Three Industry Leaders Track Lithography Trends for 2011

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"Optical forever" is a phrase I heard used by an industry expert in 2001 when asked about future lithography trends, so what do today's experts say about the next ten years? Three luminaries from the eBeam Initiative roster have kindly agreed to participate in this virtual roundtable discussion: Markus Bender, Innovation Development Engineer at the Advanced Mask Technology Center (AMTC), Naoyo Hayashi, research fellow at DNP, and Aki Fujimura, CEO of D2S, Inc. Complexity and trade-offs emerge as themes with several interesting ideas on "hybrid" approaches. Please read on!

Q: What are you seeing as the adoption schedule for the 22/20nm logic node?

Markus Bender (MB): After the 28-nm node, it seems that the leading companies will skip the 22-nm "full node" and move directly to the 20-nm "half node" with starting production B/2012.

Naoyo Hayashi (NH): 2011 at the earliest.

Aki Fujimura (AF): What I see is that R&D is full time on 20nm now for the leading logic fabs, with the schedule being ready for the first set of tapeouts in 2012.

Q: What's your lithography prediction for critical layer processing at the 22/20-nm logic node? 193i with multiple patterning, EUV, e-beam, nanoimprint, or something else?

NH: 193i with multiple patterning for high volume manufacturing, e-beam for (very) small volume or prototype products (e-beam will be feasible in 2012 at the earliest).

MB: EUV technology is not yet at the required level of maturity. So the industry has to push the limits of optical lithography by using 193i with multiple patterning like multiple exposure or multiple patterning and likely ILT/SMO approaches.

Q: Do you see the possibility of multiple lithography approaches being adopted for the 22/20nm logic node? If so, which approaches and for which applications?

AF: Yes, it is possible. The "hybrid" approach proposed by Yan Borodovsky at the SEMATECH Litho Forum in May 2010 seems credible to draw lines with 193i, and to do cuts and holes with high energy sources, like EUV or e-beam. EUV can only be affordable for extremely high volume production. E-beam direct write is a great alternative for low volume applications like derivative designs and prototype or software verification of systems.

NH: There is the possibility to use e-beam for hole layers with 193i with multiple patterning for line layers.

Q: Are complex shapes on masks required at 22nm? What percentage of critical layer masks will require complex shapes at 22nm?

MB: For a 22-nm mask set, 10% are critical layers. We expect complex shapes on all (100%) of the critical layers. The complex shapes consist of Manhattanized structures and ILT/SMO shapes, each with strong OPC.

AF: All critical layer masks will require complex shapes at 22nm. Some may go extreme with curvilinear but most will utilize Manhattanized ILT/SMO for the 20-nm logic node. Slightly decorated will not do it for 20-nm contact, gate, via or metal 1 masks. Many masks will have assist features that are less than 50nm in width.

Q: When using 193i lithography and e-beam masks, what would be the benefits of using overlapping e-beam shots? What might need to be addressed prior to adoption?

NH: Using overlapping e-beam shots may be beneficial for shot count reduction and possible wider process window, etc. Prior to adoption, optimization of proximity effect compensation (PEC) methods and concerns resulting from excessive overlapping should be addressed.

MB: Benefits of overlapping shots on e-beam produced masks are shot count reduction (write time reduction), improved resolution, and improved pattern fidelity. The topics that must be addressed are reduction or fracture complexity, local dose stability, resist characteristics and shot placement accuracy.

AF: The benefit of overlapping shots is the flexibility in both original circuit design and in OPC to take advantage of the benefits of diagonals, curvilinear main features and curvilinear assist features to

maximize wafer performance while minimizing chip area. Fear of the unknown has to be addressed, but there is no doubt that overlapping shots will work, that there are write time advantages, and the enhanced dose margin—especially for sub-100nm features—leads to superior wafer yield.

Q: Considering both the technology topics we've just discussed and the economic environment for the coming year, if you had to give 2011 a theme, what would it be?

MB: From the perspective of a mask manufacturer, cycle-time and costs as well as the number of technology nodes to be covered are the challenges in 2011.

NH: Trade-off: the solution between complexity and cost.

AF: The year the logic world committed to ArF multiple patterning and complex mask shapes for 20-nm logic.