Model of Curing Shrinkage and Kinetics Parameters of Acrylate-based UV-embossing Resist Based on Free Volume Theory

Peng Jin, Nan Liu, Jie Lin
Research Center of Ultra-precision Optoelectronic Instrumentation, Harbin Institute of Technology, Harbin, 150080, China
P.Jin@hit.edu.cn

Philips D. Prewett
Mechanical Engineering, the University of Birmingham, Birmingham, B152TT, United Kingdom

UV-embossing is a novel micro fabrication technology with the advantage such as low cost, high resolution and high efficiency. Curing shrinkage caused from distance changing between monomers molecule is one of the most important problems in UV-embossing[1]. We present such a method to forecast the shrinkage process of the polymerization of UV-embossing resist, in order to analyze the shrinkage action of resist.

First, a dynamic shrinkage model based on free volume theory is established. Combining with the relationship between shrinkage, volume relaxing parameters and free volume, classical polymerization kinetics theory, and polymerization kinetics parameters equation based on free volume theory, the model of dynamic shrinkage of UV-nanoimprint resist during curing can be proposed to analyze the dynamic shrinkage character of acrylate polymerization[2].

Then, kinetics parameters of UV-embossing resist are test by a Real Time–Fourier transform infrared (FTIR) spectroscopy Nicolet 5700. As shown in Fig. 1 and 2, the conversion data is conformed well to that from the analyzed model, and also conformed to that from others' experiments[3]. The dynamic shrinkage character of polymerization of acrylate based resist is monitored by measuring the change of polymer film thickness during curing process[4]. As shown in Fig 3, from the results, it can be seen that, the dynamic shrinkage process also conformed to that calculated from the model.

As a summery, a model which can be used to simulate the curing shrinkage and kinetics parameters of acrylate-based UV-embossing resist simultaneously is proposed. In the future, the stress and fabrication error caused by shrinkage will be studied based on this work.

---

[1] E. A. Costner, M. W. Lin, W. L. Jen, C. G. Willson, Ann. Rev. Mater. Res. 39, 155(2009).
[2] W. K. Neo, M. B. Chan-Park, Polymer. 48, 3337(2007).
[3] M. D. Dickey, C. G. Willson, Aiche J. 52, 777(2006).
[4] Q. Wang, H. Hiroshima, H. Atobe, J. Photopolym Sci. Technol. 23, 33(2010)

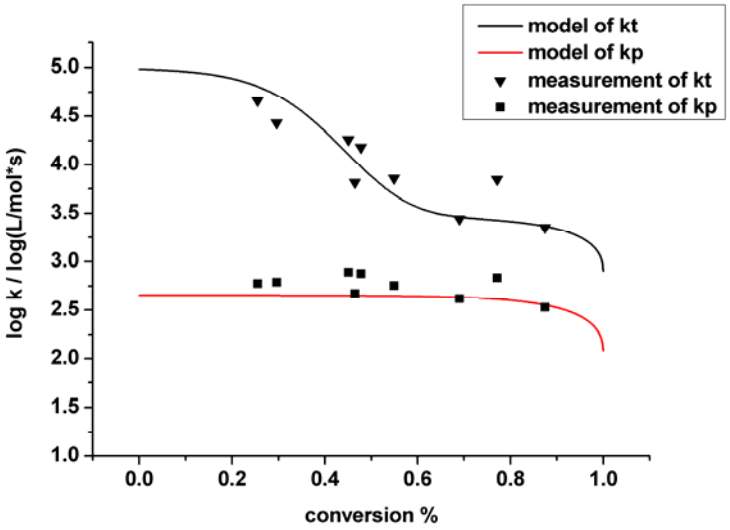

Fig. 1 Kinetics Parameters Curve: Comparison of results from experiments and theory model of reaction coefficient of polymerization based on free volume theory. The kinetics parameters k_p and k_t were monitored by dark polymerization method, which had been mentioned anywhere.

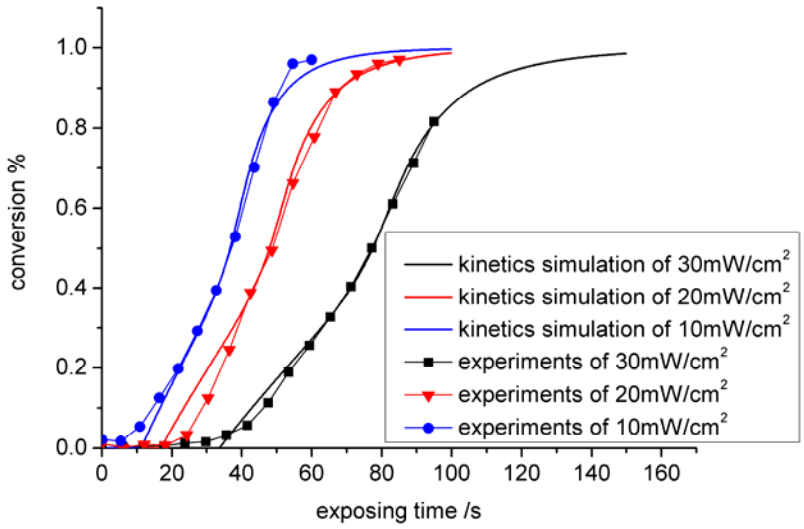

Fig. 2 Conversion Curve: Comparison of simulation model and experiment results of polymerization conversion curve under different exposing intensity.

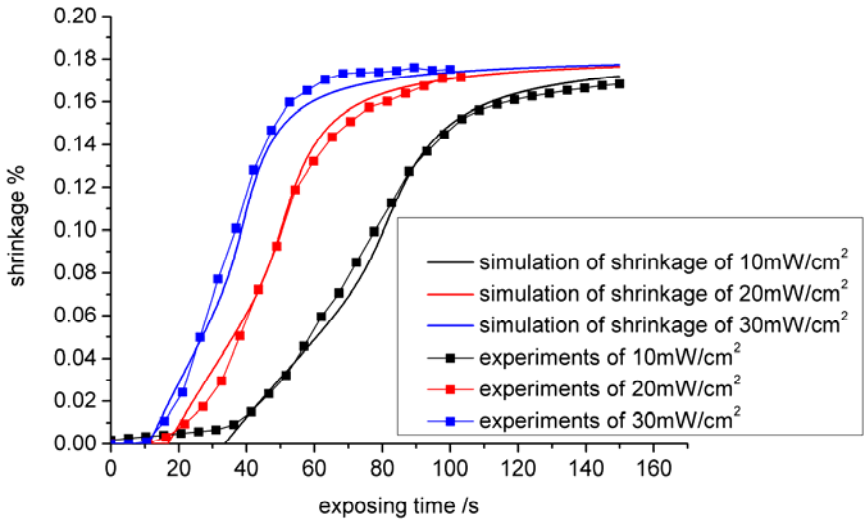

Fig. 3 Dynamic Shrinkage Curve: Comparison of simulation model and experiment results of polymerization shrinkage curve under different exposing intensity.