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Thermocapillary droplet actuation on structured solid surfaces[1]
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The present work investigates, through 2D and 3D finite element simulations, the thermocapillary-driven flow inside a droplet which resides on a non-uniformly heated patterned surface. We employ a recently proposed sharp-interface scheme capable of efficiently modelling the flow over complicate surfaces and consider a wide range of substrate wettabilities, i.e. from hydrophilic to super-hydrophobic surfaces. Our simulations indicate that due to the presence of the solid structures and the induced effect of contact angle hysteresis, inherently predicted by our model, a critical thermal gradient arises beyond which droplet migration is possible, in line with previous experimental observations. The migration velocity as well as the direction of motion depends on the combined action of the net mechanical force along the contact line and the thermocapillary induced flow at the liquid-air interface. We also show that through a proper control and design of the substrate wettability, the contact angle hysteresis and the induced flow field it is possible to manipulate the droplet dynamics, e.g. controlling its motion along a predefined track or entrapping by a wetting defect a droplet based on its size as well as providing appropriate conditions for enhanced mixing inside the droplet.

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