CONFORMALITY OF THERMAL AND PLASMA ENHANCED ALD

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The conformal, homogeneous deposition of films in 3 dimensional structures is one of the key features which make atomic layer deposition (ALD) an attractive technique in nano-electronics and other fields [1]. Due to the long deposition time, one wants to minimize pulse times, while maintaining full coverage of trenches and holes. Plasma enhanced (PE) ALD poses further restrictions, as reactive plasma species might recombine at the walls of deep trenches.

The conformality of ALD is usually studied by means of special substrates, where high aspect ratio features were realized e.g. by means of reactive ion etching. After ALD deposition, cross-sectional SEM and/or TEM are then used to determine whether conformal coating could be achieved on the entire inner surface of the trenches / holes.

In this work, we propose the use of simple and inexpensive macroscopic structures to quantify the conformality of the deposition process. A rectangle is cut from an aluminum foil (figure). The foil is then clamped between 2 pieces of SiO_2 wafer, thus creating a rectangular hole lined with SiO_2 surfaces. The aspect ratio can be varied by changing the dimensions of the rectangular opening and the thickness of the Al-foil. Because of the low pressure in the ALD reactor, the precursor flow inside these macroscopic structures will be in the Knudsen regime, as it is for microscopic trenches and vias. After ALD, both the upper and lower SiO_2 substrate can be retrieved and standard techniques such as ellipsometry can be used to measure the film thickness as a function of depth within the trench.

We deposited Al_2O_3 with a thermal process at 200°C with trimethyl aluminum (TMA) and H_2O precursors. AlN was deposited by a plasma ALD process at 200°C from TMA and N_2 plasma. The normalized film thicknesses (with respect to the film thickness outside the hole) are shown as a function of depth in the figure below. Further work is ongoing to characterize and model the conformality as a function of aspect ratio, pressure, precursor pulse time etc.

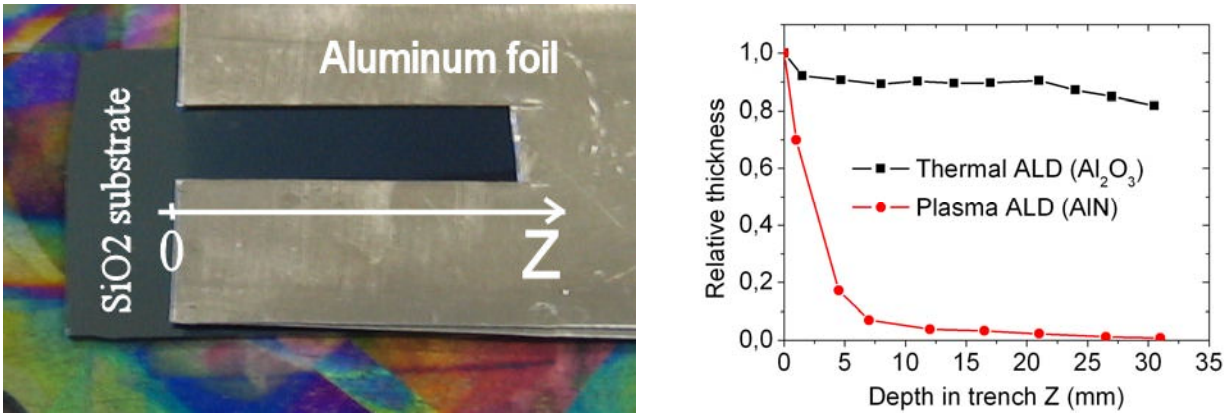

Figure: Macroscopic structure used to quantify the conformality of ALD processes (left), and initial results (thickness of the Al-foil was 0.4mm) for thermal ALD of Al_2O_3 and plasma ALD of AlN (right)

[1] R. G. Gordon, D. Hausmann, E. Kim and J. Shepard, Chem. Vap. Dep. **1,** 73 (2003)