486b Enhancement of Lithography Processes Using Co_2: Co_2-Modified Development and Post Applied Bake

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Lithography is an integral part in the production of integrated circuits. This paper investigates the use of supercritical carbon dioxide ($scCO_2$) to modify the development and post applied bake (PAB) steps in lithography to potentially enhance production and performance.

Problems arise as smaller integrated circuit features are produced to reduce the overall size of the integrated circuit. During development, water between high-aspect ratio features is dried. The high surface tension of water pulls features together and causes image collapse. The result is reduced yield and performance. In the literature, $scCO_2$ has been utilized as a zero surface tension solvent to replace rinse solutions and dry photoresist features without image collapse. The shortest time reported to perform $scCO_2$ drying for this application is 12 minutes [1]. The goal of this research is to reduce the total development time to less than 3 minutes to be competitive with standard industry development times. After investigating the rates of the major mechanisms of drying including mass transfer removal and mechanical removal, we suggest potential short time approaches to carry out high pressure drying. Simple models have been used to provide approaches to the reduction of $scCO_2$ drying time and experiments are being carried out to confirm reduction of image collapse.

Drying thick films (30-100 microns) after spin coating is another promising area to apply $scCO_2$ modifications in lithography. Thick films, used for packaging and wafer bumping applications, are currently dried in a convective oven for typically 30 minutes at 95°C to remove residual spin coating solvent. Using $scCO_2$ drying, the drying time is reduced by at least a factor of two. We will present CO_2/photoresist solvent phase behavior, residual solvent concentration profiles within the film after drying, film hydration after drying, and helium displacement of $scCO_2$ after drying.

1. Zhang, X.G., et al., Chemical-mechanical photoresist drying in supercritical carbon dioxide with hydrocarbon surfactants. Journal of Vacuum Science & Technology B, 2004. 22(2): p. 818-825.