A novel liquid Ruthenium precursor and its successful implementation in ALD

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With the semiconductor industry reaching the 2 nm node and below, Copper (Cu) as a well-established interconnect material in integrated circuits (IC's) in the back-end-of-line (BEOL) process chain is reaching its limitations due to diffusion and electromigration under operating conditions.[1] Next to Cobalt (Co), Ruthenium (Ru) is the most promising candidate to replace Cu in next generation microchips, due to higher chemical stability and shorter electron mean free path.[2] To deposit thin films homogeneously over complexly structured substrates, as in next generation 2 nm and below gate-all-around field effect transistors (GAAFETs), atomic layer deposition (ALD) is the method of choice. However, finding suitable ALD Ru-precursors matching the requirements of high vapor pressure alongside thermal stability and high reactivity is a challenging task for researchers from academia and industry likewise.

In this presentation, we report on the synthesis of a novel liquid Ru precursor and its successful utilization in a Ru ALD process. The promising thermal properties as depicted in Figure 1, prompted us to employ it for Ru metal film deposition in combination with oxygen as co-reactant. This resulted in the growth of Ru films on Si and Cu substrates in the temperature range 250 – 300 °C with a GPC of 0.8 Å. The as-deposited films were analyzed by means of scanning electron microscopy (SEM), transmission electron microscopy (TEM), atomic force microscopy (AFM), X-ray diffraction (XRD) and X-ray reflectivity (XRR). The layer composition was determined by means of X-ray photoelectron spectroscopy (XPS), Rutherford backscattering spectrometry (RBS) and nuclear reaction analysis (NRA) which revealed the high purity of the layers. The new findings on this newly developed precursor and associated ALD process can be rated as a significant step forward to meet the demands of the semiconductor industry for the 2 nm and beyond node.

[1] C. Adelmann, *IEEE Int. Interconnect Technol. Conf. Proc*, IEEE, San Jose, CA, USA **2016**, p. 38

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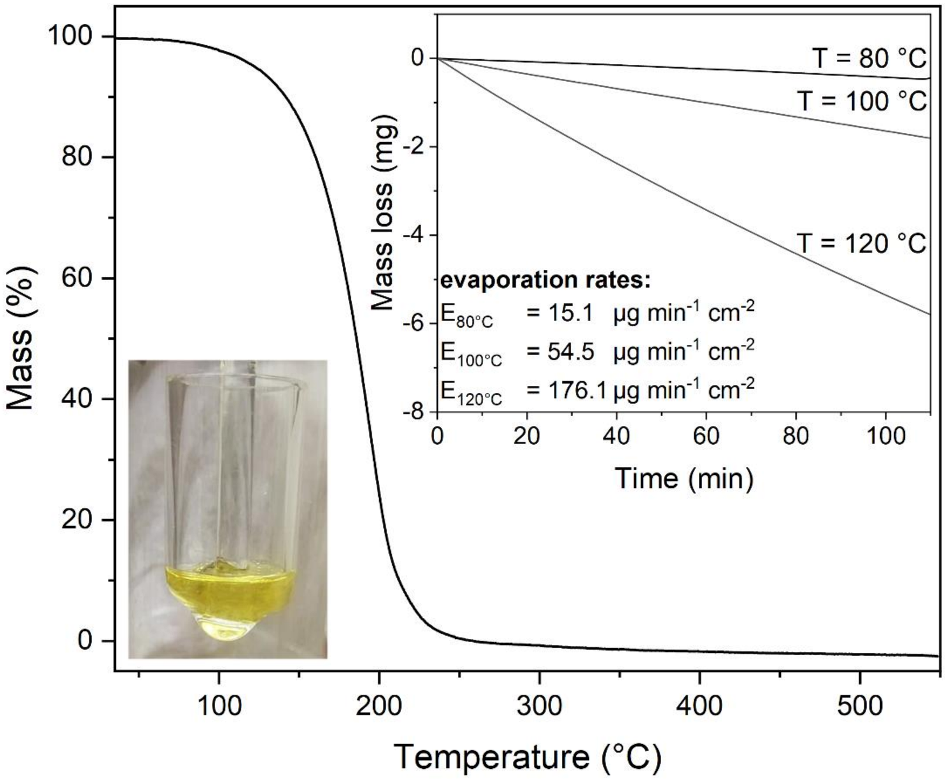

Figure 1 Thermal characteristics of the liquid Ru-precursor, depicted by TGA and isothermal TGA (insert).