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Effect of Residual Stress on Raman Spectra in Tetrahedral Amorphous Carbon(ta-C) Film

Jin-Koog Shin, Churl-Seung Lee*, Myoung-Woon Moon**, Kyu-Hwan Oh**, Kwang-Ryeol Lee
Thin Film Technology Research Center, Korea Institute of Science and Technology.

*Department of Ceramic Engineering, Yonsei University.

**Division of Material Science and Engineering, Seoul National University.

It is well known that Raman spectroscopy is powerful tool in analysis of sp^3/sp^2 bonding fraction in diamond-like carbon(DLC) films. Raman spectra of DLC film is composed of D-peak centered at 1350cm^{-1} and G-peak centered at 1530cm^{-1} . The sp^3/sp^2 fraction is qualitatively acquired by deconvolution method. However, in case of DLC film prepared by filtered cathodic arc process (namely, tetrahedral amorphous carbon, ta-C), there is controversy in Raman analysis. In case of conventional DLC film, it is generally observed that G-peak position shifts toward low wavenumber as the sp^3 fraction increases. However, opposite results were frequently observed in ta-C films.

ta-C film has much higher residual compressive stress due to its high sp^3 fraction compared to the DLC films deposited by CVD method. Effect of residual stress on G-peak shift must be thus considered and excluded in the case of ta-C films. Especially, G-peak position is most recommendable parameter in Raman analysis of ta-C, due to its smallest fitting error among many parameters acquired by peak deconvolution of symmetric spectra.

In current study, the effect of residual stress on Raman spectra was quantitatively evaluated by free-hang method. ta-C films of different residual stress were deposited on Si-wafer by modifying DC-bias voltage during deposition. The free-hang is prepared by chemical etching the Si wafer using $\text{HF} \cdot \text{HNO}_3$ mixed solution. The variation of the G-peak position along the etching depth were observed in the free-hangs of $20\sim 30\mu\text{m}$ etching depth. Mathematical result based on Airy stress function, was compared with experimental results. The more reliable analysis excluding stress-induced shift was possible by elimination of the Raman shift due to residual compressive stress.

Key words: DLC, ta-C, Raman Spectroscopy, Raman Shift, Free-hang, Delamination, Buckling