

***In Situ* Mass Spectrometer Studies of Volatile Etch Products During Thermal Al₂O₃ Atomic Layer Etching Using HF and Trimethylaluminum**

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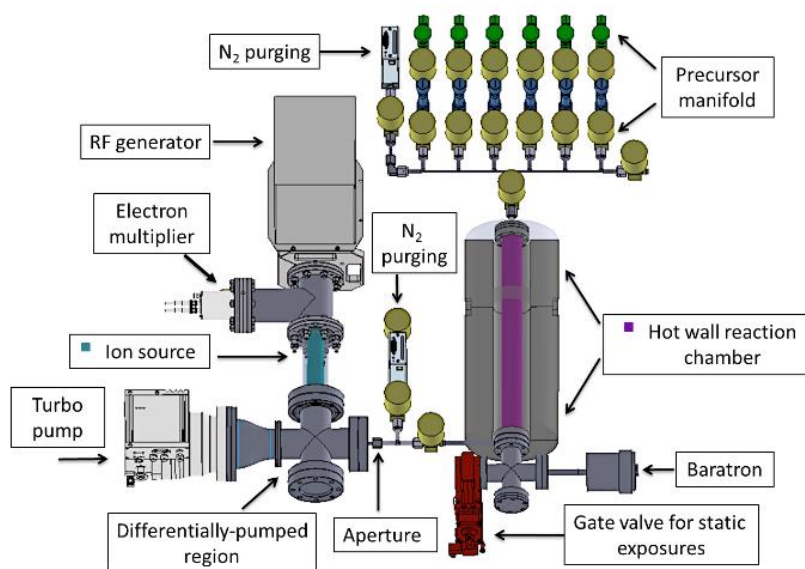


Figure 1. Schematic of ALE reactor with *in situ* quadrupole mass spectrometer (QMS), showing important features. The QMS ionizer is situated in a differentially-pumped region perpendicular to the incoming gas stream. This configuration improves the signal-to-noise ratio of volatile etch products as well as minimizes exposure to the corrosive HF reactant vapor. The gate valve separating the reaction chamber from the vacuum system enables static reactant exposures. This allows for complete saturation of the surface reactions on the high surface area Al₂O₃ substrate. Individual N₂ purging of the precursor manifold and the aperture region ensure that the reactant gases are completely removed between each ALE half cycle.