

Development of an Adjustable Intelligent Microstructured Imprinting Mold and Replication Process

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Abstract:

This study proposes a novel design and fabrication approach for intelligent polymer-based microstructured soft mold, aiming to enhance the precision and adaptability of microforming processes. We integrate auxetic geometrical structures with metamaterial properties and employ a specialized injection technique to dynamically regulate the mechanical properties and Poisson's ratio of the material. By controlling injection parameters and environmental conditions, we achieve effective modulation of the mold core's microstructural deformation characteristics, thereby improving the stability and reproducibility of imprinting-based replication. Additionally, this study develops a magnetically assisted injection technique to optimize the flexibility and functional adjustability of the mold core, further validating its feasibility in microfabrication applications. Through experimental and simulation analyses, we demonstrate that this method enables high-precision replication of microstructures and controllable deformation, offering a novel material design and processing strategy for micro-manufacturing technologies and advancing the development of intelligent micro-system components.

Keywords:

Microstructure, Negative Poisson's Ratio, Metamaterials, Polymer.