SPIE—

JM3 Journal publishes special issue on EUV sources

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During the 2011 SPIE Advanced Lithography Symposium (SPIE), Tony Yen of TSMC proposed to the editorial board of The Journal of Micro/Nanolithography, MEMS, and MOEMS (JM3) a special issue on EUV sources in which experts could share new ideas on how to further advance the EUV source technology. Chris Mack suggested that Tony and I co-edit this issue, which I happily agreed to do as EUV sources are of much interest to me. EUV source power was as critical an issue then as it is today. Knowing that power requirements would only increase for next generation scanners, we also wanted to hear from source experts on how far we can take the current technologies, and what to do next to get to power levels of 250 W (or more) at intermediate focus (IF).

After more than a year of peer reviews of submitted articles, we will publish the JM3 special issue in July, with 23 papers covering such topics as laser produced plasma (LPP) and discharge produced plasma (DPP) sources, mask metrology sources, modeling source components (debris mitigation, spectral purity filter [SPF] and lasers) and papers on many alternate concepts for EUV sources. Although all of them are well worth reading, I want to highlight papers that analyze technology limits, offer solutions on how to advance current technology, and provide alternate EUV source concepts.

DPP sources have some definite advantages. They are simpler and cheaper than LPP, and I can personally testify that they can run continuously for eight hours and more. However, since 2007, the power for installed DPP sources has remained in the 7-10 W range, although their reliability has improved. My guess is that thermal mitigation is still the issue. Over the last five years, I have seen convincing data on power scaling potential for these sources, and I see even more conclusive scaling data now. However, I will withhold judgment on how well these sources can scale in power, until end customers report on their long term operation at higher power.

A paper by Koshelev et al. on metal jet offers an interesting approach to DPP power scaling. It was shown to be more than a concept when he provided experimental results at the 2011 Source Workshop. Koshelev expects to soon scale his source power to 800 W at source (80 W at IF) by using 32 kW input and

2.5% conversion efficiency (CE), and details his new DPP approach in this issue. As with all new concepts, it will need engineering work to become a commercial product.

LPP source power has improved from the mW range in 2007 to ~10 W today. The physics of scaling seems straightforward for these sources as well. Now that many LPP sources are in the field, much more attention is paid to them today. But in fairness, I must withhold judgment on the power scaling potential of LPP sources as well, until I see more field data from customers.

Papers from Toshio Tomie and Gerry O'Sullivan provide excellent reviews of LPP technology and offer opinions on its limits. Also worthwhile is a theoretical paper from Koshelev et al. on distributed targeting for LPP (Akira Endo expanded on this concept in his talk at the 2011 Source Workshop). The distributed target approach is interesting and promises higher CE and better debris control, but it needs to be brought into practice and then into manufactured products.

Alternate concepts for EUV sources are explored in papers on EUV lasers, the Laser Compton effect, tabletop synchrotron, inverse laser Compton effect, EUV lasers, electron cyclotron resonance (ECR)-based plasma and free electron lasers (FEL) lasers. Of these approaches, FEL, tabletop synchrotrons, and ECR plasma papers claim the ability to scale up for high EUV source power requirements. Other alternate concept papers focus on metrology applications. All of these papers provide experimental proof at some level.

An FEL paper delivered by William Barletta at the 2012 SPIE Advanced Lithography conference claimed a 500 W source with an estimated cost of $100 million. I support serious examination of these concepts, most probably by a group of experts that include end users as well as scanner makers. Even so, it's difficult to find funding for alternate technology development when conventional suppliers are claiming that such high source power capability lies within reach of their technology in the near future. But if we do not see significant power scaling results this year, a serious review (not development) of alternate technology would be desirable. We owe it to ourselves, and it is very much worth the effort, to at least do a serious assessment. In any case, I encourage you to read the papers on current and alternate concepts and share your comments with me.