The effect of substrate bias on the structure and mechanical properties of the a-C:N films by a 90^{o}-bend filtered cathodic arc plasma (FCAP) system

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ABSTRACT

The carbon-related materials have been attracting lots of attention for decades in flat panel display, optoelectronic devices, etc. due to their unique chemical, electronical, mechanical, and thermal properties. In this study, amorphous nitrogenated carbon (a-C:N) films have been prepared on silicon wafer at 800℃ with varying substrate bias upto -650V in a 90^{o}-bend filtered cathodic arc plasma (FCAP) system. The magnetic coil removes neutral carbon atoms and macroparticles from the plasma stream and in this case only the carbon arc discharge is available to form nitrogen ions. XRD showed the peak of (111) plane actually from the nanodiamond nucleated in the a-C:N films and agreed well with the result of HRTEM of d-spacing of 1.76 Å. The hardness of the resulting film was found to be 12.2GPa under an optimal bias of -350V.

The ratio of I_D/I_G of the Raman analysis increased to ~3.5 under the bias of -350V, indicating enriched sp^3-bonded carbon of the graphite domain. The FTIR spectra showed that the higher intensity at 1330cm^{-1} of D-band and 709 cm^{-1} of plane bending mode resulting from the graphite-like domains with N ions incorporated; more sp^3 bonds facilitated the completion of the nanodiamond structure. Binding energies of C1s, e.g., 287.6 (sp^3), 285.5 (sp^2), and 284.6 eV (free carbon), and N1s, e.g., 402.0 (N-O), 400.0 (sp^2), and 399.0 (sp^3) eV, have been resolved in the XPS spectra. The ratios of N/C were able to reach as high as 50% at -350V, indicating that higher substrate temperatures together with higher contents of nitrogen promotes the sp^3 clusters in the a-C:N films. These properties and the structure of the a-C:N film are sensitive to the energy of depositing C^+ and strongly dependent on the substrate bias.

Keywords: FCAP, amorphous carbon nitride (a-C:N) films, nanodiamond

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