In Situ Hard Mask Growth for Break Healing in Ultra-Thin Layers Patterning

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One of the challenges introduced by High NA EUV lithography include defectivity management, particularly when working with (ultra-)thin resists and low EUV exposure doses[1]. Reducing the bridges and breaks density is thus a major point of focus when patterning Line/Space[2]. Traditionally, a descum step is used to remove bridges, resulting in a reduced resist budget for underlayer patterning and leading to the creation of breaks. Therefore, recovering breaks is a strategic capability for defect reduction.

The method consists of patterning an underlayer of suitable thickness for thin resists and run an in situ PECVD process onto this underlayer, selectively to the material below in order to prevent and recover breaks[3]. This way, the hard-mask budget is increased in-situ during the etch process to prevent the formation of breaks while patterning from a thin underlayer (~10nm). This approach is presented in Fig1. Moreover, this method offers a reduced environmental footprint compared to conventional one as thinner ULs need fewer Global Warming Potential gases (GWP)[4]. Patterning of such ultra-thin layers (≤5nm) may come with high bridge/ break density which can be addressed by using this break healing strategy, thanks to in-situ selective HM growth.

In this work, the selectivity of deposition has been achieved, along with a notable decrease in break density and these results are shown in Fig2 and Fig3. However, the presence of additional deposited material brings new challenges. The focus of this work is to investigate the etch mechanisms which occur at the amorphous Carbon layer level, as well as to ensure the pattern transfer uniformity. Preliminary defectivity measurements will also be explored. Applications for both resist types, CAR and MoR, will be discussed. MoR is expected to induce more breaks, particularly problematic for low dose strategies. In addressing this issue, our break healing strategy emerges as a potential candidate for further exploration.

[1] L. Meli et al, *Proc. SPIE* 11609, 116090P (2021)
[2] P. De Bisschop, *J. Micro/Nanolithogr. MEMS MOEMS* 16, 041013 (2017)
[3] R. Vallat et al, *AVS69*, (PS+NS+FrM-3) (2023)
[4] P. Bézard et al. *Advanced Etch Technology and Process Integration for Nanopatterning XIII*. SPIE (2024)

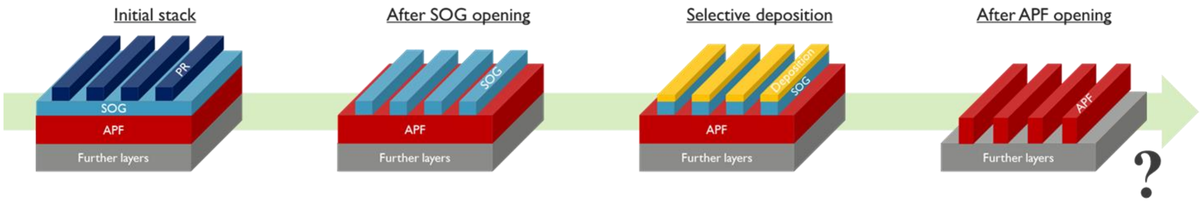

Figure 1 – Standard flow result in non-continue aC lines. An approach using a PECVD process in order to add a selective layer on top of SoG prior aC transfer is introduced to reduce the defectivity (especially the number of breaks).

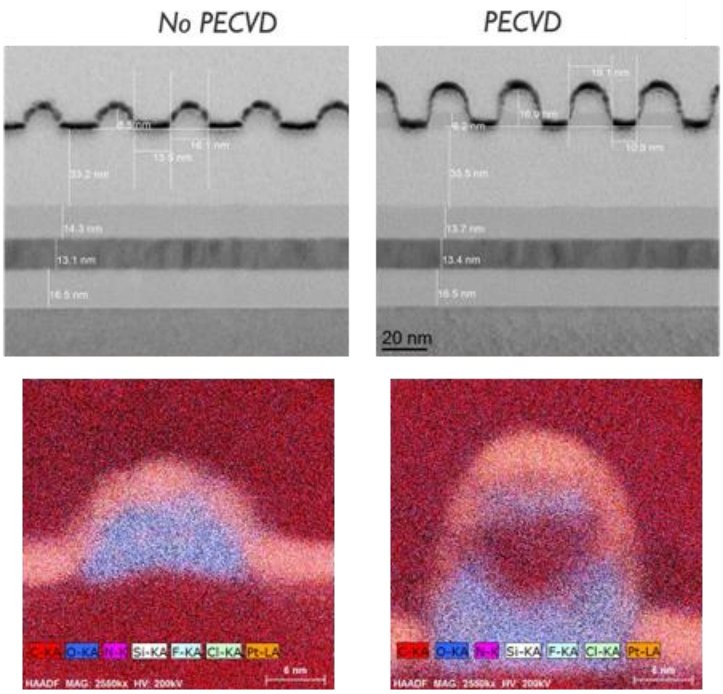

Figure 2 – TEM(EDS) views post SoG opening + PR strip a) without PECVD and b) with selective PECVD

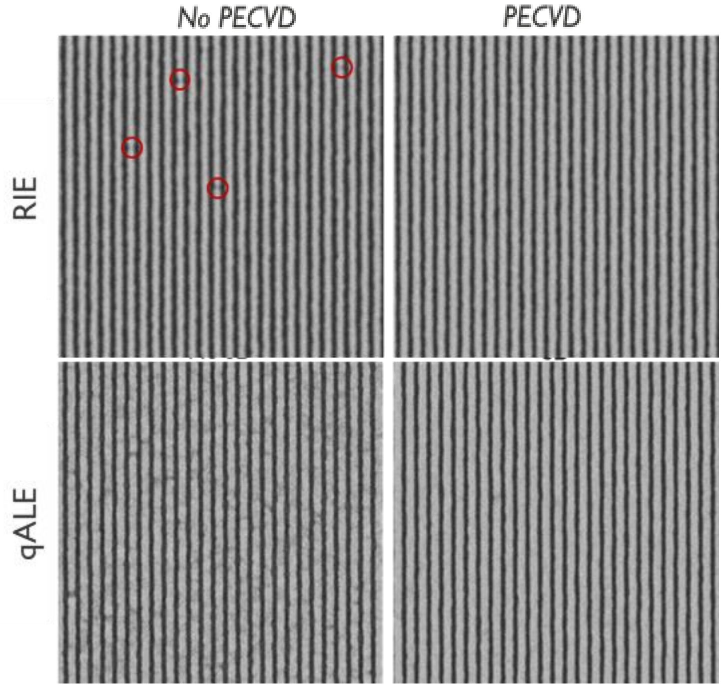

Fig 3 - CDSEM inspections post aC opening (qALE) w/wo PECVD at wafer center