Multiple e-beam direct write enters pre-production mode: Overview of performances and comparison study between in-line metrology and on wafer measurements

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Lithography has, and will continue to be the main driver of Moore's Law. To extend optical lithography, multiple patterning, and EUV lithography are currently explored, but face, besides technical constraints, a serious cost of ownership issue. Massively parallel electron beam direct write (MEBDW) remains thus an attractive solution to address high volume production for advanced nodes, benefiting of high resolution and low cost of ownership[1]. Since 2009, CEA-Leti leads a collaborative program to promote the insertion of the mask less lithography approach developed by Mapper Lithography.

After technology demonstration achieved on pre-alpha tool in CEA-Leti[2], Mapper Lithography introduced a new technological platform for pre-production suitable for CMOS 28/20/14 nodes on 300mm wafer and targeting a 1wph throughput: FLX-1200. Installed in the CEA-Leti clean room and interfaced with a Sokudo Duo track (picture of Figure 1), it represents the first worldwide lithography cluster using massively parallel electron beam for direct write. The results of first exposures using a pre-programmed blanker and an optical alignment system will be shown and discussed in terms of critical lithography parameters such as exposure latitude, depth of focus, CD uniformity and overlay. We also demonstrate that MEBDW is able to expose a 300mm wafer, coated with a lithography standard tri-layer stack and p-CAR resist, in 1 hour independently of the pattern density.

Also, the need for an accurate, reliable and fast in-line metrology is key technology enabler for MEBDW. We will review and demonstrate how on wafer measurements match with the in-line tool metrology for the critical tool parameters. As example, the spot sizes measured with an inside tool knife edge (Figure 2) are compared with "in resist" spot size measurements using a previously described method[3,4]. As another example, the 7x7 sub-beam pitch (Figure 3) is also extracted from a knife edge measurement and from resist exposures with a dedicated writing strategy.

The research leading to these results has been performed in the frame of the industrial collaborative consortium IMAGINE driven by CEA-Leti.

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[1] Lin et al., Proc. of SPIE 8323, 832302 (2012)
[2] Pain et al., Proc. of SPIE 7970, 79700Y (2011)
[3] Rio et al., J. Vac. Sci. Technol. B 28, C6C14 (2010)
[4] Delachat et al., J. Vac. Sci. Technol. B 32, 06FJ02 (2014)

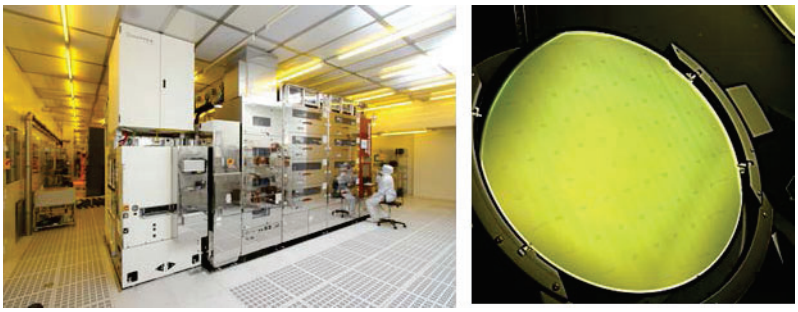

Figure 1: First worldwide MEBDW lithography cluster: Installed in CEA-Leti clean room, the Mapper Lithography FLX-1200 platform is "in line" interfaced with a Sokudo Duo track. On the right part of the image, a picture of a 300mm wafer exposed in less than one hour, independently of the pattern density.

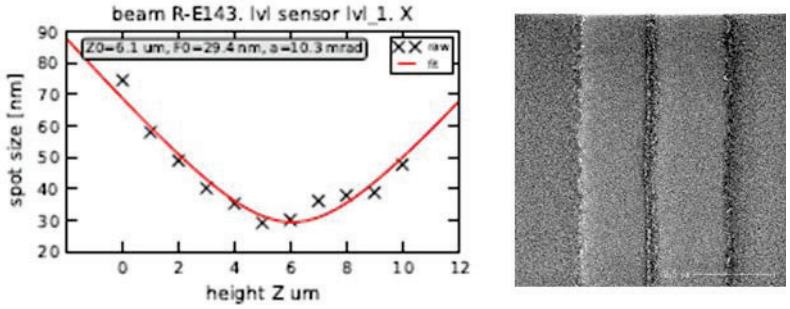

Figure 2: Spot size measurements: On the left, the beam spot size is measured inside the FLX-1200 with a knife edge for different focus position. On the right a SEM image of a cross-linked p-CAR exposed with one beam. The *Rio Delachat Constancias* method[3, 4] is used for beam spot size extraction.

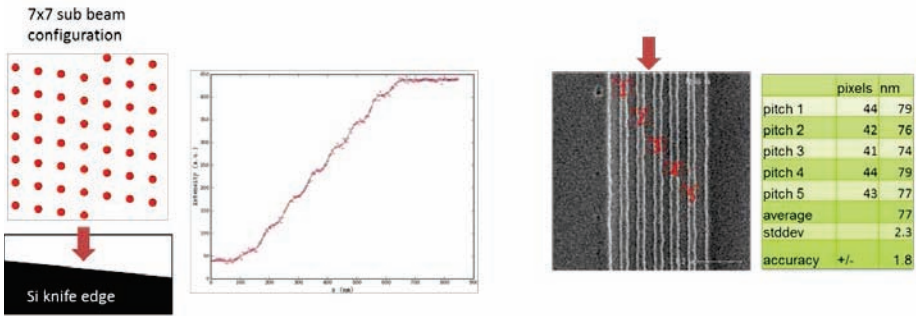

Figure 3: Sub beam pitch measurement: On the left, the sub-beam pitch is measured inside the FLX-1200 with a knife edge and compared with measurements on resist which is exposed specifically.