ABSTRACT

Hydrogenated silicon nitride alloy SiNH thin film has been grown on silicon and glass substrate from a DC plasma glow discharge decomposition of silane (SiH_4) and ammonia (NH_3) mixture, utilizing a home-built parallel-plate radial flow system. The properties of these films have been investigated using the Fourier Transform Infrared (FTIR) Spectroscopy and Ultraviolet-Visible transmission spectrum as a function of deposition parameters, namely NH_3 to SiH_4 flowrate ratio $R=[NH_3]/[SiH_4]$ and substrate temperature. IR absorption revealed the incorporation of nitrogen into the Si-matrix through the broad Si-N stretching mode vibration in the region 700 to 1000 cm^{-1} and centred around 860 cm^{-1}. A closer analysis yields 5 components underlying the broad band, reproduced by superposition of Gaussian profiles using the least - squares method. Two different bonding environment for Si-N stretching absorption modes are observed at around 860 cm^{-1} and 960 cm^{-1} respectively. The presence of H has been readily observed in the vicinity of 2100 cm^{-1} and 3500 cm^{-1}, attributed to the Si-H and N-H stretching modes respectively. An appreciable oxygen content is detected through the Si-O stretching absorption around 1000 cm^{-1}. The film compositional mole ratio x = N/Si is estimated from a quadratic dependence of the optical energy gap, E_g on the concentration of the incorporated N, and x values obtained ranging from zero to 0.88. A strong correlation between N/Si ratio, x and the NH_3 to SiH_4 flowrate ratio, R is observed, in the experimental regime, of the form $x=CR^a$. E_g increases smoothly from 2.03 eV towards 3.02 eV when the NH_3 to SiH_4 flowrate ratio is increased from zero towards 5. Whereas with increasing substrate temperature a gradual shift to lower E_g value is observed, from 3.66 eV to 2.71 eV. Hydrogen content seemed to have an influence on E_g. The static refractive index n_0 displayed a decreasing trend when the NH_3 to SiH_4 flowrate ratio is increased while a reversal trend is displayed as the substrate temperature is increased. The average deposition rate of the films were relatively low as expected from a DC-induced field plasma decomposition. The variation of the average deposition rate as a function of NH_3 to SiH_4 flowrate ratio does not show a constant trend. A decrease in the average deposition rate with increasing substrate temperature is observed.

ABSTRAK

Aloi filem nipis *silicon nitride* terhidrogen SiNH telah disediakan di atas substrat silikon dan kaca melalui kaedah Penguraian Nyahcas Berbara Arus Terus daripada campuran gas-gas *silane* (SiH_4) dan ammonia (NH_3), dengan menggunakan sistem plat selari aliran sepusat buatan sendiri. Filem nipis ini telah dicirikan dengan menggunakan Spektroskopi Transformasi Fourier Infra-Merah dan Spektrum Ketelusan Ultra-Lembayung, berfungsikan parameter penyediaan sampel iaitu nisbah kadar aliran gas *silane* terhadap gas ammonia $R=[NH_3]/[SiH_4]$ dan suhu substrat. Kehadiran unsur nitrogen di dalam matrik silikon disahkan melalui penyerapan Infra-merah yang dominan di lingkungan 700 ke 1000 cm^{-1} dan berpusat sekitar 860 cm^{-1}, yang disebabkan oleh ikatan teregang Si-N. Kajian yang lebih terperinci menggunakan kaedah gandadua terkecil ke atas Taburan *Gaussian*, menunjukkan kawasan serapan yang dominan ini adalah hasil daripada pertindihan 5 komponen. Didapati terdapat 2 jenis ikatan teregang Si-N dengan sekitaran setempat yang berbeza dengan puncak-puncak serapan pada 860 cm^{-1} dan 960 cm^{-1}. Kehadiran unsur hidrogen dikesan melalui puncak serapan pada 2100 cm^{-1} yang disebabkan oleh ikatan teregang Si-H dan puncak serapan di 3500 cm^{-1} yang disebabkan oleh ikatan teregang N-H. Kandungan oksigen juga dikesan melalui puncak serapan di sekitar 1000 cm^{-1}. Nisbah komposisi mol sampel x=N/Si telah dianggarkan melalui hubungan kuadratik di antara jurang tenaga optik E_g bahan dan nisbah kandungan unsur nitrogen x, dan nilai x didapati berubah daripada sifar ke 0.88. Nisbah N/Si juga diperhatikan jelas bergantung dengan nisbah kadar aliran gas R melalui hubungan $x=CR^a$. Nilai E_g bertambah secara berterusan daripada 2.03 eV kepada 3.02 eV apabila nisbah kadar aliran gas bertambah. Manakala dengan penambahan suhu substrat, nilai E_g beransur-ansur menurun daripada 3.66 eV ke 2.71 eV. Kandungan hidrogen di dalam sampel dipercayai berperanan melebarkan nilai E_g. Nilai indeks biasan statik n_0 pula menunjukkan pola menurun dengan penambahan nisbah kadar aliran gas R dan menunjukkan pola menaik dengan penambahan suhu substrat. Secara relatif kadar purata pemendapan filem nipis ini adalah rendah sebagaimana yang telah dijangka bagi penguraian plasma dalam medan arus terus. Kadar purata pemendapan filem nipis ini tidak berubah secara seragam dengan nisbah kadar aliran gas NH_3 terhadap SiH_4. Walaubagaimanapun dengan peningkatan suhu substrat kadar purata pemendapan filem nipis didapati menurun.