation of properties like surface coverage, size distribution and average radius. By rapid merging of droplets, their net surface coverage is reduced compared to typical cases, leaving more 'bare surface' for further condensation. Furthermore the droplets roll off faster on the surface. This increased mobility leads to more efficient heat transfer, as preliminary measurements show – done in collaboration with a research group of MIT. Apart from practical applications, like improved heat exchangers, the research gives more fundamental insights into theoretical analysis of dropwise condensation at a wide range of energy levels: it shows what the preferred locations for the alignment of droplets, for example.

The research has been done in the Physics of Complex Fluids group of Prof Frieder Mugele, part of the MESA+ Institute for Nanotechnology of the University of Twente. It was supported by the Netherlands Organisation for Scientific Research (division Applied and Engineering Sciences) and the Vici-programme.

More information: Davood Baratian et al. Breath Figures under Electrowetting: Electrically Controlled Evolution of Drop Condensation Patterns, *Physical Review Letters* (2018). DOI: 10.1103/PhysRevLett.120.214502

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