Extending ALD adoption in Sub-14nm Nodes, and Beyond Semiconductors, Through Precursors Innovation

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In the recent years, Atomic Layer Deposition (ALD) has been widely adopted for processing sub-28nm semiconductors integrated devices, due to advantages such as nanometer scale control, ease of film composition tuning, unique conformality for 3D architectures, relatively low hardware dependency, excellent uniformity etc… ALD has been deployed to deposit a large variety of binary or ternary metal oxides capacitors (HfMOx, ZrMOx), metals (Co, Ru, W, Mo) and metal nitrides (TiN, TaN, WN) electrodes and barriers. More recently, ALD is also getting attention for non semiconductor applications such as optical and hydrophobic coatings, where spatial ALD reactors can combine high quality ALD films at a CVD-like throughput.

Examples of common challenges faced by the industry include: a) tuning the precursor physical properties (melting point, vapor pressure etc) for industrial scale compatibility, b) stabilizing precursors despite lowering deposition thermal budget, c) maintaining conformality in shrinking trenches opening diameter, d) controlling surface reactions to selectively deposit desired material on one substrate only with high contrast to the others, e) increasing ALD growth-per-cycle (GPC) to maximize process throughput.

This talk aims at illustrating how precursor innovation and chemistry based solutions enables to overcome those challenges, with a particular focus on sub-10 nm semiconductor nodes. At first, it will be shown how combining surface silylation agents and innovative metal-organic chemistry allows to selectively deposit metal oxides on silicon oxides, with example of H_2O based Y_2O_3 selective ALD on dielectric at 300°C, which film can also be used for as bulk hydrophobic coatings [1].

Second, the review will present innovative ways of increasing ALD processes throughput by developing more complex, functionalized, higher order molecules [2]. Specific focus will be given to extra low temperature SiN Plasma-Enhanced ALD processes for SAQP lithographic schemes and new memory encapsulation applications, with introduction of new, high GPC, silicon precursor source and its applicability to nitride.

Finally, the talk will focus on metal CVD/ALD processes challenges resolution, by showing how ingenious combinations of diverse ligands in a precursor can provide tremendous benefits to the deposition process. Example of low temperature Cobalt metal CVD using improved stability silylated molecules, as well as Ni metal PEALD through metastable phase [3] will be discussed.

[1] I-K. Oh et al., ALD Russia, Moscow, Russia 2015
[2] A. Zauner, 16th ALD Conference, Dublin, 2016
[3] S. Gatineau et al., ADMETA 24th Asian session, Tokyo, 2014