Detailed characterization of HSQ for e-beam application in DRAM pilot line environment

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Electron beam direct write (EBDW) is highly attractive for a possible use in device and technology development because of its high resolution. Gaussian beam writers can provide the latter, but with the drawback of their low throughput. Thus, faster variable shaped beam writers have been integrated in semiconductor device manufacturing [1] with improved electron optics which feature the resolution capability for the 32nm node. But the resolution of today's commercial chemically amplified e-beam resists still restricts the total tool performance. Here non-chemically amplified resist systems like the negative tone hydrogen silsesquioxane (HSQ) can assist.

HSQ has been widely investigated in research environments with manual coating and development. Now for the first time 300mm wafers have been uniformly processed on an Act12 Clean Track (Tokyo Electron Ltd.) in the DRAM pilot line environment of Qimonda Dresden in collaboration with Fraunhofer CNT. Exposures were performed using a 50kV variable shaped electron beam writer SB3050 DW (Vistec Electron Beam GmbH). Three different independent methods were applied and interpreted for the characterization of HSQ:

- The interpretation of the isofocal dose method with its application in EBDW with chemically amplified resists was reported recently [2]. For HSQ, the method shows large differences between the target CD and the measured CD because of a huge film thickness loss with regard to the isofocal dose (Fig. 1).
- As second method, the vacuum stability of HSQ was investigated. The stability highly depends on the applied process, especially post apply bake (PAB) and post coat delay. With no PAB and a 24 hours delay, post litho CDs have constant values if the wafer stays at least two hours in vacuum before the exposure starts.
- In a final step, the so-called doughnut method [3] was tested to provide a point spread function for HSQ on bare silicon substrate. By this means, a simplified proximity effect correction could be set up for HSQ e-beam exposure on bare silicon for the first time (Fig. 2).

Three methods for resist and process evaluation have been checked and interpreted for HSQ. Details for further processing and integration of the resist will be presented. Nevertheless, the application in a DRAM pilot line environment could be challenging. Analyses of contrast curves show a worse contrast and potential instable working point. The comparison to research environments, where usually heated or higher concentrated TMAH developer is used, will be discussed.

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[2] Keil et al., MNE 2007, accepted for Microelectron. Eng. (2008).
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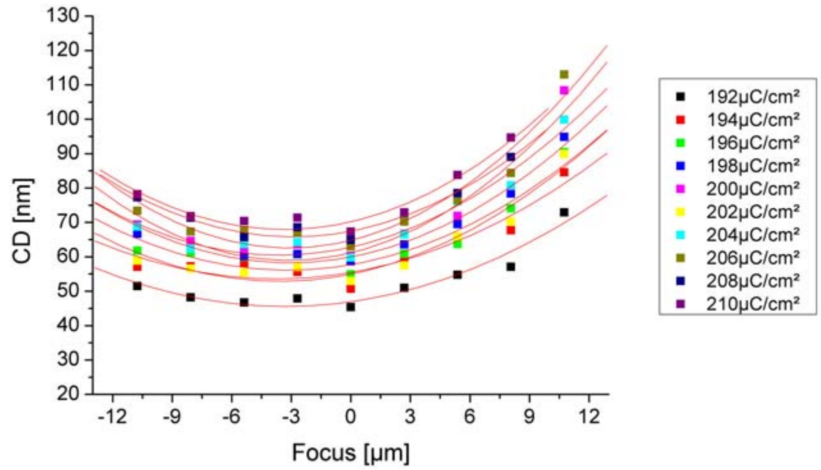

Fig. 1: Bossung plot of 60nm horizontal dense lines a result of the isofocal dose test.

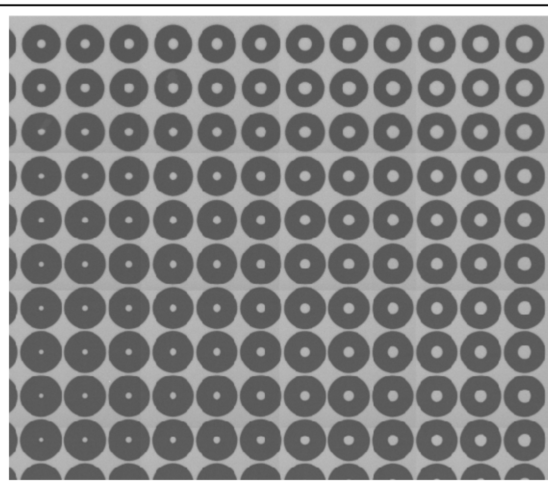

Fig. 2: Matrix of doughnut cells exposed in HSQ, where outer radius is constant and inner radius as well as exposure dose vary.