Towards computing with water droplets—superhydrophobic droplet logic

7 September 2012

Researchers at Aalto University, Finland, have developed a new concept for computing, using water droplets as bits of digital information. This was enabled by the discovery that upon collision with each other on a highly water-repellent surface, two water droplets rebound like billiard balls.

In the work, published in the journal *Advanced Materials*, the researchers experimentally determined the conditions for rebounding of water droplets moving on superhydrophobic surfaces. In the study, a copper surface coated with silver and chemically modified with a fluorinated compound was used. This method enables the surface to be so water-repellent that water droplets roll off when the surface is tilted slightly. Superhydrophobic tracks, developed during a previous study, were employed for guiding droplets along designed paths.

Using the tracks, the researchers demonstrated that water droplets could be turned into technology, "superhydrophobic droplet logic". For example, a memory device was built where water droplets act as bits of digital information. Furthermore, devices for elementary Boolean logic operations were demonstrated. These simple devices are building blocks for computing. (Video 1)

Furthermore, when the water droplets are loaded with reactive chemical cargo, the onset of a chemical reaction could be controlled by droplet collisions. Combination of the collision-controlled chemical reactions with droplet logic operations potentially enables programmable chemical reactions where single droplets serve simultaneously as miniature reactors and bits for computing. (Video 2)

"It is fascinating to observe a new physical phenomenon for such everyday objects – water droplets," tells Robin Ras, an Academy Research Fellow in the Molecular Materials research group.

"I was surprised that such rebounding collisions between two droplets were never reported before, as it indeed is an easily accessible phenomenon: I conducted some of the early experiments on water-repellent plant leaves from my mother's garden," explains a member of the research group, Henrikki Mertaniemi, who discovered the rebounding droplet collisions two years ago during a summer student project in the research group of Ras and Academy Professor Olli Ikkala.

The researchers foresee that the present results enable technology based on superhydrophobic droplet logic. Possible applications include autonomous simple logic devices not requiring electricity, and programmable biochemical analysis devices.

More information: Mertaniemi H., Forchheimer R., Ikkala O., and Ras R.H.A., Rebounding droplet-droplet collisions on superhydrophobic surfaces: from the phenomenon to droplet logic, *Advanced Materials* (2012). dx.doi.org/10.1002/adma.201202980

Provided by Aalto University