

GUEST EDITORIAL

COMPUTATIONAL LITHOGRAPHY

Computational lithography, as we know it today, is the result of an evolutionary process that began in the 1970s when IBM scientists and academics from University of California, Berkeley, developed a photoresist and optical projection simulator that eventually became SAMPLE. This early work helped us explain what we were seeing and measuring in our fabs. By the 1980s, the simulation program PROLITH was written for the personal computer and distributed freely. This allowed numerous lithography practitioners easier access to simulation software that enabled not only fundamental understanding of the process, but also the beginnings of methods to do root-cause problem solving. By the 1990s, numerous other programs were being written by commercial and academic entities that further enhanced our problem-solving capabilities, and researchers even started to delve into the optimization of imaging systems. During this period, the industry broke the $k_1=0.5$ barrier and had to start working with nonlinear imaging processes. This necessitated using simulation and modeling programs to enable methods to optimize our optical tools. For example, numerical aperture (NA) and σ optimization could be first accomplished with computation methods before attempting the more costly experimental methods, and optical effects, such as aberrations, could be routinely explored and understood before problems occurred in manufacturing. This period also saw the advent of rule-based optical proximity correction (OPC), which was an early use of computation to optimize the lithographic imaging process.

In our current period, we are essentially pulling out “all the stops” and trying to optimize the entire lithographic system such that imaging can be done close to the diffraction limit of $k_1=0.25$. This is only possible by using computational methods to simultaneously design each optical and chemical component in the lithographic system to print our desired patterns. These components include the illumination shape, the reticle features, and the projection lens, while also considering the strong effects of the photoresist process and the optical filmstack.

This special section on computational lithography brings together six papers that explore some of the difficulties associated with rigorous modeling in today's environment. Three of the papers concentrate on the use of simulation and modeling to understand applications such as EUV mask defects, phase masks, and polarization. The other three papers focus more on the methods of the computational theory used to compute and optimize the lithographic image. These papers represent another step in the evolution of computational lithography — enjoy!

Donis Flagello

Nikon Research Corporation of America

Chris Mack

Consultant

Guest Editors