Electron Shot Noise Effects For 5kV EBDW

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Maskless lithography tools represent today an attractive solution to address industry needs for the sub-20nm technology nodes with high throughput and significant manufacturing costs reduction[1]. Linked to these productivity requirements (10 wph/module), high sensitivity resists are needed to reach the throughput target: 30 and 60 µC/cm² for respectively 5kV MAPPER and 100kV KLA RBEL platforms. Therefore, dealing with the well-known triangle of death, resist tuning becomes a complex game in which the determination of electron shot noise sensitivity is important. The know-how of this parameter can be also helpful for tool aspects to monitor blur, for example.

The aim of this work is focused on the impact of the shot noise effects on 32nmhp design rules for various resists using the MAPPER Pre-Alpha tool[2]. In a first step, the electron interactions in resist are experimentally characterized. Then, in parallel, based on a previous work from P. Kruit et al. [3], a 2 parameters model for shot noise sensitivity determination has been developed. The first parameter is the spot size which determines via exposure latitude how the shot noise dose errors translate into CDu and LWR errors. The second parameter is a measure for which fraction of the electrons contribute to the counting statistics. This second parameter is influenced by two resist characteristics: acid diffusion length and effectiveness of dose-to-clear. To validate the model, both Monte-Carlo simulation and experimental data have been correlated using Poisson law. This work will show that a good correlation between experimental data and this paper's model has been achieved (figure 1). Those data are helpful to extract resist fundamental parameters such as acid diffusion length and effectiveness of dose-to-clear to L-CDU performance. From these first results, it will be shown how shot noise contribution to L-CDU performance can be calculated. In the Figure 1 example, for this CAR resist, the contribution is around 50%! This highlights that shot noise effects cannot be neglected and has to be taken into account towards resist formulation optimization.

This paper will study the impact of process parameters. It will benchmark, as well, the shot noise sensitivity of various resist formulations (figure 2). Its objective will be to propose a methodology to help determining optimized resist and process parameters with the objective to minimize shot noise sensitivity.

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] G.de Boer et al., EIPBN Conference (2013)

[2] L.Pain et al., Proc. of SPIE, Vol 7970 (2011)

[3] P. Kruit et al., JVST B24(6) (2006)

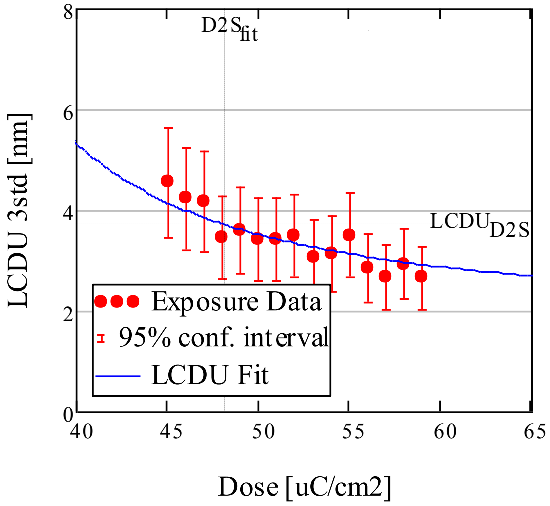

Figure 1: Fit comparison between shot noise model and experimental data

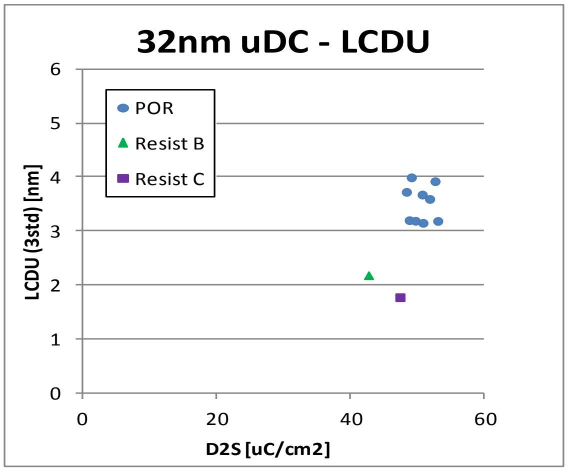

Figure 2: Local CDu at dose to size for various resists

Local CDU (LCDU) ITRS target for 32nm hp node: 2.1nm for 3sigma