DROPLET PROPULSION AND DIRECTION CONTROL ON A PLANAR SURFACE USING A SELECTIVE LEIDENFROST EFFECT

L.E. Dodd[1], N.R. Geraldi[2] , B.B Xu[1], G.G. Wells[1], S. Stuart-Cole[3], J. Martin[1], M.I. Newton[2], G. McHale[1], and D. Wood[1]

[1]Faculty of Engineering and Environment, Northumbria University, Newcastle upon Tyne, UK; [2]School of Science and Technology, Nottingham Trent University, Nottingham, UK; [3]Reece Innovation, Newcastle upon Tyne, UK

Linzi.Dodd@Northumbria.ac.uk

The Leidenfrost effect is a bulk effect, involving the super-heating of fluids to the point whereby they are suspended by their own vapour layer and thus thermally insulated from the heat source below, thereby reducing the evaporation rate. The bulk nature of this effect means that its properties have not been used in many practical applications on the scale of droplets due to the high energy input required. Previous work has shown that the Leidenfrost effect can be achieved selectively on a planar surface using micron-scaled features, which are created photolithographically, providing energy savings at the micro-scale, macro-scale and also in the time domain via current pulsing[1]. In the macro scale, Leidenfrost propulsion has been achieved by super-heating brass structures in the form of herringbones[2], ratchets[3] and herringbone-ratchets[4]. By taking the original serpentine patterns, used to selectively heat the planar substrate to create the Leidenfrost effect, and positioning them in to a herringbone structure to replicate herringbone[2] and herringbone ratchet[4] structures, droplet propulsion and directional control can be achieved using a selective Leidenfrost effect. In this work, instead of using physical structures to control the vapour flow under the droplets, the selective heating of a planar surface uses thermal gradients to direct the vapour flow. Furthermore, the central region of the design has been modified to provide a lower current density region, which makes the centre of the Leidenfrost region cooler than the regions on either side, thus trapping the fluid droplet in the centre of the pattern. Interestingly, the direction of propulsion is in the opposite direction to that of the macro brass structure. It is believed that the hot regions directly above the serpentines have thicker vapour regions and convection occurs between the heated and unheated regions, causing the vapour flow to occur in parallel to the direction of the serpentines.

ACKNOWLEDGEMENTS: The authors thank the UK Engineering & Physical Sciences Research Council (EPSRC) for financial support (EP/L026899/1, EP/L026619/1, EP/L026341/1, and EP/P005896/1).

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