Drying Developed Electron-beam Resists Using Supercritical Carbon Dioxide: Compatibility Issues

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With the shrinkage of critical dimension (CD), nanolithography naturally produces high aspect-ratio (AR) resist nanostructures. To transfer them to substrate materials using reactive ion etch processes, the requirement to AR can easily go beyond 5. Surface tension caused pattern collapse becomes an inevitable problem during the drying stage after resist development. On the other hand, MEMS industry has adopted liquid carbon dioxide (LCO2) critical point drying (CPD) to eliminate the hazard of surface tension for decades. Efforts have been made to solve resist pattern collapse problem with CPD for HSQ resist.[1] However e-beam resists other than HSQ were seldom reported to be dried with CPD. In this work, multiple popular e-beam resists have been explored for the feasibility working with LCO2 CPD process.

Four e-beam resists were tested in this work, which are two positive resists (PMMA 495 and ZEP520) and two negative resists (Ma-N 2405 and SU-8). All these resists are irradiated with 100 keV electron beam at a various dose. After exposure, development and rinsing, one group of the samples are blown dry with nitrogen while the other group are dried in a critical point dryer. For CPD process, a standard operation procedure suggested by tool manufacturer is adopted, which includes a pre-CPD soaking in isopropanol (IPA).

The results show that CPD has different impact on four resist samples. Unlike HSQ which doesn't show changes on its lithography performance, all the contrast curves of these organic resists change. For positive resists they shift to low dose side while for negative resists they shift to high dose side. Relatively, ZEP520 and SU8 are less sensitive to CPD while the other two are more sensitive to CPD.

Three additional processes are then applied to undeveloped resist to investigate the mechanism of these changes, which are pure IPA soaking, pure LCO2 soaking and CPD (no IPA), and pure IPA soaking with normal CPD. The results show that both IPA and LCO2 have their contribution to these changes.

Based on the results from above experiments, general rules to use CPD in resist pattern drying process will be discussed.

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[1] H. Namatsu, K. Yamazaki, K. Kurihara, Microelectron. Eng., 46, 129 (1999).