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Trifurcated Splitting of Water Droplets on Engineered Lithium Niobate Surfaces

Controlled splitting of liquid droplets is a key function in many microfluidic and industrial applications. In recent years, various methodologies have been used to accomplish this task. In this work, I present an **optofluidic platform** based on an engineered surface formed by coating a z-cut iron-doped lithium niobate (**Fe:LiNbO3**) crystal with a lubricant-infused layer (**LIS**), which guarantees hydrophobicity and provides a very slippery and robust surface for prolonged use. Illuminating the crystal with a laser light spot creates surface charges of opposite signs on the two crystal faces because of the photovoltaic effect. In this way, sessile water droplets having volume of microliters (which correspond to millimeters in size) can be easily actuated, guided, merged and even split due to dielectrophoretic force; in particular in this work I focus my attention on the splitting of water droplets. If the illumination intensity is enough, a water droplet placed near the illuminated area can be split into two charged fragments: one fragment remains trapped in the illuminated area, while the other moves away from it. The presence of the lubricant layer with a proper thickness is crucial to observe the splitting of water droplets. The second fragment does not move randomly but rather follows one of three well-defined trajectories separated by 120°, which reflect the crystallographic anisotropy typical of Fe:LiNbO3. Numerical simulations explain the behavior of the splitting phenomenon of water droplets in the framework of the forces induced by the interplay of **pyroelectric**, **piezoelectric**, and **photovoltaic effects**, which originate simultaneously inside the LiNbO3 crystal, when illuminated. Such a synergetic effect studied in the proposed optofluidic platform can provide a valuable feature in applications that require splitting and coalescence of droplets, such as chemical microreactors, biological encapsulation and screening.

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