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ACCEPTED MANUSCRIPT

Dielectrowetting: The Past, Present and Future

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Abstract:

Liquid dielectrophoresis is a bulk force acting on dipoles within a dielectric liquid inside a non-uniform electric field. When the driving electrodes are interdigitated, bulk liquid dielectrophoresis is converted to an interface-localised form capable of modifying the energy balance at an interface. When the interface is a solid-liquid one, the wetting properties of a surface are modified and this approach is known as dielectrowetting. Dielectrowetting has been shown to provide the ability to reversibly modify the contact angle of a liquid droplet with the application of voltage, the strength of which is controlled by the penetration depth of the non-uniform field and permittivities of the fluids involved. Importantly, dielectrowetting provides the ability to create thin liquid films, overcoming the limitation of contact angle saturation present in electrowetting. In this paper, we review the development of dielectrowetting - its origins, the statics and dynamics of dielectrowetted droplets, and the applications of dielectrowetting in microfluidics and optofluidics. Recent developments in the field are also reviewed showing the future directions of this rapidly developing field.

Keywords: Wetting; Liquid Dielectrophoresis; Microfluidics; Optofluidics

1.1 Introduction:

The behaviour of liquid droplets on surfaces plays a fundamental role in both domestic and industrial environments; from the application of paint onto a wall to the dispersal of pesticides. Each of these processes benefits from the controllability of the wetting properties of both the surfaces and droplets involved in the system. Thus, the prominence of liquid surface interactions has led to the field of capillarity being one of the largest scientific fields of modern science [1]. The wetting properties of a surface are often defined by the contact angle θ, which for a droplet in air, is the angle between the liquid-vapor interface and the solid-liquid interface (see figure 1). The contact angle is the result of the local minimum in the surface free energy arising from the solid-vapor, solid-liquid and liquid vapor interfaces (γ_{SV}, γ_{SL} and γ_{LV}). This local energy minimum is described by the Young equation:

$$\cos(\theta_Y) = \frac{(\gamma_{SV} - \gamma_{SL})}{\gamma_{LV}} \tag{1}$$

While the equilibrium behaviour of a droplet is defined by equation 1, this is only applicable to ideal atomically smooth and chemically heterogeneous surfaces. Real world surfaces are often rough and inhomogeneous chemically, and in these cases the contact angle of a droplet exists between two extremes, the advancing and receding angle. This phenomenon is known as contact angle hysteresis [2] and controls the ability of a droplet to move over the surface. The wetting properties of a surface can be modified through changing the surface chemistry [3] or surface morphology [4], making the

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