New Precursors and Approaches to ALD and AS-ALD of Metallic Films

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Metal ALD is a topic where high industrial relevance combines with inspiring and challenging scientific questions. As always, the success of ALD builds on chemistry. There is constant need for new precursors to enable ALD of metals of interest with improved characteristics. Major challenge arises from the strong tendency of metals to agglomerate, hence preventing achieving continuous films at the smallest thicknesses. Lowering of the deposition temperature is of utmost importance to tackle this issue. This requires highly volatile and reactive metal precursors and reducing agents. Overall, the lack of an efficient universal reducing agent is a major challenge for metal ALD process development. In this presentation examples will be shown of our recent work on both metal precursors and reducing agents, including also reaction mechanism studies on selected processes.

Area-selective ALD (AS-ALD) of metals, and also other materials, is an important topic for self-aligned thin-film patterning. Ideally, the selectivity should be inherent with no need for passivation or activation of the surfaces. Here noble metal processes using metal β-diketonates and O_2 will be shown to have excellent inherent selectivity [1].

As an entirely new approach to self-aligned thin-film patterning *area-selective etching* of polymers will be presented (Fig. 1) [2, 3]. In these etching processes the selectivity arises from the materials underneath the polymer layer. Both O_2 and H_2 can be used as an etchant gas. Etching gas molecules diffuse through the polymer film, and when they reach a catalytic surface underneath, they dissociate into the respective atoms which then react with the polymer etching it away. On noncatalytic surfaces the polymer film remains. When combined with AS-ALD, self-aligned etching of polymers opens new avenues for the fabrication of semiconductor devices. Fig. 1 shows an example where area-selective etching of polyimide from Pt is followed by area-selective ALD of iridium using the patterned polymer as a growth-inhibiting layer on SiO_2, eventually resulting in dual side-by-side self-aligned formation of metal-on-metal and insulator (polymer)-on-insulator.

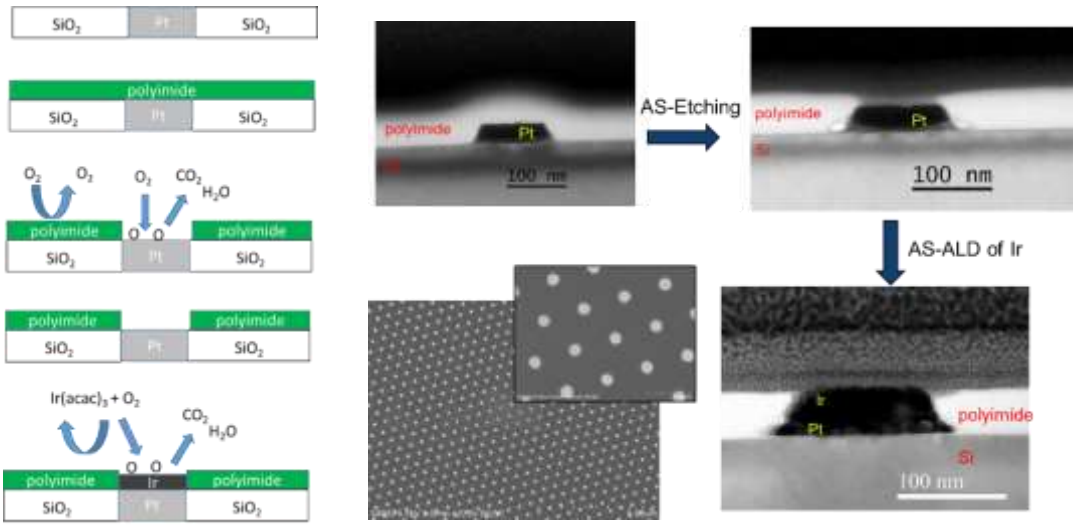

Fig. 1. Principle of area-selective etching followed by AS-ALD (left), and cross-sectional SEM images before and after area-selective etching of polyimide from Pt and after AS-ALD of Ir (right).

References

1. C. Zhang, E. Tois, M. Leskelä and M. Ritala, *Chem. Mater*. 34, 8379 (2022).
2. C. Zhang, M. Leskelä and M. Ritala, *Coatings* 11, 1124 (2021).
3. V. Lasonen, A. Vihervaara, G. Popov, E. Tois, L. Mester, M. Karimi, Y. Ilarionova, R. J. Jam, J. Sundqvist and M. Ritala, *Chem. Mater.* 35, 6097 (2023).