Hiden Reference: AP-HPR-30-0002
Hiden Product: HPR-30 Vacuum Process Gas Analyser

Mass spectrometer study in Time-Multiplex SF_6+CH_4 Plasma Etching of Silicon

The chemical study of radiofrequency (RF) sulphur hexafluoride (SF_6) plasma, either pure or mixed with other gases such as oxygen (O_2), methane (CH_4) and argon (Ar), is growing everyday due to different applications in the semiconductor industry. Plasma etching of materials such as silicon (Si), silicon dioxide (SiO_2) and others, allows one to integrate the sensor structures with electronics making possible the formation of trench structures for construction of basic electronics components such as capacitors, resistors, etc in micro/nano scale. However, in this field of application, processes involved in the formation of the plasma and the interaction between the plasma particles and etched surface are not fully understood, therefore the study of SF_6 plasma chemistry (pure or mixed with other gases) is essential to better control the generation of reactive species in the plasma and consequently the process outcome. In this work, a HPR-30 Vacuum Process Gas Analyser is used for temporal monitoring of neutral atoms and molecules as can be seen in figure 1.

Figure 1. HPR-30 Vacuum Process Gas Analyser coupled to RIE plasma etch.

Basically, the Si etch can be performed in two different ways: single-step or multi-step. In single-step the gas is inserted continuously during whole Si etching process. For multi-step, also known as the Bosch method, a cyclic gas injection routine that results in alternating etching and deposition steps, is performed. A multiple-step deep Si etch process is performed which involves separate etch and polymerization steps. In multiple-step processes, a sidewall passivation film (usually a polymer) is first deposited, and the film plus Si surface are etched from the bottom of the trench in the subsequent step. These cyclic etching and deposition steps are repeated to obtain features as deep as desired.

Several steps are usually involved in the process of fluorinated plasma etching. Initially reactive particles are generated in plasma by dissociation of neutral gas molecules by electron impact, and then these particles are directed to the material surface by diffusion where they are adsorbed. Subsequently, volatile products are formed through chemical reactions and are desorbed from the surface before being removed by the vacuum system as can be seen in figure 2. If the reaction product is not volatile, a passivated film is formed. In the case of SF_6 molecules, these are dissociated (SF_6+e→S_xF_y or ($S_xF_y^+$)+F_n+e, where x = 1-2, y = 1-5 and n = 1-5) to generate atomic fluorine (F) which is the main agent in the silicon etch due to its high affinity. Initial results indicate a cyclic behavior for the gas feed pattern in the RIE reactor (SF_5^+ and CH_4^+) as well for the formation of SiF_3^+ products (figure 3).

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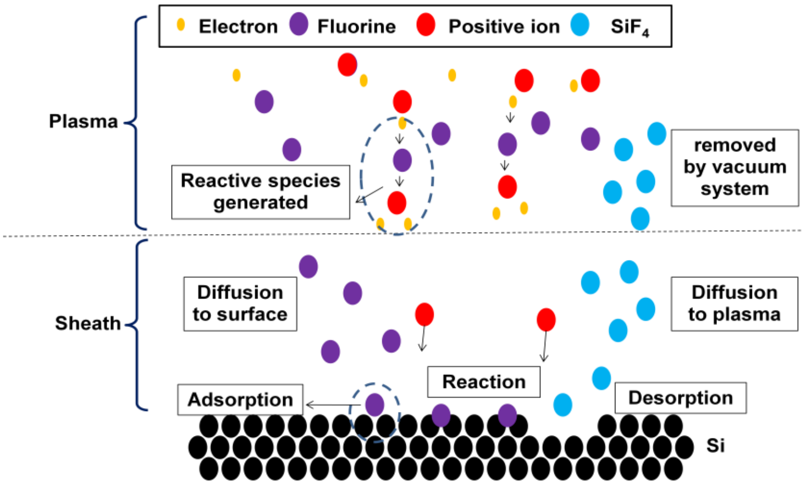

Figure 2. Schematic diagram of the Si fluorinated plasma etch process.

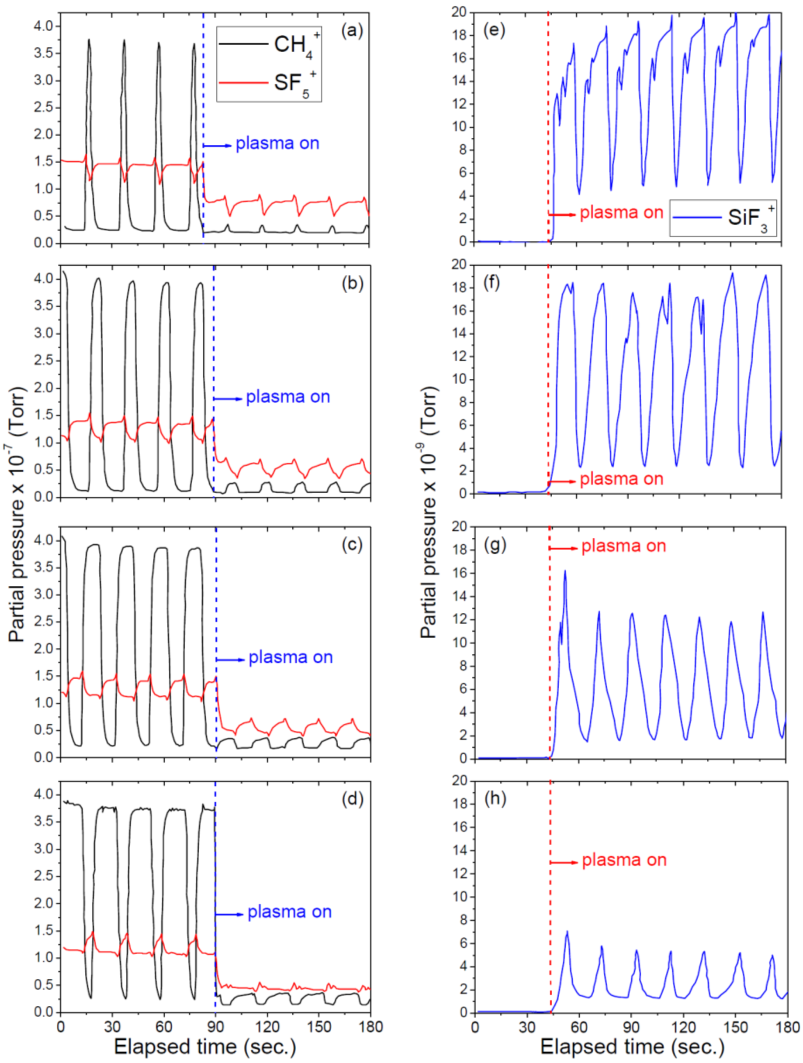

Figure 3. Partial pressure time evolution of SF_5^+ and CH_4^+ species for SF_6 gas in continuous mode and CH_4 as in intermittent mode for various duty cycle values: (a) 20%, (b) 40%, (c) 60% and (d) 80% and also, the

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SiF_3^+ specie behavior for the same duty cycles: (e) 20%, (f) 40%, (g) 60% and (h) 80%. Here, the process time evolution is used to investigate the effect of plasma on and off, as well as the duty cycle effect.

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Hiden Product:
HPR-30 Vacuum Process Gas Analyser

Follow the link to the product catalogue on our website for further information
http://www.hidenanalytical.com/index.php/en/product-catalog/182-gas-analysers-hpr-series/462-hpr-30-rga-cart