

Incorporation of nanofillers to prevent water uptake in epoxy-based microstructures

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SU8 photoresist has become widely popular in the field of micro-electro-mechanical systems (MEMS). Using the UV-LIGA technology, SU8 has been used for the fabrication of high-aspect-ratio micro-components due to its unmatched optical, chemical, and mechanical properties. However, such system possesses a major limitation. During the electroplating process, the SU8 molds can uptake water, which in turn leads to the swelling of the microstructure. Consequently, in case those microstructures are used as plating molds for high precision devices, such swelling behavior can lead to dimensional errors in the electroplated micro-components.

We propose the addition of inorganic nanofillers to SU8 to serve as a barrier for water and to enhance the crosslinking density with the goal of slowing down the diffusion of water inside the nanocomposite system and consequently preserve the structural stability of the mold. In this context, we tested nanoparticles as fillers and investigated the effects of different particle surface-functionalizations, concentrations, sizes, and distribution on the properties of SU8.

In summary, two different types of nanocomposites were successfully prepared, one involving the addition of hydrophilic 80 nm silica nanoparticles (colloidal, Stöber) and the other using hydrophobic silica nanoparticles (commercial, Aerosil®R972). Dynamic Light Scattering (DLS), Transmission Electron Microscopy (TEM), Ultraviolet-Visible Spectroscopy (UV-Vis) and Scanning Electron Microscopy (SEM) were used for the characterization of the pure nanoparticles and the nanocomposite material. It could be observed that the nanoparticles aggregated in the process of SU8 composite formation. This information is crucial because nanoparticle aggregation has an impact on the optical particle properties and in turn on the crosslinking of the SU8 outside the patterning range. Additionally, the presence of voids within the composite was observed. This is problematic because these voids can serve as reservoirs for water storage resulting in higher water uptake and could also lead to the weakening of the final composite system.

Counter-intuitively, it was found that the incorporation of the two types of silica nanoparticles did not reduce water uptake in SU8 composite compared to the pure SU8, but the opposite effect was observed. From gravimetric measurements, SU8 containing hydrophobic silica nanoparticles took up less water compared to the colloidal silica (at 0.25 wt.%). Furthermore, it was also found that the water uptake increases with silica nanoparticle concentration. An increase in particle concentration inevitably led to the formation of larger clusters which minimizes the wettability of individual particle surface toward the matrix. Therefore, a better understanding of functionalized particles is required to yield a much-improved composite system.

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