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Accuracy control of SiO2 etching in inductively coupled CF4/Ar plasmas**

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Plasma etching and deposition are essential steps in the fabrication of micro-electro-mechanical-systems (MEMS) and very large scale integrated circuits (VLSI). Atomic layer etching (ALE) is a technique analogous to atomic layer deposition (ALD) in which processing proceeds in a cyclic, self-limiting manner [1], and removal of monolayer of the top surface, so that atomic-scale etching achieved. As microelectronic device sizes continue to shrink, high aspect ratio (AR), high selectivity, low radiation damage and applications of complex structures such as 3D transistors, traditional reactive ion etching (RIE) is difficult to meet the needs in some critical steps. ALE has entered the critical stage from research to industrial application.

A complete ALE cycle includes two steps of evacuation of the chamber which costs a large amount of time resulting in a considerable restriction on its yield. Therefore, study on bias voltage waveform and radio frequency pulse source use for control of monoenergetic ions energy is pouring, which is plasma enhanced atomic layer etching (PE-ALE). PE-ALE can improve tens-fold of efficiency.

In this work, a multi-scale numerical model [2] consists of reactor, sheath, trench is used to study the PE-ALE of silicon dioxide (SiO2) in Ar/CF4 plasmas. The reactor model built by CFD-ACE+ can calculate ions density used at the sheath boundary, and then the sheath model will give out IEDs, IADs and IEADs, finally the IEADs can be used in the trench model. PE-ALE and traditional RIE of SiO2 in Ar/CF4 plasma under different pressure, chemical fluxes (including ions and neutrals) and bias voltage waveform were calculated. The purpose of this work is to explore better bias voltage waveform, as well as near surface ion and neutral effects on aspect ratio dependent etching (ARDE) by modeling of SiO2 structure etching. Some results show that the chemical fluxes can influences the vertical of sidewall, and the tailored bias voltage waveforms can modulate IEADs effectively to improve the trench profile.

References:

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[2] SUI Jiaxing, Zhang Saiqian, LIU Zeng, YAN Jun, DAI Zhongling, Plasma Science and Technology, 2016, 18 (6) :666-673

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