X-ray Absorption Spectroscopy Study on Ultrananocrystalline Diamond

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Ultrananocrystalline diamond (UNCD) film (grain size ~2–5 nm) is an excellent candidate for the industrial applications from macro to nanodevices, such as the next generation of high-definition flat panel displays, in-vivo biomedical implants, and biosensors.

It has been found that either by suitable doping or reducing the grain size can improve the electron field emission property [1]. The n-type conductivity of UNCD can be induced by nitrogen doping. Moreover, the high field emission of UNCD film is the result of the presence of electron conducting channels in the grain boundary. It is believed that the sp^2 and sp^3 hybrid is one of the most important facts to characterize the field emission property.

X-ray absorption spectroscopy (XAS) is powerful techniques for studying the bonding structure and directly the density of unoccupied electronic states. In particular the sp^2 versus sp^3 bonding ratio can be straightforwardly derived toghether with Raman spectroscopy.

The C 1s XAS measurements were carried out at the 20A beamline of National Synchrotron Radiation Research Center (NSRRC). All data were taken in the total electron yield (TEY) mode at room temperature.

All the UNCD films were prepared using the microwave plasma enhanced chemical vapor deposition (MPECVD) and show the similar grain size ~ 10 nm, based on the scanning electron microscopy (SEM). The different surface treatments were applied to these films, H- and O-terminated surfaces by hydrogen and oxygen plasma treatment, respectively.

Figure 1 exhibits the C 1s XAS spectra of UNCD film with different surface treatment (hydrogen and oxygen). The π* peak at ~ 285.5 eV is characteristics of the UNCD film indicating sp^2 bonding while the exciton peak at ~ 289.6 eV (vertical dots) and a second band gap at ~ 302.7 eV (downward arrow) indicate the quality of diamond [2].

In the different surface treatments, the sp^2 features (π*) are slightly reduced while the sp^3 features (σ*) are enhance in the inset. In addition, the second band gap becomes dipper. These changes are inconsistent with other study with nitrogen added, implying the degradation of field emission properties.

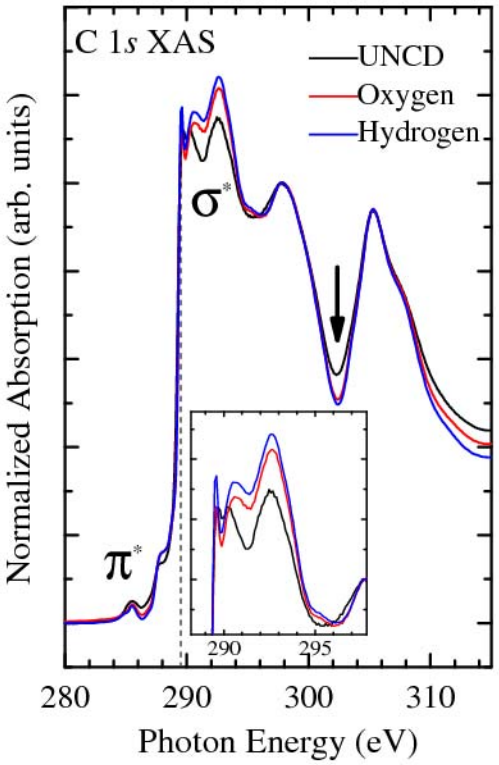

Fig. 1: The C 1s XAS spectra of UNCD film with different surface treatment (hydrogen and oxygen).

References

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