FABRICATION OF SMOOTH LOW STRESS AMORPHOUS CARBON MICRO-STRUCTURES BY PHOTOLITHOGRAPHY AND WET KOH ETCHING

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Abstract

The amorphous carbon films prepared by filtered cathodic vacuum arc (FCVA) deposition system are superior in nature with very smooth surface morphology, relatively high hardness, exceptional tribological behaviour and excellent bio-compatibility [1]. These exceptional qualities make them suitable for many device applications. However, these superior quality films prepared at relatively lower substrate bias such as -80V exhibits high compressive stress [1]. The stress reduction is achieved by preparing the film in conjunction with high substrate pulse biasing. In the present study, pure a-C films of about 1μm in thickness were prepared, on highly doped n-type <100> Si wafer, using FCVA system in conjunction with high substrate pulse biasing of -5kV, 600Hz and 25μs. The intrinsic compressive stress in the film, measured by the curvature technique is approximately 300MPa. Free-standing amorphous carbon (a-C) film structures were successfully fabricated by photolithography together with anisotropic wet etching in 40% KOH (see Fig.1). However, it has been observed that etching in KOH for longer time or at higher temperatures for a relatively shorter duration can create pin holes on the surface of the pure a-C film. So we have also analysed the micro-structural and morphological changes of pure a-C films as a function of etching temperature and duration, for two different concentrations (20 and 40%) of KOH.

Fig. 2 shows the optical images of the as-deposited a-C film, which is compared with that treated for 20 and 90 hrs in 40% KOH at 25°C. It is obvious that the number of pin-holes increased with treatment duration. Visible Raman spectra of the KOH treated films as well as the as-deposited film is shown in Fig. 3. The Raman spectra clearly show that the micro-structure of the film does not change with KOH treatment.

Even though the as-deposited film looks so smooth and pin-hole free, very fine holes, which are not observed with ordinary microscopes or SEM, are present in the film. The solution enters through these holes and etches the Si beneath the a-C film. The typical dark dots shown in the optical images (label as pin-holes) are looked under the SEM (see Fig.4, the scale is different, left one 0.5μm and the right one 10μm)). The film after 20hrs of etching shows only few pin-holes contradict to the film after 90hrs of etching. This study suggests that if the fabrication process requires longer etching in KOH solution, one has to use a process that prevents the direct contact of KOH with the a-C film. A detailed study of the above mentioned properties as function of etch-depth as well as the temperature will also be discussed in the paper.

1. X. Shi, B.K. Tay, H.S. Tan, Li Zhong, Y.Q. Tu, S.R.P. Silva, W.I. Milne, J. of Appl. Phys., 79, (1996) 7234 –7240

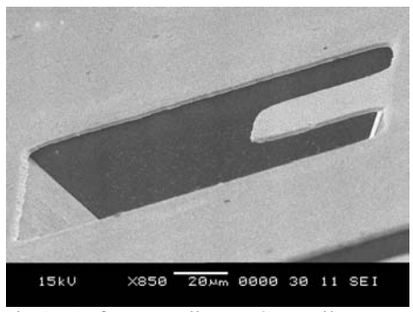

Fig.1: A free-standing a-C cantilever, prepared at -5kV, 600Hz and 25μs

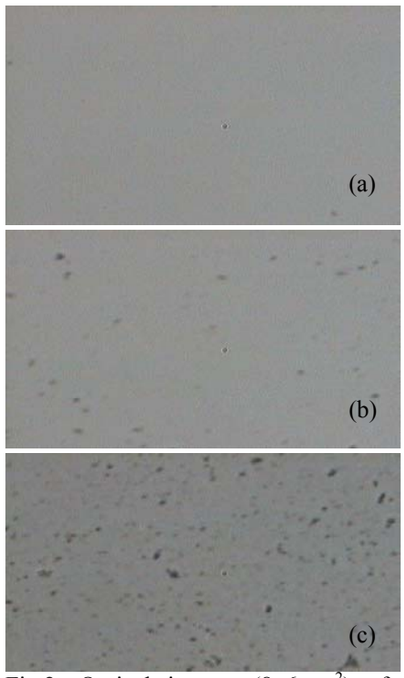

Fig.2: Optical images (8x6mm^2) of a-C film (a) as deposited (b) after treating in 40% KOH at 25°C for 20 hrs (c) after treating in 40% KOH at 25°C for 90 hrs

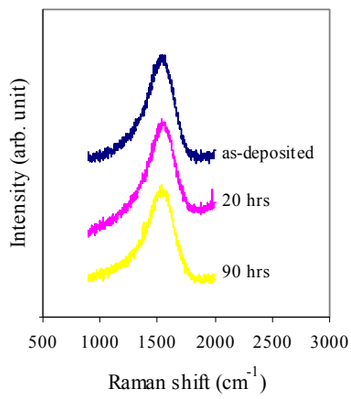

Fig.3: Raman spectra of the film (as-deposited and treated in 40% KOH at 25°C for 20 and 90 hrs)

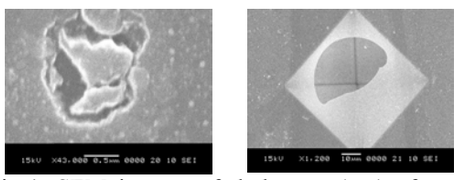

Fig.4: SEM images of dark spot (top) after treating in 40% KOH at 25°C for 20 hrs (bottom) after treating in 40% KOH at 25°C for 90 hrs