Batch ALD for MIM Capacitors

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Scaling down of semiconductor devices has entered a new challenging era in which limits are reached with the currently used techniques and materials, and substitutes have to be found. The ALD (Atomic Layer Deposition) method for deposition of a large variety of isolator- and conductor materials has proved to have the highest potential to comply with the requirements of the coming technology nodes for the high-k films [1]. This is due to the extraordinary good step coverage, the low deposition temperature and the superior layer quality, inherent to this deposition method when compared to the standard CVD technologies. The main drawback is the low throughput and thus high Cost per Wafer (CpW), a consequence of the layer-by-layer growth of ALD. This is particularly evident for thicker layers. Batch processing equipment can compensate for this drawback.
ALD developments have mainly taken place in single wafer equipment. ASMI and ASM Microchemistry, who pioneered the ALCVD™ deposition method, have extensive experience in the field of ALD. In addition to the single wafer tool for advanced thin layer high-k semi-conductor applications, ASM is now developing also a batch solution, together with its customers. Aimed applications are memory and wireless applications.
In this contribution we will present some first results obtained with The Advance® 400 Series of batch furnaces with Al_2O_3 and Ta_2O_5 for and outline future plans and expectations.
Figures 1 and 2 show respectively the thickness uniformity and electrical results for a 100-cycle Al_2O_3 film. The EOT value of 36.44 Å was obtained with D_{it} equal to 5.67e10 #/(eV-cm^2). Figures prove that the typical performance for Al_2O_3 film is comparable to that of the single wafer tools. Significant advantage of batch furnaces, particularly for MIM capacitors, is high throughput. In case of a 100-cycle Al_2O_3 film the obtained throughput is 35 wafers per hour per reactor with 100-wafer load size. Higher load sizes are also possible (125 and 150 wafers). This renders throughput of over 40 wafers per hour feasible in batch furnaces for this application.
Cost of ownership modeling shows that for a 100-cycle Al_2O_3 film, batch equipment gives cost per wafer value of around 2 $/wafer. Typical CpW of single wafer tools is at least 4 times higher. In addition to throughput, main items beneficial for CpW of batch processing are efficient footprint, high reliability performance and lower system costs.

Future work includes investigation of radical generation in a batch furnace for anneals and in-situ chamber cleans, solid source delivery, higher wafer load sizes, as well as processing with other materials than the ones listed above.
More information will be disclosed in the conference contribution.

REFERENCES

1. S. Haukka and T. Suntola, Interface Sci., 1997, pp 119

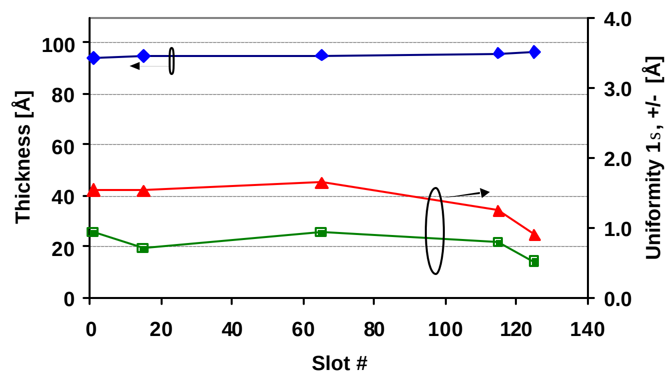

Figure 1. Thickness and uniformity results for the 100Å Al_2O_3 (1s and range values are given). The obtained throughput is 35 wf/hr.

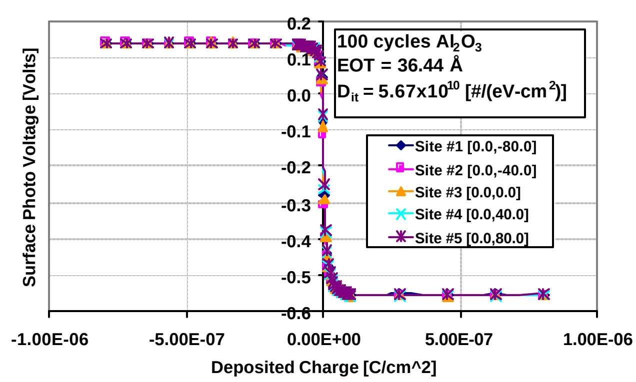

Figure 2. Electrical performance of a typical Al_2O_3 process in a batch furnace is comparable to the performance of the single wafer tools.