Literature Digest
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Plasma Etching – Compound Materials

"Plasma-Assisted Dry Etching of Ferroelectric Capacitor Modules and Application to a 32M Ferroelectric Random Access Memory Device with Submicron Feature Size"
S.W. Lee, S.K. Joo, S.L. Cho, Y.H. Son, K.M. Lee, S.D. Nam, S.K. Park, Y.T. Lee, J.S. Seo, Y.D. Kim, H.G. An, H.J. Kim, Y.J. Jung, J.E. Heo, M.S. Lee, S.O. Park, U.I. Chung, J.T. Moon
Jpn. J. Appl. Phys. 41 (2002) 6749

The etch behavior of (111)-textured $Pb(Zr,Ti)O_3$ (PZT) in a Ar – CF_4 – Cl_2 – O_2 plasma was studied. Surface modifications were investigated on blanket wafers. A drastic reduction of the Pb concentration was observed after etching. Pb_4^+ or metallic Pb binding energies were not detected. The authors conclude that this contradicts previously proposed etch mechanisms were preferential Pb removal by Ar sputtering (J. Jung, W. Lee; Jpn. J. Appl. Phys. 40 (2001) 1408). Since PbCl2 and PbF2 have high boiling points, the removal through the formation of $Pb(ClO_3)_2$ or $Pb(ClO_2)_2$ with low melting points (230 and 126 °C) is proposed. This is supported by mass spectroscopic investigations. As for Pb, different oxidation states were not observed for Zr and Ti but their binding energies shifted towards higher binding energies. Small mounts of F but no Cl were detected. The authors conclude that there are Zr-O-F and Ti—O-F are formed on the surface. The concentration of Ti increased from about 32 to 62 atomic % after etching. The Zr concentration remained unchanged. After mask formation and patterning, a sidewall slope of 70° with a smooth sidewall surface were achieved.

"Inductively Coupled Plasma Reactive Ion Etching of SiC Single Crystals Using NF_3-Based Gas Mixtures""
H.J. Choi, B.T. Lee
Journal of Electronic Materials 32 (2003) 1

This paper reports on the inductively coupled reactive ion etching of SiC with NF_3 chemistries. The effects of adding CH_4 and O_2 as well as use of Ni, SiO_2 and PR masks were studied. The selectivity of the PR mask increased from 0.2 to 0.4 when 30 % CH_4 were added while the etch rate deceased by 50 to 70 %. Ni and SiO_2 masked samples did not show a change in selectivity for methane addition but a reduction in etch rate was observed. Microtrenching was observed for all experiments with silicon oxide mask. Neither NF_3 nor O_2 addition changed the SiO_2 mask selectivity significantly.

Devices – High k Dielectrics

"Origin of the Threshold Voltage Instability in SiO_2/HfO_2 Dual Layer Gate Dielectrics"
A. Kerber, E. Cartier, L. Pantisano, R. Degraeve, T. Kauerauf, Y. Kim, A. Hou, G. Groeseneken, H.E. Maes, U. Schwalke
IEEE Electron Device Letters 24 (2003) 87

Capacitance-time trace and charge pumping measurements show that the V_t instability is caused by the fast charging and discharging of preexisting defects near the SiO_2/HfO_2 interface and in the bulk of the HfO_2 layer. The following model is proposed to explain the complex behavior of the V_t instability: 1. A defect band in the HfO_2 has an energy above the Si conduction band. 2. The defect band shifts rapidly in energy with respect to the Fermi level in the Si substrate as the gate

bias is varied. 3. The rapid energy shifts allow for efficient charging and discharging of the defects near the SiO_2/HfO_2 interface by tunneling. The physical origin of the defect band may be related to oxygen vacancies, chlorine impurities and or water-related defects, such as OH (OH^-) groups, introduced by the precursor chemistry.

Devices – Carbon Nanotubes

"Electrically induced optical emission from a carbon nanotube FET"
J. A. Misewich, R. Martel, P. Avouris, J. C. Tsang, S. Heinze, J. Tersoff
Science 300 (2003) 783

This paper reports on light emission from an ambipolar FET made from semiconducting single-walled carbon nanotubes (s-SWNT's). It was found that the light originates from radiative recombination of electrons and holes that are injected simultaneously into the undoped nanotube. The carbon nanotube source relies on the presence of narrow metal-nanotube Schottky barriers that are present at each junction at the ends of the tube. This allows the simultaneous injection of e^- and h^+. The investigated nanotubes had a diameter of approximately 1.4 nm and a corresponding band gap of 750 meV (emission wavelength of about 1650 nm). Because the band gap of carbon nanotubes is inversely proportional to the tube diameter, it should be possible to control the emission wavelength by selecting nanotubes with variable diameter. The authors also show that the carbon nanotube is a linearly polarized dipole radiation source.

Nanotechnology

"Wafer-scale strain engineering on silicon for fabrication of ultimately controlled nanostructures"
H. Omi, D.-J. Bottomley, Y. Homma, T. Ogino
Phys. Rev. B 67 (2003) 115302

In this paper, method is proposed to achieve nanostructure self-assembly through strain distribution control on planar Si(001) and Si(111) wafers. Oxygen ions are implanted through patterned layers on the silicon wafer. The sample is then annealed to produce bulk oxide inclusions that yield a tensile and/or compressive strain distribution on the silicon surface. The strained epitaxial growth of Ge on the Si(001) substrate surface produces three dimensional islands whose location and size distribution can be controlled.