Literature Digest
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Plasma Etching

50 nm gate electrode patterning using a neutral-beam etching system
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A neutral-beam etching (NBE) system using a pulse-time-modulated inductively coupled plasma for the generation of negative ions is described. The negative ions are neutralized as they pass through 1 by 10 mm apertures in the carbon bottom plate of the source. SF_6, Cl_2, and SF_6/Cl_2 mixtures were tested to etch 150 nm undoped poly-Si on 2 nm SiON films with KrF lithography resist patterns which had been trimmed to 50 nm width by plasma etching using HBr/O2 gas chemistry.

Undercut profiles were observed for SF_6 when a negative voltage was applied to the top plate of the plasma chamber in order to drift the negative ions towards the neutralizing apertures in the bottom plate. The same experiment yielded tapered to flared profiles for a Cl_2 mixture. A mixture of 30 sccm Cl_2 and 10 sccm SF_6 resulted in less undercut profiles compared to SF_6. The etch rates for Cl2 were very low, around 5 nm/min which is explained by measurements indicating that the neutral beam energy was with 5 eV below the etch threshold for etching silicon with Cl ions (9eV). In order to increase the neutral beam energy, a 60 W 600 kHz RF field was applied to the bottom extraction plate of the plasma chamber. A broad energy distribution with energies up to 80 eV was measured. The resulting profiles for the SF_6/Cl_2 mixture are much more anisotropic, but the SEM cross section indicate significantly reduced resist selectivity. The overetch was performed with pure Cl_2 with cw biased source. The leakage current of a MOS capacitor etched using NBE was one order of magnitude lower than that of a capacitor produced by conventional plasma etching.

Direct trim etching process of Si/SiO_2 gate stacks using 193 nm ArF patterns
K. M. Tan, W. J. Yoo, H. H. H. Ma, F. Li, L. Chan
J. Vac. Sci. Technol. A 22 (2004) 1500
A polysilicon gate of 30 nm length is produced by direct trim of poly-Si a with HBr/Cl_2 plasma chemistry in an inductively coupled plasma ICP etcher. HBr is found to be more effective than Cl_2 for poly Si trimming. A maximum trimming rate of 32 nm/min is obtained with gas chemistry of 80% HBr and 20% Cl2. The trim rates increase with an increase in ICP power from 200 to 800 W and decrease in pressure from 70 to 10 mTorr. The dense / iso microloading for this process is significant especially at low pressures. The trim process with HBr/Cl_2 mixtures results in footed profiles which can be addressed by using an $HBr/Cl_2/O_2$ main etch and SF_6/Cl_2 softlanding step prior to the poly-Si trim step.

Identification of halogen containing radicals in silicon etching plasmas and density measurement by UV broad band absorption spectroscopy
M. Kogelschatz, G. Cunge, N. Sadeghi
J. Phys. D: Appl. Phys. 37 (2004) 1954
A low pressure high density $HBr/Cl_2/O_2/CF_4$ plasma etching a 200mm diameter silicon was studied with broadband UV absorption spectroscopy and the absolute densities of $SiCl_X$ (X = 0–2), SiF_X (X = 1–2) and SiO species, as well as SiBr molecules were measured. A new absorption spectrum has been observed and attributed to the SiClF radical. The experiments were carried out with a Xe arc light source and a photodiode array detector in the spectral range of 200 to 400 nm.

Reactive etching of platinum-manganese using a pulse-time-modulated chlorine plasma and a H_2 plasma post-etch corrosion treatment
S. Kumagai, T. Shiraiwa, S. Samukawa
J. Vac. Sci. Technol. A 22 (2004) 1093
PtMn based materials are one of the most promising candidates for a spin-valve in MRAM devices because of their high thermal stability and high blocking temperature. It was found that by using a pulsed chlorine plasma at the pulse timing from 10 to 100 μs, highly anisotropic PtMn etching with smooth features and sidewalls without corrsion could be achieved. The enhancement of PtMn etching reaction was attributed to the incidence of the negative ions that were produced during the pulse-off time through the dissociative electron attachment. The substrate was powered with a 600 kHz generator. The substrate was kept at room temperature.

Plasma Diagnostics

Spectrometry of 0.46 and 13.56 MHz Ar/SF6 inductive plasma discharges
M. Tuszewski, W. K. Scarborough, R. R. White
J. Appl. Phys. 96 (2004) 1811
SF_6 gas is dissociated primarily into SF_x with x=0–2 and S_2F_x with x=0–1 neutral species. SF_3^+ and SF_5^+ are the main positive ion species for most discharges. The SF_6 gas dissociation increases as the gas pressure is lowered and as the RF power is increased. At the same time, the concentrations of the SF_x^+ and $S_2F_x^+$ ion species increases, and S^+ can become the main ion species.

Advanced Devices

Pentacene nanotransistor with carbon nanotube electrodes
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Appl. Phys. Lett. 85 (2004) 1021
Pentacene thin film can behave as semiconductors with electron mobilities comparable to that of amorphous silicon films. This paper reports on a pentacene nanocrystal transistor with multiwalled carbon nanotubes (MWNTs) electrodes as a nanosize source and drain. The evaporated pentacene selectively grows around the nanotube electrodes. The nanotransistor showed controllable transistor operation at room temperature and Coulomb blockade oscillations at 4.2 K in gate voltage characteristics.