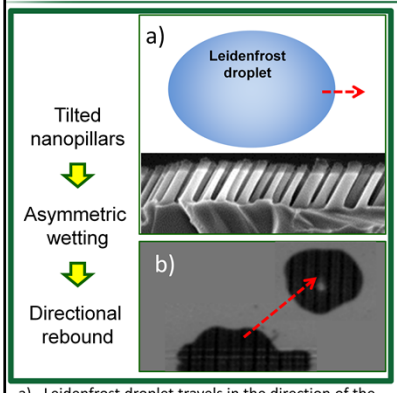
Asymmetric Wettability of Nanostructures Directs Leidenfrost Droplets



a) Leidenfrost droplet travels in the direction of the nanopillar tilt.
b) Asymmetric wetting of a tilted nanopillar array by a dynamic Leidenfrost droplet upon impact leads to directional rebound of the droplet

Scientific Achievement

For the first time a clear link between droplet directionality in the dynamic Leidenfrost regime and asymmetric wettability imparted by asymmetrically nanostructured surfaces has been established.

Significance and Impact

Directional self-propelled movement of droplets in partial liquid-solid contact opens up new scenarios for controlling heat transfer, hydrodynamic drag and fluid flows in multiphase systems with potential applications spanning from heat exchangers to marine vessels and microfluidics devices.

Research Details

- Fabrication protocols that rely on a combination of metal dewetting and glancing-angle reactive ion etching have been established and optimized in order to enable lithography-free processing of tilted nanopillar arrays.
- Analysis of recorded high speed video reveals that asymmetric wetting of the tilted nanopillar arrays leads to a directional rebound of the water droplets.

Work was performed at the Center for Nanophase Materials Sciences, ORNL

R.L. Agapov, J.B. Boreyko, D.P. Briggs, B.R. Srijanto, S.T. Retterer, C.P. Collier, N.V. Lavrik, *ACS Nano* **2013**, DOI: 10.1021/nn405585m.

U.S. DEPARTMENT OF ENERGY | Office of Science

Center for Nanophase Materials Sciences AT OAK RIDGE NATIONAL LABORATORY

OAK RIDGE National Laboratory

A water droplet deposited onto a surface heated above a certain temperature can levitate on a thin cushion of its own vapor. This phenomenon, known as the Leidenfrost effect, is associated with dramatically reduced friction and heat exchange between the solid and liquid phases and can also lead to directionally self-propelled droplets on surfaces with asymmetric micro and macro scale features resembling surface profiles in ratchet gears.

Here, we demonstrate for the first time that directionality of self-propelled Leidenfrost droplets can be achieved on surfaces with nanoscale features, namely, on tilted nanopillar arrays. High speed video analysis of bouncing Leidenfrost droplets on such asymmetrically nanostructured surfaces reveals an unexpected role of the asymmetric wettability of tilted nanopillar arrays during their intermittent contact with the Leidenfrost droplets as a key mechanism responsible for the directional droplet rebound and subsequent movement.

Reference:

"Asymmetric Wettability of Nanostructures Directs Leidenfrost Droplets"
ACS Nano DOI: 10.1021/nn405585m

Rebecca L. Agapov,[1] Jonathan B. Boreyko, [1] Dayrl P. Briggs, [1] Bernadeta R. Srijanto, [1,2] Scott T. Retterer, [1] C. Patrick Collier, [1] and Nickolay V. Lavrik[1]
[1]Center for Nanophase Materials Sciences, Oak Ridge National Laboratory,
[2]Department of Materials Science and Engineering, University of Tennessee

Acknowledgment :
This research was conducted at the Center for Nanophase Materials Sciences, which is sponsored at Oak Ridge National Laboratory by the Scientific User Facilities Division, Office of Basic Energy Sciences, U.S. Department of Energy.