Fluid simulation on plasma characteristics of RF capacitively coupled plasma sustained in $SiH_4/N_2/O_2$ and $Ar/SiH_4/N_2O$

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Silicon oxide, silicon nitride, or silicon oxynitride thin films grown by plasma enhanced chemical vapor deposition (PECVD) have been widely used in the semiconductor devices or integrated circuits. These thin films are often deposited in radio-frequency (RF) capacitively coupled plasmas (CCPs) sustained in mixtures of SiH_4/N_2O, $SiH_4/N_2/NH_3$ and SiH_4/O_2 in which inert gases, such as Ar or He, are often added in order to improve discharge characteristic.

In this work, the characteristic of $SiH_4/N_2/O_2$ and $Ar/SiH_4/N_2O$ discharge in a RF CCP reactor is investigated, using a two-dimensional fluid model. In $SiH_4/N_2/O_2$ plasma, its possible gas phase precursors, such as SiH_3O, SiH_2O, SiO, SiN, $HSiNH_2$, and NH for the deposition of Si-based film are examined as a function of pressure, gas mixture and voltage. It is found that SiH_3O, SiH_2O, O, N and NO may be the most important deposition precursors. In addition, possible gas phase precursors in $Ar/SiH_4/N_2O$ plasma are also discussed. And, we mainly focus on gas ratio effects on deposition precursors at relatively higher pressure, i.e. 1 and 2 Torr, and discuss the role of the inert gases Ar in the discharge and the effect of vibrational excitation of N_2O and SiH_4 on possible gas phase precursors. We found that the content of argon gas in the mixtures can effectively increase the electron density and adjust the electronegativity of the plasma to reduce the occurrence of dust particles, but reduce the content of possible gas phase precursors. Further, important chemical reactions in possible gas phase precursors are also analyzed in detail for precise control of the chemical reaction path by the changing external conditions.

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