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z-GrAdd_Facile Fabrication of Wettability Gradients Via DLP 3D Printing for Liquid Manipulation Applications

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Wettability gradients are particularly advantageous for controlled liquid imbibition and transfer, and they can be achieved through compositional variations in surface energy or topographical alteration of the surface, or both. Common methods to create wettability gradients including chemical modification of surfaces or the roughness patterning through etching and/or lithography are limited in scalability, do not allow for fabrication of complex structures with high resolution and often need costly equipment. Here, we present the z-GrAdd (z-Gradient by Addition of a reagent) method, which enables continuous alteration of resin composition during the layer-by-layer 3D printing, resulting in diverse gradient properties in z-direction. We demonstrate the fabrication of gradients in surface energy and porosity to create wettability gradients using a range of acrylate-based resins. Surface energy gradients (18–29 mN/m) with subsequent static contact angle variation of 86 ° to 71 °, and porosity gradient resulting in variation of roughness between 52–401 nm (Sq) and thus, SCA changes up to 50 ° (from 88 ° to 139 °) within a single structure were created using the z-GrAdd method. Versatile wettability gradient-related applications were shown. First, conical structures featuring different range of porosity gradients were utilized to control liquid imbibition rates, demonstrating advantages compared to structures with a uniform pore size. Second, porous structures with a uniform pore size but compositional gradient were fabricated through the z-GrAdd method and employed for passive droplet manipulation; the contact line of a water droplet only moved towards the more hydrophilic areas with larger pores or more hydrophilic properties and was able to even move uphill from one side. Our results prove that the z-GrAdd method can be used to create wide range of gradients including wettability gradients within a single structure along the z axis, and is suitable for various acrylate-based resin compositions using a cost-effective setup adaptable to various vat 3D printing systems.

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