Got a Litho Question? Ask the Experts

Chris A. Mack

Q Why do critical dimensions respond asymmetrically to defocus (different results for plus focus errors versus minus focus errors)?

A For a perfect lens, the aerial image responds to focus symmetrically (a plus focus error gives the same image as a minus focus error). Thus, the cause of the observed asymmetry must involve the way that the aerial image interacts with the photoresist to produce the final CD. In fact, it is the thickness of the photoresist that gives rise to this asymmetry. As the aerial image travels through space, it becomes more "in focus" as it approaches the focal plane, then defocuses as it travels away from this plane of best focus. Because the photoresist has a non-zero thickness, different parts of the resist will experiences different amounts of defocus. Suppose the focal plane were placed just above the top of the resist. At the top, the resist sees an aerial image that is near best focus and thus very sharp. As this image propagates towards the bottom of the resist, however, it goes further out of focus. As a consequence, the top of the resist profile looks sharp but the bottom is curved or "blurred" by the defocused image. If, on the other hand, the plane of best focus were placed below the bottom of the resist, a very different resist shape will result. The bottom of the resist will see a sharp aerial image, while the top of the resist will experience a more defocused image. The result will be a resist profile with straight sidewalls at the bottom, but a very rounded top. These two different shaped resist profiles will invariable give different values for the CD (see my column in the previous issue of Yield Solutions Magazine for an example).

In addition, aberrations in the imaging lens (such as coma) or phase errors on a phase shifting mask will also cause an asymmetric CD response to focus.

Q For chemically amplified resists, there is a tradeoff between exposure dose and post-exposure bake temperature. How do I optimize this tradeoff?

A Exposure of a chemically amplified resist produces a photogenerated acid. During PEB, this acid catalyzes a deblocking reaction that changes the solubility of the resist. The amount of deblocking that occurs is a function of the amount of acid (exposure dose) and the amount of baking (thermal dose), controlled by either the bake time or the bake temperature. Thus, a high dose, low post-exposure bake temperature process can yield the same amount of deblocking as a low dose, high bake temperature process. At first glance, exposure dose can be easily traded for thermal dose. However, there are other processes that are also bake temperature dependent, namely acid diffusion and acid loss. Acid diffusion tends to degrade the quality of the printed image by diffusing acid from the exposed regions into the unexposed regions. If the bake temperature is too high, an excessive amount of diffusion can degrade linewidth control. Also, several acid loss mechanisms (such as acid evaporation) may also increase with temperature. This puts an upper limit on the possible bake temperatures.

In general, optimization is carried out experimentally, usually be examining the size of a focus-exposure process window at different bake conditions. Simulation can also be used if the activation energies of all of the relevant resist parameters have been accurately measured.

Do you have a lithography question?

Just e-mail lithocolumn@kla-tencor.com and have your questions answered by Chris Mack or another of our experts.

Yield Management Seminar

A valuable venue for innovative ideas

KLA-Tencor's Yield Management Seminars (YMS) focus on value-added, integrated process module control solutions for defect reduction, process parametric control and yield management. Key topics include the sub-0.13 µm technology node, with special emphasis on copper/low-κ interconnect, sub-wavelength lithography, and the 300 mm wafer.

To register online for the upcoming YMS, please visit us at: http://www.kla-tencor.com/seminar

Date: Wednesday, October 16, 2002
Time: 9:00 am – 6:00 pm
Location: Austin, Texas

Call for future papers

Papers should focus on using KLA-Tencor tools and solutions to enhance yield through increased productivity and performance. If you are interested in presenting a paper at one of our upcoming yield management seminars, please submit a one-page abstract to: Cathy Silva by fax at (408) 875-4144 or email at cathy.silva@kla-tencor.com.

YMS at a Glance

Date	Location
October 16	Austin, Texas
December 5	Hakuhari, Japan
TBD	Shanghai, China
TBD	Seoul, Korea