Methodology for Reducing Process Variability through In-Situ Production of Positive Photoresist Developer

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Abstract

Process variability in a photolithographic process can arise from a number of sources including photoresist developer assay variation. A change in activity of only ± 0.001 eq/l in a developer solution with a normality of 0.2624 eq/l can consume or exceed the allowable ± 5.0% CD specification set by most fabs. This change, which represents a relative error (error/setpoint) at 3σ of only ± 0.4%, is typical of the allowable variability from developer suppliers.

Developer production systems with tighter assay tolerances should reduce process variability and increase process robustness. This study compared the effectiveness of several control techniques for blending tetramethyl ammonium hydroxide (TMAH) developer. Techniques with feedforward and feedback control were investigated.

An analysis of sources of error in developer blending systems indicated that feedforward techniques could not achieve the desired relative error of ± 0.4%. An experimental study was undertaken to determine the relative error of three feedback control methods. The feedback techniques yielded considerably tighter assay control than that expected from the feedforward techniques. An analog setpoint control algorithm used with conductivity measurements provided more precise control than a discrete setpoint control algorithm. However, only feedback control with titration met the goal, achieving a relative error of only ± 0.13% at 3σ (± 0.00034 eq/l).

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