EFFECTS OF SILICA ON NANO-IMPRINTING PATTERN FORMATION OF PHOTO-REACTIVE ACRYLATE RESINS

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ABSTRACT

For photo-curable imprinting composites with silica particles, effects of silica content on UV curing characteristics and formation of defect patterns of hundreds nanometer size were studied. An increase in elasticity and a decrease in shrinkage were observed with an increase of the silica content in acrylate resin which was photo-cured at room temperature. However, patterned nano-walls were stuck together with neighboring ones if the amount of silica in the resin is more than 7 wt%. This can be ascribed to imperfectly cured acrylate resin due to obstruction of the photo-reaction by silica particles. The addition of silica to the imprinting resin is useful in enhancing the strength of the cured resin although it is difficult to get good imprinted patterns at the higher concentration of silica particles.

1 INTRODUCTION

Nano-imprinting technique has received considerable attention because of its advantages, such as low cost and high resolution for nanoscale patterns applied in various fields [1-3]. The UV nano-imprinting technique can be carried out at room temperature, so it is more useful in realizing precise nanoscale patterning than the conventional thermal type of nano-imprinting process. Since the UV imprinting technique is free from thermal expansion mismatch and requires much smaller imprinting pressure than the thermal imprinting technique, it is desirable to produce precise nanoscale patterning. UV cured imprinted resins require high mechanical strengths in order to maintain nanoscale patterns with high aspect ratios. In the present study, nano-size silica particles were mixed with acrylate-based UV curable resins to enhance the mechanical strength of UV-imprinted nano-patterns. Effects of silica content were studied on curing characteristics of imprinted nano-size patterns with photoreactive acrylate resins.

2 RESULTS AND DISCUSSION

Effects of silica particles on nano-size pattern formation through photoreaction of the acrylate resin were investigated. Imprinted patterns of silica nanocomposites were observed using scanning electron microscopes (Figure 1) in order to elucidate the effects of silica content in the resin on nanoscale pattern transfer with different aspect ratios. When silica particles having a high mechanical strength were added to the UV imprinting resin, the mechanical properties of the cured resin can be improved. The inorganic fillers help to maintain strength and shape of imprinted nano-size walls. An increase in elasticity and a decrease in shrinkage were observed with increasing silica content in the imprinting resin which was UV cured at room temperature. Such an increase in the modulus of elasticity plays an important role in maintaining the nano-size wall structure without bending the transferred pattern after the imprint process

As a number of silica particles increases, however, the photoreaction rate becomes slower and conversion rate is reduced because silica particles block incoming UV light. This results in obstruction of the photo-reaction and imperfect curing of the acrylate resin. Since the acrylate resins are not fully cured at the higher concentration of silica particles, patterned nano-size walls were stuck together with neighboring ones (see Figure 1). This can be ascribed to the increased viscosity of imperfectly cured resin due to the obstruction of the photo-reaction by silica particles. The processing temperature during the UV imprinting technique is another important parameter of affecting the precise pattern transfer for nano-size patterns. When the temperature of imprinting process increases, the photo-cured imprint pattern fails to form the transferred shape of nano-walls as a number of silica particles increases. At higher temperature (~ 60 ^{o}C), when the silica particle concentration exceeded even 3 wt%, defects in the transfer pattern of the nano-walls sticking to each other were observed.

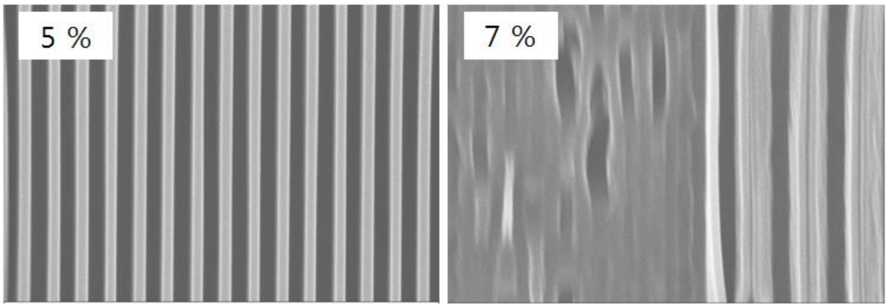

Figure 1. FE-SEM images of nano-wall patterns fabricated using UV imprinting process with acrylate composites of different silica contents.

3 CONCLUSIONS

Silica particles reduce the shrinkage rate of the imprinted acrylate resin, contributing to maintaining the accuracy of nano-size patterns. Although the mechanical strengths can be improved with silica particles, the precise patterning may not be achieved in the UV imprinting technique depending on silica compositions and curing conditions of the silica containing acrylate composite. The addition of silica to the imprinting resin is useful in enhancing the strength of the cured resin although it is difficult to get good imprinted patterns for the resin with more than 7 wt% of silica due to the reduction of photoreactive acrylate conversion.

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