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RESEARCH PAPER

Droplet transport by electrowetting: lets get rough!

Florian Lapierre · Martin Jonsson-Niedziolka · Yannick Coffinier · Rabah Boukherroub · Vincent Thomy

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Abstract Since the pioneering works of Wenzel and Cassie Baxter in the 1930s, and now with the trivialization of the micro- and nanotechnology facilities, superhydrophobic surfaces have been announced as potentially amazing components for applications such as fluidic, optical, electronic, or thermal devices. In this paper, we show that using superhydrophobic surfaces in digital microfluidic devices could solve some usual limitations or enhance their performances. Thus, we investigate a specific monophasic (air environment) microfluidic device based on electrowetting integrating either a hydrophobic or a superhydrophobic surface as a counter-electrode. The droplet transport using a superhydrophobic surface compared with a classical hydrophobic system led to some original results. Characterization of the dynamic contact angle and the droplet shape allows us to get new insight of the fluid dynamics. Among the remarkable properties reported, a 30 % lower applied voltage, a 30 % higher average speed with a maximum instantaneous speed of 460 mm/s have been measured. Furthermore, we have noticed a huge droplet deformation leading to an increase by a factor 5 of the Weber number (from 1.4 to 7.0) on SH compared to hydrophobic surfaces. Finally, we discuss some of the repercussions of this behaviour especially for microfluidic device.

Keywords Electrowetting · Superhydrophobic surfaces · Hydrophobic surfaces · Droplet motion

F. Lapierre (✉) · M. Jonsson-Niedziolka · Y. Coffinier · R. Boukherroub
Interdisciplinary Research Institute (IRI), USR CNRS 3078, University of Lille 1, 50 Avenue Halley, 59658 Villeneuve d'Ascq, France
e-mail: florian.lapierre@csiro.au

R. Boukherroub
e-mail: rabah.boukherroub@iri.univ-lille1.fr

F. Lapierre · M. Jonsson-Niedziolka · Y. Coffinier · V. Thomy
Institute of Electronics, de Microelectronics and Nanotechnology (IEMN), UMR CNRS 8520, University of Lille 1, 59652 Villeneuve d'Ascq, France
e-mail: vincent.thomy@iemn.univ-lille1.fr

1 Introduction

Superhydrophobicity, super-repellent surfaces, extreme non-wettability, rolling-ball effect; it is clear nowadays, that these words are largely widespread both in the public opinion and in the scientific community. Since the pioneering works of Wenzel and Cassie Baxter in the 1930s, and now with the trivialization of the micro- and nanotechnology facilities, numerous papers have been published detailing and predicting some remarkable behaviour of these surfaces (e.g. high contact angle, low or null hysteresis, self-cleaning properties) (Zhang et al. 2005; Verplanck et al. 2007a, b; Zhang and Han 2009; Maali and Bhushan 2012; Dufour et al. 2012). Usually these reports announce potentially amazing properties for applications such as fluidic, optical, electronic, or thermal devices as recently outlined by Bocquet and Lauga (2011).

But despite all these particular performances, only textile and glass-coating industries have shown interest in these surfaces (Neverwet, Nanoshell, and Saint-Gobain). One can see that even if it is now quite "easy" to produce and characterize superhydrophobic surfaces, it is still not common to associate their properties to specific a setup in order to enhance their expected performances. In microfluidic domain, for example, no commercial applications