

Journal of
Micro/Nanolithography,
MEMS, and MOEMS

Nanolithography.SPIEDigitalLibrary.org

The Year of Stochastics

Chris Mack



The Year of Stochastics

The most important conference of the year in the field of semiconductor lithography is SPIE's Advanced Lithography Symposium, held annually in San Jose, California, at the end of February. With an average annual attendance in the last decade of about 2,000, it brings together a wide mix of people, most from industry but many from academia as well, covering the full range of topics involved in lithography: tools and processes, patterning materials, metrology, etch, chip design, and novel technologies.

The first SPIE lithography conference was held in 1976 (two days, 26 papers). I have been fortunate enough (and old enough) to attend every Advanced Lithography Symposium since 1985, and it is amazing to think about the changes that have taken place over those many years. Topics and themes wax and wane as new ideas generate excitement and past novel techniques become routine. In 1985, i-line (365 nm wavelength) lithography was new, one-micron features were small, and lithography was still considered by most to be more art than science. Today could not be more different. The latest technology of EUV lithography uses a wavelength of 13.5 nm, our 10-nm node devices have line/space pitches as small as 34 nm, and manufacturing would not be practical without predictive computational lithography models.

A topic that was hardly ever discussed in those early lithography conferences is stochastic phenomena: randomness in

lithography that gives rise to rough features and other sources of patterning variation. For large feature sizes, a large number of photons, molecules, and chemical events work together to form patterns, so that counting statistics approach the continuum approximation and stochastics can be safely ignored. What is different today are the sizes of the features and the much smaller numbers of photons, molecules, and chemical events affecting those smaller features. Roughly speaking, the importance of stochastic phenomena scales as one over the feature size cubed, which is why the importance of stochastics seems to have come on fast.

This quick onslaught of stochastic variation was on full display at the SPIE Advanced Lithography Symposium this year. Just a couple of years ago, the topic of stochastic-induced roughness attracted the attention of a few die-hard roughness junkies (like me) but was at best a sideline to more important topics for the majority of attendees. Not this year. It seemed that roughness and the related topic of stochastic defects were making everyone nervous and capturing a large share of almost everyone's reluctant attention. I have dubbed this the Year of Stochastics in lithography. It may not be everyone's favorite topic, but it can no longer be avoided.

We'll see some of this Year of Stochastics play out in the pages of this journal. Submissions are due soon for a special section on the topic Control of IC Patterning Variance Part 3: LER, LWR, LCDU, and Stochastic Defects, to be published in the last issue of JM3 of this year. Those papers will join a long list of contributions to the field of roughness in lithography that have been published in our journal, as well as at the SPIE Advanced Lithography Symposium. We all hope that further advances in our fundamental understanding of stochastic phenomena in lithography will lead to better ways to reduce and control stochastic variability. In any case, the Year of Stochastics is unlikely to be confined to just one year — the problem will be with us from now on.

Chris Mack
Editor-in-Chief