Approach of fine resist filling technologies for UV-NIL at AIST

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There has been increasing demand for a low-cost nanofabrication technique such as ultraviolet nanoimprint lithography (UV-NIL) for high-volume production of large-scale integrated circuits, optical and bio device components. To accomplish this, we have actively pursued research and development on fine resist filling technologies for UV-NIL using spin-coated resins. In this talk, I will first review some research activities of AIST on quick and bubble-free UV-NIL, then cover the design and low-cost fabrication of a mold for lithography.

Although bubble-free filling can be accomplished by performing UV-NIL under vacuum, non-vacuum processes are desirable because of their lower equipment and operating costs. Bubble defects could be avoided by using a condensable alternative chlorofluorocarbon gas, pentafluoropropane (PFP) as an atmosphere gas [1]. A PFP atmosphere not only is beneficial for quick and bubble-free cavity filling but also offers benefits such as decreasing the viscosity of the UV-curable resin and lowering the demolding forces. PFP occasionally causes large pattern shrinkage and degrades the pattern quality depending on the monomer chemical structures included in the UV-curable resins. However, recent research results that we achieved demonstrated that such degrade can be avoided by mixing with the Helium gas [2] or by utilizing other condensing gas (trans-1,3,3,3-tetrafluoropropene, TFP) having a higher vapor pressure than PFP [3].

The uneven distribution of a mold pattern density may cause a variation in a residual layer thickness (RLT), and consequently may result in the variation of lateral critical dimensions or may lose patterns in the subsequent etch transfer process. Therefore, making the residual layer thin and uniform over the entire imprint region even for the uneven density distribution of pattern is important for achieving high fidelity in the etching process. As a solution, we have suggested the use of capacity-equalized (CE) mold, where deeper complementary cavities are added to the original trench pattern areas to achieve a uniform pattern capacity per unit area. By using this method, pattern capacity in mold can be equalized without changing the original pattern layout. To enhance the possibility of industrial use of CE molds, a mold design software program (stamp topography automated modification program, STAMP), that can be applicable to real device patterns where shapes are complex and variation in the pattern density is large has been developed [4].

Additionally, an ultra-high speed electron beam (UHSEB) lithography system is being developed as a tool for the low-cost fabrication of wafer-level mold through the collaborative work between AIST and Elionix Inc. The design concepts and capabilities of the UHSEB prototype (e.g., 100 times higher throughput over conventional point-beam type EB systems) will be introduced briefly.

Reference:

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