Formation of popcorn-like nanostructure in C_{60}-incorporated DLC by exposing to H_2O vapor

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Diamond like carbon(DLC) is a metastable form of amorphous carbon containing bonded carbon atom with sp^2 and sp^3 hybridized orbitals. We incorporated C_{60} molecules in DLC by co-deposition during The properties of DLC Plasma-Assisted Chemical Vapor Deposition (PACVD) in order to find a method to make well-defined nanostructures of sp^2/sp^3 carbons in the DLC. Surprisingly, the material swelled and vivid structure colors appeared after being exposed to air. We report the characterization of the material and discuss the formation mechanism of "carbon nano-popcorn".

The C_{60}:DLC film was deposited by PACVD, and the C_{60} molecules were evaporated from a Knudsen cell directing to the substrate. The ratio of DLC and C_{60} was 100 : 1 as estimated from nominal thickness. Just after the deposition, the samples was almost identical to ordinary DLC, but they started to show vivid interference colors covering most of the visible region wavelength depending on the thickness. From SEM image shown in Fig.1, we can clearly observe the nano-structures with 10 - 50 nm sizes. By ellipsometry characterization, we found this film have very high refractive index in the visible region reaching to the 3.6, which is much higher than ordinary DLC film in the literatures (1.8-2.8).

By changing the gas for the venting of the sample preparation chamber, we found that the formation of nanostructure is due to chemical reaction with water vapor. Figure 2 shows FTIR spectrum of pristine DLC, C_{60}: DLC after exposing to H_2O vapor, and C_{60}: DLC after exposing to D_2O vapor. The sample after the exposure to D_2O shows distinct peaks around 3600 - 3800 cm^{-1}, which suggests the formation of chemical bonds with D or OD.

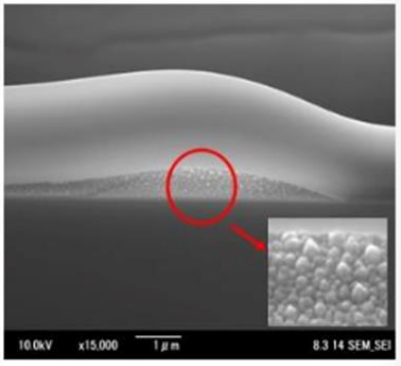

Fig. 1 Cross section SEM of a C_{60}:DLC film after swelling

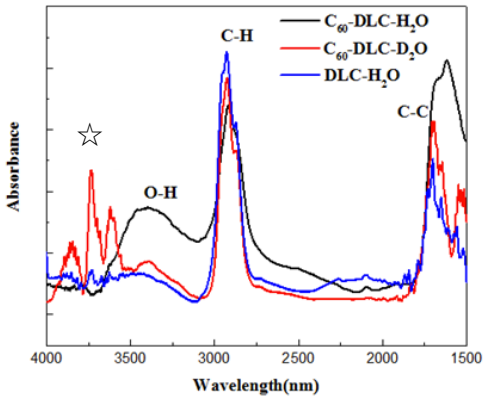

Fig. 2: FTIR spectra

1. B. Zhou et al., Surface Coatings Technol. 208, 101(2012).

2. S. Gayathri et al, . AIP Adv 3, 122113(2013).