APPLICATION NOTE: AN 01

PILLARHALL LHAR4 – COMPATIBILITY TO PE-CVD

In addition to ALD, also CVD is known as a deposition technology compatible to grow conformal thin films onto the high aspect ratio structures. The predominant academic view is that ALD is more controlled and reproducible than CVD to grow conformal thin films. The conformal CVD is typically enabled by driving the process in conditions when the film growth mechanism is surface controlled, which is also a basic condition of ALD.

PillarHall LHAR4 test chip (and its previous model LHAR3), has been used in the following published conformal thermal CVD and plasma enhanced (PE) ALD thin film process studies and demonstrations:

- Thermal CVD. Ag CVD process development and conformality characterization by PillarHall [1]
- Thermal CVD. Demonstration of inhibitor controlled conformal CVD in ultra high aspect ratio structure by boron-carbon thin films [2].
- Plasma ALD, experimental approach to exctract recombination probabilities in PE-ALD of SiO2, TiO2 and HfO2 [3] and studies of effects of low energy ions in SiO2 PE-ALD [4]

In general, PE-CVD is closely related to thermal CVD and PE-ALD, and therefore overall rationale conclusion can be that PillarHall is compatible to PE-CVD. However, the use of PillarHall in PE-CVD has not yet been proven or demonstrated experimentally. On the other hand, PillarHall studies have contained many ALD processes where the results have depended on eg. the used materials and details of the experimental set-up. Therefore, it should be assumed that PillarHall compatibility to PE-CVD will depend on the experimental parameters, and possibly results are even more sensitive to the parameter variations than is the case with ALD.

The sensitive parameters in PE-CVD can be due to to eg. plasma source and reactor design, precursors and other gas phase components participating to the growth mechanisms, temperature and its control, total pressure and partial pressure of reactant species, etc.

In plasma involved processes, it is also possible that the role of directional deposition and film growth becomes more important than in thermal processes. This effect is observed in some extent in PE-ALD, where generated ion species do not contribute much on the conformal SiO2 film growth under the membrane, while conformal part of the SiO2 film growth is associated more with the radicals instead of ions. This result is shown in Fig.1. and more details of the study are described in Ref [4].

PillarHall use in directional thin film growth studies is less utilized, although PillarHall LHAR4 test chip contains such features and possibilities for experimental arrangements. The PillarHall Technical Note TN-02 describes the experimental arrangements for the directional thin films.

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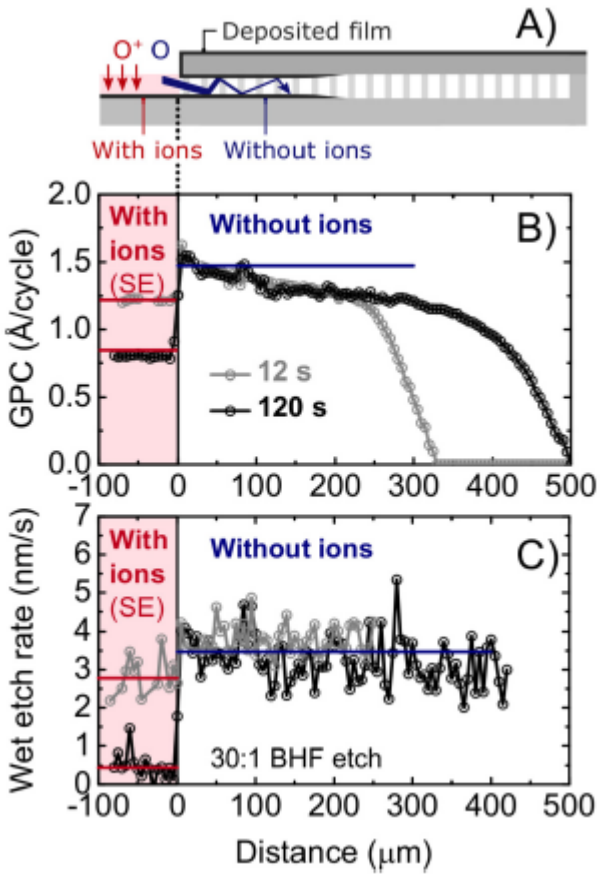

Fig.1. LHAR channel structures (a) with which the GPC (b) and wet etch rate (c) of PE-ALD SiO_2 films grown with and without the ion contribution. [4]

References

1. Two-Step Approach for Conformal Chemical Vapor-Phase Deposition of Ultra-Thin Conductive Silver Films, S. Wack, P.L. Popa, N. Adjeroud, C. Vergne and R. Leturcq, ACS Appl. Mater. Interfaces 12 (2020), 32, 36329–36338, https://doi.org/10.1021/acsami.0c08606
2. Surface-Inhibiting Effect in Chemical Vapor Deposition of Boron–Carbon Thin Films from Trimethylboron, L. Souqui, H. Högberg and H. Pedersen, Chem. Mater. 31 (2019) 5408-5412; https://doi.org/10.1021/acs.chemmater.9b00492
3. Film Conformality and Extracted Recombination Probabilities of O Atoms during Plasma-Assisted Atomic Layer Deposition of SiO2, TiO2, Al2O3, and HfO2
K. Arts, M. Utriainen, R. L. Puurunen, W. M. M. Kessels, H. C. M. Knoops, J. Phys. Chem. C 123 (2019), 44, 27030-27035, https://pubs.acs.org/doi/10.1021/acs.jpcc.9b08176
4. Evidence for low-energy ions influencing plasma-assisted atomic layer deposition of SiO2: impact on the growth per cycle and wet etch rate, K. Arts, J.H. Deijkers, T. Faraz, R.L. Puurunen, W.M.M. (Erwin) Kessels and H.C.M. Knoops, Appl. Phys. Lett. 117 (2020), 031602, https://doi.org/10.1063/5.0015379