

## Thoughts on Photomask Japan

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This past April, an important part of our lithography community was able to meet at Photomask Japan face-to-face, for the first time since 2019. It was also this conference's 30<sup>th</sup> anniversary. The first Photomask Japan was held in April 1994 at the Kawasaki Science Park, and SPIE was already involved, publishing the conference proceedings (Vol. 2254). In 1999, Photomask Japan moved to Yokohama, where it was again held this year, with nearly 500 attendees. In addition to the opportunity to listen to interesting and informative presentations, meeting in April gave the attendees of Photomask Japan the opportunity to enjoy beautiful cherry blossoms!

Much has changed in the world of lithography since that first Photomask Japan. In 1994, i-line lithography was used for most leading-edge manufacturing, DUV lithography was undergoing development, and X-ray lithography was the topic of nearly a third of the papers at Photomask Japan. Although the wavelengths of interest have changed over the years, many of the issues discussed by presenters at the first Photomask Japan are still with us – mask stability, materials for phase-shifting masks, design rules checking, mask repair, and electron beam writers for mask making – and there were presentations on these topics at the most recent Photomask Japan.

This year, there were also some new topics. Curvilinear patterns on masks were discussed by several presenters. Such patterns represent a significant change in patterning for semiconductors, as the features of integrated circuits have long been designed with Manhattan shapes (with the transitory exception of X Architecture<sup>1</sup>). The transition to curvilinear patterns requires that many issues related to masks and mask-making be addressed. For example, the concept of critical dimension is not obvious for curvilinear features. At Photomask Japan this year, an interesting proposal to address this was presented by a member of the JM<sup>3</sup> editorial board, Dr. Leo Pang of D2S, Inc. As another measure of the level of activity on curvilinear masks, in this volume of JM<sup>3</sup> is [Part 2](#) of a Special Section on Curvilinear Masks, with [Part 1](#) having been published in the preceding volume.

This year at Photomask Japan, there was a session on energy sustainability in lithography, a topic that received only occasional consideration at lithography conferences previously. A significant reason for greater attention to this topic recently is the considerable amount of electricity required to power the many EUV exposure tools now in operation in wafer fabs. Also discussed in the session on energy sustainability was the reduction in electricity consumption for operating optical mask writers, which was achieved by the use of solid state lasers that were developed to meet the stringent requirements of lithography equipment. This was a good example of how advances in technology can increase energy efficiency. Also presented in the session at Photomask Japan on energy sustainability were presentations on simulations for guiding improvement in the energy efficiency of laser-produced plasma (LPP) EUV light sources, free-electron lasers as energy-efficient alternatives to LPP sources, and a speculative paper on increasing light transmission in EUV projection optics.

Photomask Japan 2024 was interesting and informative, and I look forward to attending this conference in years to come!

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### References

1. S. L. Teig “The X architecture: not your father’s diagonal wiring,” in *Proc. 2002 Int. Workshop on Syst.-Level Interconnect Predict.*, pp. 33–37 (2002).