Experimental and Numerical Simulation of Hot Embossing for Fabrication of Glass Microlens Array

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ABSTRACT

In this work, a hot embossing process for replication of glass microlens array (MLA) on optical glass substrate is proposed. Both numerical simulation and experimental validation were employed to investigate the filling behavior of the glass material into the microstructure mold cavities. The finite element method (FEM) was carried out using Ansys software after the establishment of the model layout and boundary condition. For validation, the K-PG375 optical glass samples were pressed at a temperature above the glass transition temperature Tg, using a home-made hot embossing setup. Then, the correlation between two- dimensional (2D) FEM analysis and experiments were established, which provide a guideline for understanding of the glass filling behavior in the viscoelastic region. The replication quality of the embossed glass was confirmed using scanning electron microscopy (SEM) and atomic force microscope (AFM). Overall, the simulation result gave a very useful insight to predict the optimum processing condition for the thermal replication process primarily the temperature, pressure and holding time.

KEYWORDS: Atomic force microscopy, embossing, finite element analysis, glass transition, microlenses, moulding, optical fabrication, optical glass, scanning electron microscopy, viscoelasticity

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REFERENCES

[1] Shin, So-Ra, Hock Beng Lee, Won-Yong Jin, Keum-Jin Ko, Sunghee Park, Seunghyup Yoo, and Jae-Wook Kang. "Improving light extraction of flexible OLEDs using a mechanically robust Ag mesh/ITO composite electrode and microlens array." Journal of Materials Chemistry C 6, no. 20 (2018): 5444-5452.

[2] Chen, C. C., Kuo, M. H., Chen, C. H., & Yao, P. H.Laser Illuminated Projection Displays. In SID Symposium Digest of Technical Papers (Vol. 37, No. 1, pp. 997-999). Oxford, UK: Blackwell Publishing Ltd.

[3] Chen, Cheng Huan, Chien Chuan Chen, and Po Hung Yao. "Microlens array homogenizer for laser illuminated projector." In Key Engineering Materials, vol. 364, pp. 143-147. Trans Tech Publications Ltd, 2008.

[4] Nikitin, Alexander N., Ilya Galaktionov, Julia Sheldakova, Alexis Kudryashov, Nikolay Baryshnikov, Dmitrii Denisov, Valerii Karasik, and Alexey Sakharov. "Absolute calibration of a Shack-Hartmann wavefront sensor for measurements of wavefronts." In Photonic Instrumentation Engineering VI, vol. 10925, pp. 118-125. SPIE, 2019.

[5] ….