

3D CHARACTERIZATION OF HIGH ASPECT RATIO TRENCH USING SIMS

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Achieving precise conformal doping in high-aspect-ratio trench (HART) structures like CMOS image sensors, 3D NAND and 3D DRAM is becoming increasingly important for next generation device performance. 1.5D SIMS has been used to characterize sidewall *dopant dose conformity* for 2 decades. This technique was developed mostly in application to FinFet transistor where trench depth typically doesn't exceed 200-300 nm and trench width is of the order of 100-150 nm [1]. 1.5D SIMS measurement, however, does not provide information on sidewall dopant concentration which is crucial for contact manufacturing in 3D DRAM process.

1.5D SIMS analysis requires a-Si trench backfill. There are adverse effects associated with that sample preparation step. One of them is the loss of sidewall dopant [2]. Another effect is specific to the HART itself: unfilled void in the middle of the trench due to the “bottleneck” forming at the top. As a result-SIMS measurement artifact which appears as “oscillations” in dopant distribution, Fig.1. This artifact is caused by formation of significant crater bottom roughness as revealed by SEM micrographs inserted in the upper and lower part of Fig.1. To eliminate this problem, we developed primary beam trench auto-filling technique. Relevant SIMS results along with SEM micrographs are presented in Fig.2 and show absence of any artifacts.

Besides adverse effects associated with backfill void formation, HART depth measuring from 5 to 30-40 μm opens a possibility for *through-sidewall SIMS dopant distribution measurement* [3]. This technique is called **Lateral SIMS** (Fig.3). It is discussed in detail in the present paper. Lateral SIMS in combination with 1.5D SIMS comprises **3D HART dopant characterization**. Sidewall dopant distribution obtained by *Lateral SIMS* is corroborated by the correlative APT analysis.

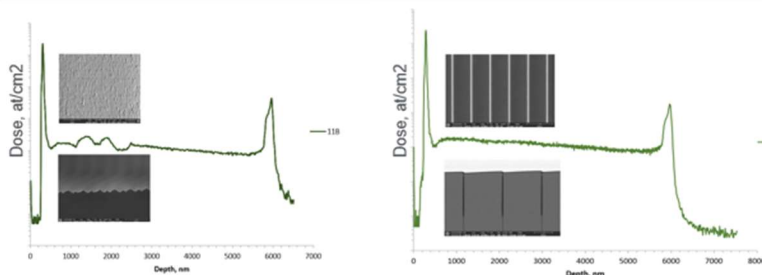


Fig.1. 1.5D SIMS of trench with void- no autofill, significant crater bottom roughness, dopant measurement artifact

Fig.2. 1.5D SIMS of the same structure as Fig.1, this time with void autofill: smooth crater bottom surface with filled trench under the crater

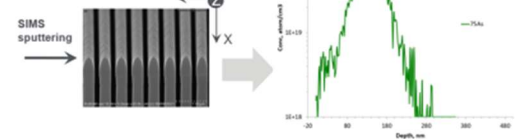


Fig.3. Lateral through-sidewall profiling revealing dopant (As) concentration through sidewall

References:

1. J. Mody et al, J. Vac. Sci. Technol. B **28**, C1H5 (2010); <https://doi.org/10.1116/1.3269755>
2. D. Kouzminov et al, *Microscopy and Microanalysis*, Volume 25, Issue 2, 1 April 2019, Pages 511–516
3. D. Kouzminov, V. Bhosle et al, Patent Number: US12575379