Fabrication Optimization of Flexible 3D Micro-/Nano-structures for Potential Sensor Applications

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Micro-/nano-structured surfaces in nature inspire many cutting-edge applications. Chameleon skin contains flexible micro-/nano-structures that can be geometrically tuned in response to environment to create different colors. Inspired by chameleons, this research focuses on fabricating flexible hemi-ellipsoidal micro-/nano-holes that be used in a long-term project for colorimetric strain sensing. Precise fabrication of 3D micro-/nano-structures, especially flexible structures, is difficult due to the small scale. To address this challenge, a two-photon lithography system was used to fabricate a master with micro-/nano-pillars. A program was written to control the laser parameters of the system to produce a variety of pillars sizes. Then, a flexible polymer was cast over the master to create flexible micro-/nano-holes. After fabrication, a 3D laser-scanning microscope was used to obtain the surface height maps of the samples. To efficiently extract structure dimension data from hundreds of surface height maps, a MATLAB program was developed. A model was created using JMP software to establish the relationship between the process parameters and the final structure dimensions. The study confirmed that higher laser powers and longer exposure times produce larger structures, as expected. Interesting interactions between the process parameters were also revealed. The physics of two-photon lithography was used to explain observed phenomena. This study enables colorimetric strain sensors with extremely high resolutions that could be used for cell development monitoring and other cutting-edge applications in many fields. Furthermore, the developed fabrication processes, MATLAB program, and JMP model can also be adapted for creating micro-/nano-structures for other applications.