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Raman characterization and mechanical properties of *a*-C:H films deposited by rf-PECVD

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[Background] Raman behavior and mechanical properties i.e., hardness and elastic modulus of hydrogenated amorphous carbon films (*a*-C:H) were evaluated. In order to report on the improvements of the application of *a*-C:H films, where there are only a few studies on effect of the thickness of films on the mechanical properties that give formation to the elastic and plastic properties of these films such as to I_D/I_G ratio and G-peak position.

[Experimental] The *a*-C:H film was deposited on p-type Si (100) substrates at different thickness by radio-frequency plasma enhance chemical vapor deposition technique (rf-PECVD) with 0.5 kV of bias voltage and 13.56 kHz of rf power, using benzene (C_6H_6) and hydrogen gas (H_2) as precursors. Raman spectroscopy is performed to characterize the *a*-C:H film due to its ability to distinguish bonding type and domain size. The hardness of all samples was investigated by Pico-indentation under ultralow-load 3 mN, which is a preferred technique because it minimizes the influence of the substrate on the results. Sixteenth indents were performed on each sample using the diamond Vicker tip and the average value of the hardness was calculated.

[Results & Discussion] The Raman spectra of all samples were curve fitted with two Gaussian functions by Origin Pro 8.5 software to evaluate the intensity I_D/I_G ratio and the G-peak position. Fig.1 shows the Raman spectra prepared under different thicknesses, which display asymmetric diamond-like peaks in the range of 1000-2000 cm^{-1}, representative of *a*-C:H films; two broad peaks were detected, a G-peak centered around 1571-1577 cm^{-1} and D-peak centered around 1374-1391 cm^{-1}. The intensity I_D/I_G ratios were integrated in the area under the curve of D-peak and G-peak that reveal the sp^3/sp^2 contents in the film. The results of hardness and elastic modulus values are related to the thickness of *a*-C:H films. The harnesses of A, B, C, D and E are 13, 15, 15, 9 and 18 GPa, respectively. It is obvious that the E sample has a higher hardness than the A, B, C and D samples. This is because the effects of thickness and density of *a*-C:H film increased. Therefore, it possesses the ability to resist the compressive force from the indenter tip. In contrast, the D sample had the lowest hardness with 600 nm thickness because the film presented defects e.g., pinholes and delamination. In addition, It was found that the elastic modulus of all samples is directly proportional to the hardness, whereas the A, B, C and E samples are in the range of 127-143 GPa, which is an indicator of the high hardness of the *a*-C:H films.

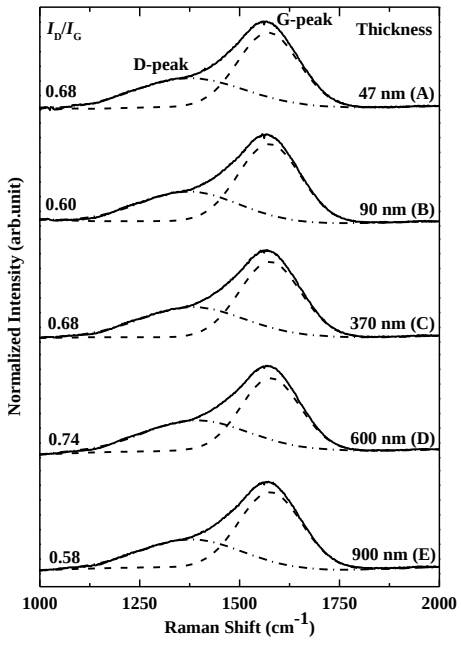

Fig. 1 Raman spectra of *a*-C:H films.