Optik 127 (2016) 5289–5294

Contents lists available at ScienceDirect

Optik

journal homepage: www.elsevier.de/ijleo

An application of composite soft material microstructure in development and formability of multi-axis dynamic transfer technology

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ARTICLE INFO

Article history:
Received 26 January 2016
Accepted 4 March 2016

Keywords:
Multi-axis
Dynamic transfer
Formability
Microstructure

ABSTRACT

This study examines the application of composite soft material microstructure in the technical development of multi-axis dynamic transfer, conducting forecast research aimed at the complementary microstructure. This study uses the PDMS soft materials of different proportions for multi-layer composition to research the characteristics of many composite inner-layer disperse materials and to discuss the mechanical properties of the composite soft materials. One innovation from this research is a multi-axis dynamic mold clamping system, which allows for a discussion of the anisotropic asymmetric dynamic regulation microstructure within the elastic range; controls its appearance characteristics effectively within the elastic range of the microstructure soft mold materials; deduces the appearance characteristics after multi-axis dynamic regulation transfer through the mathematical and geometrical principles; and makes a comparison with the result after the actual impression. The result shows that the composite soft mold proposed in this experiment has a better material mechanical property versus the traditional soft mold, and that the dual-axis dynamic clamping system developed and designed in this research can effectively regulate the microstructure dynamically. Finally, the deduced forecast method also conforms to the experiment result and provides more microstructure-oriented usage and innovation procedures for application in the microstructure industry.

1. Introduction

Microstructures and micro-systems [1–3] are initially used in the design and micro-assembly process and usually under consideration of actual industrial demand. For the mold assembly design, micro-regulation is possible under the condition that the mold can be forecasted with many purposes and adaptations to many configurations [4–7]. However, in the large-scale reproduction process, there are many deformation modals for the actual molds, and they can adapt to various configurations within the tolerance, which is typically not easy [8–10]. Such a problem needs to be urgently solved in the scale-production process of micro-system assembly as well as the research and development of microstructure molds.

This study targets the application of composite software microstructure in the development and formability of multi-axis dynamic transfer technology aimed at the problem above. First, this study makes a soft mold of composite material microstructure, discusses its deformation and relevant mechanical properties within the elastic range, deduces the appearance of the dynamic deformation theory of a microstructure mold in the process of multi-axis dynamic tension, and designs and develops a multi-axis dynamic mold clamping system. Finally, a micro-tensile impression is conducted in the system, and the deformation characteristics are compared with the forecasted characteristics before formation to confirm the formation forecast and the actual formability of the appearance dynamic deformation theory of the microstructure mold.

2. Experimental

2.1. Multi-axis dynamic transfer system

This research independently develops and designs a multi-axis dynamic transfer system, including a four-axis dynamic mold clamping system (Fig. 1) and a three-axis dynamic mold

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http://dx.doi.org/10.1016/j.ijleo.2016.03.016

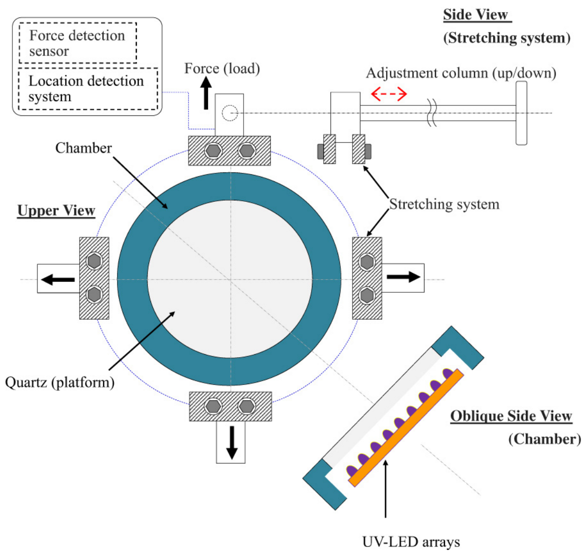

Fig. 1. Schematic diagram of a four-axis dynamic mold clamping system.

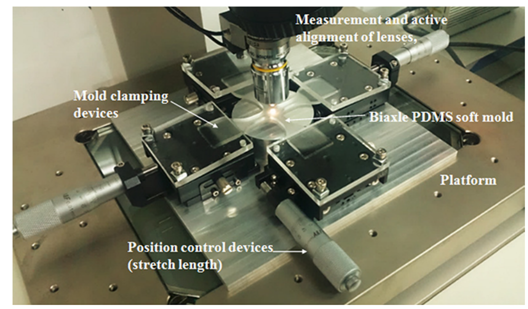

Fig. 3. Seat of four-axis embossing molding of a multi-axis dynamic transfer system.

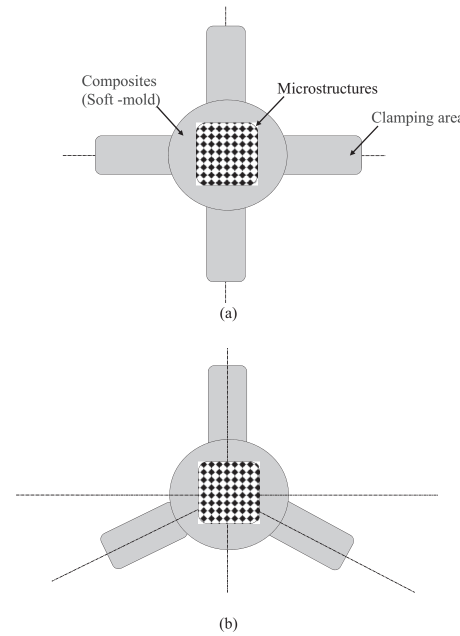

Fig. 4. Microstructure soft mold with (a) four axes of central symmetry, (b) equal angle of three axes.

clamping system (Fig. 2). The design of an axial dynamic mold clamping system mainly takes the axial clamping system of individual units as the unit, and through the setting of angular symmetry it form the multi-axis dynamic mold clamping system. This system consists of four important mechanism systems: clamping, one-way application of force, regulation of relative height position (inclination setting), and displacement detection. They form a multi-axis dynamic clamping system, and the main body of the system is an imprinting device, as shown in Fig. 3.

2.2. Appearance design, selection of materials, and resist of composite soft material microstructure mold

The microstructure soft mold in this research is designed into a circular plate in the middle, in the form of central symmetry and divergence in both four directions and three directions, so as to provide the force direction of clamping, as shown in Fig. 4. The microstructure soft mold material allows one to composite a microstructure soft mold as an embossing mold with PDMS (Polydimethylsiloxan, Sylgard^{TM} 184, Dow Corning) combined with iron powder and unequal-proportion PDMS. The resist selected is SU8 ultraviolet curing photoresist, which exhibits an epoxy structure.

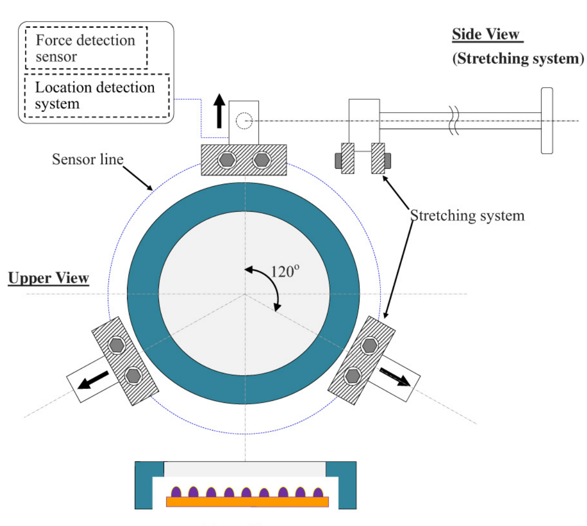

Fig. 2. Schematic diagram of a three-axis dynamic mold clamping system.

2.3. Micro-tensile test of composite soft material microstructure

The composite soft material microstructure mold in this research is mainly to composite the iron powder of unequal-proportional content and the PDMS microstructure soft mold of unequal-proportional curing agent (Fig. 5), so as to improve the structure Young's modulus, mechanical strength, and duration of the materials in the process of embossing. For the microstructure soft mold of iron powder of different proportions, after the micro-tensile test, Table 1 lists the material mechanical property found.

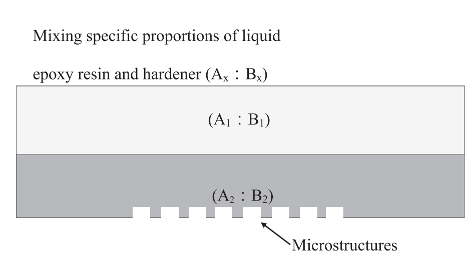

Fig. 5. Schematic diagram of PDMS microstructure soft mold with different proportions of a curing agent.