Performance of a high-resolution negative tone resist

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As the minimum lithographic feature size continues to shrink, the development of lithography techniques and resist materials capable of high resolution, high sensitivity and low line edge roughness for next generation lithography has become increasingly important. Furthermore as feature sizes less than 20 nm are routinely required, pattern collapse upon development has become a serious limiting factor, independent of the lithography technique involved. As such small pitches the critical aspect ratio of collapse approaches 1:1 requiring extremely thin resist films for successful patterning which significantly increases line edge roughness and impacts pattern transfer. The main factor leading to pattern collapse in high aspect ratio features is the poor adhesion between the resist material and the silicon substrate. Therefore, alongside with constantly developing and adapting the resist platforms there is the need to introduce an interface that significantly improves the adhesion of the resist material to the silicon substrate, reducing pattern collapse and allowing for ultra high resolution, high aspect ratio patterning.

In this work the performance of a three compound negative tone chemically amplified resist material was analyzed using electron beam lithography. The material consists of a base molecule, xMT, a crosslinker and a PAG. The xMT molecular structure was modified to create the three versions of the material. The three materials were tested in electron beam lithography at 100 kV and 30 kV. To increase the adhesion of the resist to the wafer and reduce pattern collapse, a silane-based monolayer interface with crosslinking tail groups was investigated. Isolated pillar and semi-dense lines with aspect ratios above 1:1 were patterned in electron beam to evaluate the pattern collapse issue.

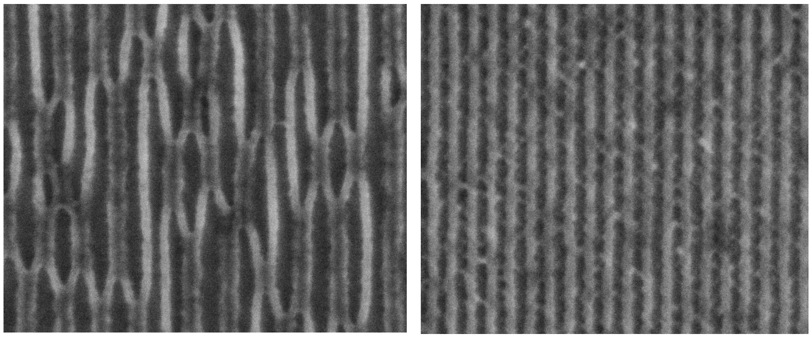

Figure 1. SEM micrograph of 18 nm half pitch semi-dense lines a) collapsed pattern on bare Si substrate and b) non-collapsed on silanized Si substrate