

Identifying ALE window in plasma
etching of SiO₂ and Si₃N₄ with
Impedans Octiv VI probe

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Introduction

Impedans serves the semiconductor manufacturing industry by providing Octiv VI Probes. Whether it's an ALD, ALE, RIE or ICP plasma tool, Octiv VI probes provide live and cost-effective solutions to RF measurements including current, voltage, phase and Impedance in CW and pulsed RF/DC environments. These measurements provide crucial insights into the tool performance enabling correlation of electrical variables with process parameters like ion flux, etch and deposition rates etc.

A recent publication in Plasma Processes and Polymers highlights the effectiveness of Impedans Octiv Poly VI probe system in atomic layer etching of SiO₂ and Si₃N₄. Octiv measurements played a key role in elucidating the relationship between the etch rate and the bias voltage across various precursors.

Experimental setup

Plasma etching of SiO₂ and Si₃N₄ samples were studied in an inductively coupled plasma reactor equipped with a source of 13.56 MHz on top and bias power of 12.56 MHz applied through the bottom electrostatic chuck as shown in Figure 1a. Throughout the process, the bias voltage was monitored using a voltage-current (VI) probe (Octiv Poly; Impedans). Experiments employed C₄F₈ alongside the low global warming potential gases, especially of perfluoroisopropyl vinyl ether (PIPVE) and perfluoropropyl vinyl ether (PPVE) precursors to assess the etch rate of SiO₂ and Si₃N₄ in relation to the bias voltages.

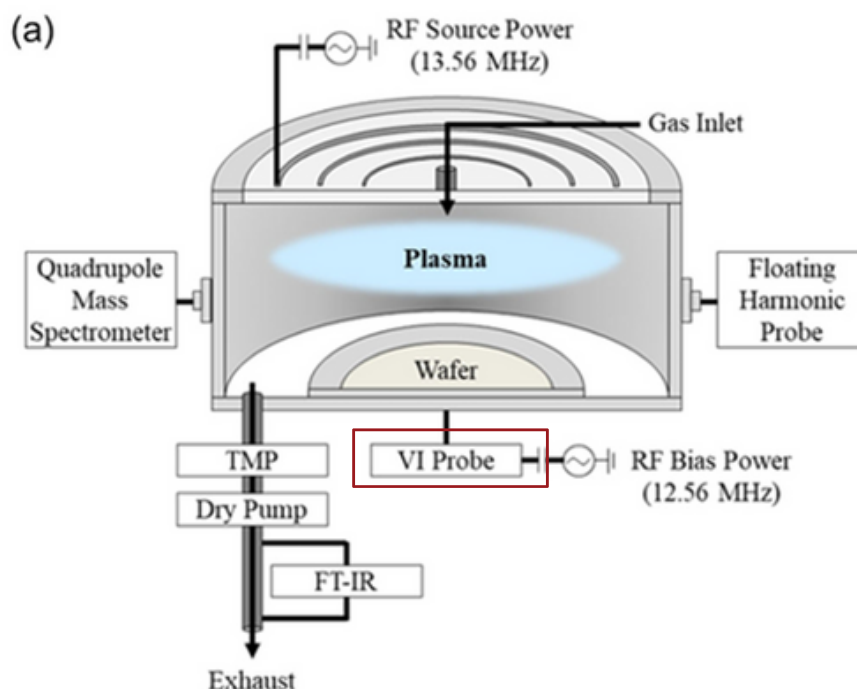


Figure 1 Schematic of the inductively coupled plasma reactor and diagnostic tools.

Results

The ion energy is the most important parameter in the anisotropic ALE process, with three different regions— incomplete etch, ALE window, and physical sputtering—identified based on the ion energy in the etching step. The Etch Per Cycle (EPC) of SiO₂ investigated by controlling the bias voltage in Ar plasma is shown in Figure 2. The ALE window region with a constant EPC of SiO₂ was confirmed at bias voltages between 50.0 and 57.5 V for all precursor plasmas.

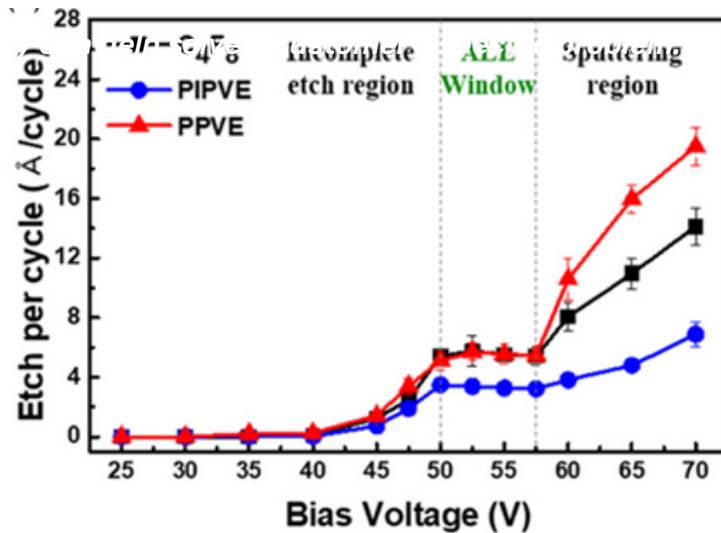


Figure 2 Etch per cycle of SiO₂ using C₄F₈, PIPVE and PPVE plasmas in the fluorination step in ALE process as a function of bias voltage.

The EPC of Si₃N₄ was also investigated with respect to the bias voltage, as shown in Figure 3. The ALE window region of Si₃N₄ was observed at bias voltages between 50.0 and 57.5V, the same as that of SiO₂ while the EPC of Si₃N₄ was approximately two times higher than that of SiO₂.

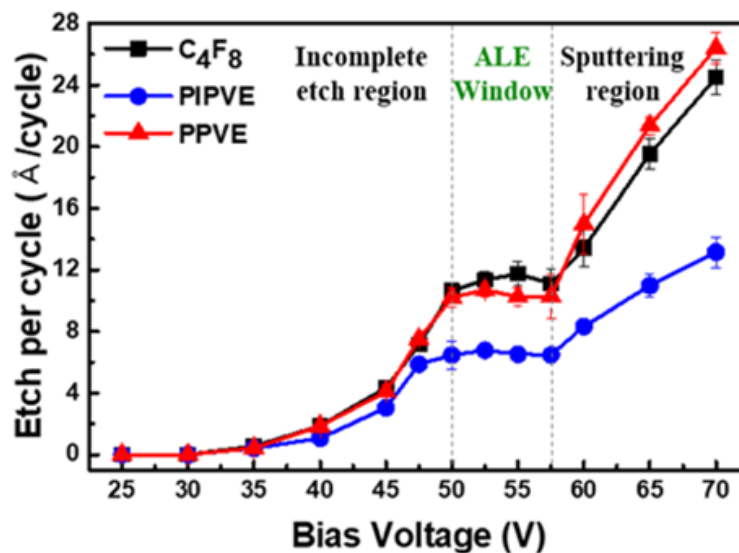


Figure 3 Etch per cycle of Si₃N₄ using C₄F₈, PIPVE and PPVE plasmas in the fluorination step in ALE process as a function of bias voltage.

Summary

Octiv measurements helped the researchers to identify the ALE window for both SiO₂ and Si₃N₄ substrates. These measurements revealed the significant influence of bias voltage in regulating ion energies crucial for the etching process. Further, it was found that the bias voltage for ALE window is same for both SiO₂ and Si₃N₄ samples under similar conditions while the etch per cycle is double for the later as compared to the former.

Utilizing Impedans' Octiv VI probe to measure bias voltage offers direct insights into the etching process, enabling precise identification of the ALE window. Consequently, control over the etching profile can be achieved through manipulation of bias voltages.

To know more about Impedans Octiv VI Probes [click here](#).