XPS and TEM analysis of Multi-elemental Nano-composites in Diamond-like amorphous carbon films

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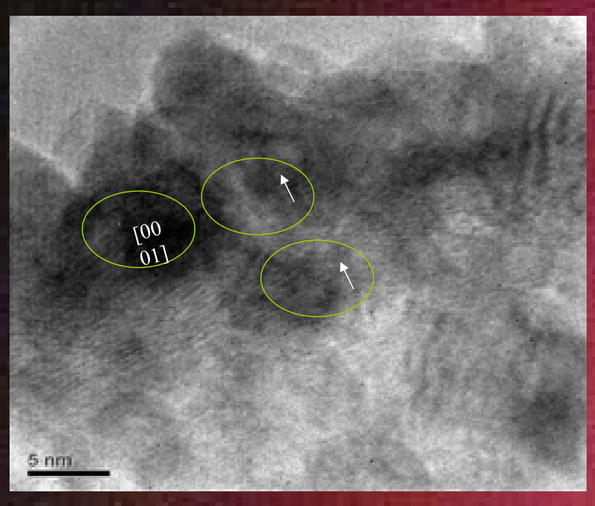
Abstract
Multielemental nanocomposite DLC films were deposited using KrF pulsed laser deposition system and the films were studied using XPS and TEM. Two case studies is reported here:- First, ZnO were successfully incorporated into the diamond-like carbon matrix. Second, a combined alloy Ti and Ni metals were successfully doped into ultrahard Diamond-like carbon.

Introduction

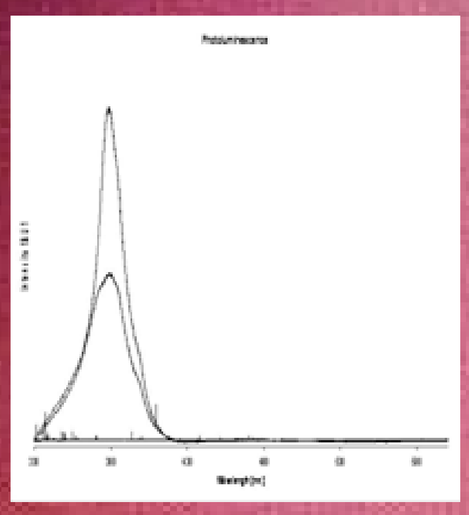
Non-hydrogenated high sp^3 (>85%) content diamond-like amorphous carbon films have physical and material properties approaching that of crystalline diamond. In order to further enhance its properties, many researchers attempt to incorporate metals such as Ni, Ti, Co, W, Cu into the DLC films.

Case Study 1: ZnO incorporated into DLC

TEM analysis confirmed the presence of nanosized ZnO clusters (~5nm) in carbon matrix. High resolution TEM confirmed ZnO (0002) planes in each cluster.



TEM image of 10at% ZnO @ 100k Magnification



PL spectra of 10at% ZnO (strongest) followed by 5at% ZnO

XPS confirmed stiochiometric ZnO and minor Zn-C-O peaks. The latter may be due to ZnO-carbon interface bonds.
Monochromatic emission at 380nm observed with no other defect state emission. Possibly due to quantum size effects.

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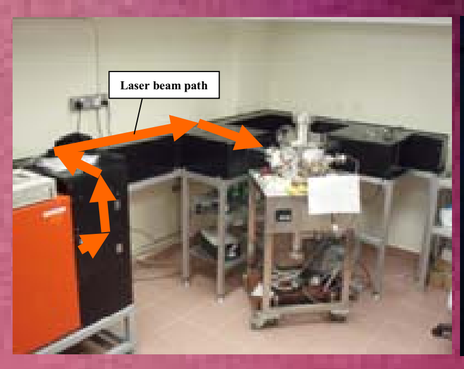
Conclusion

Incorporation of metals and metal/oxide can give additional material properties which pure DL-aC films will not be able to provide. For example, monochromatic photoluminescence were observed from embedded ZnO at 380nm. In addition, controlled growth of carbon nanotubes were observed from Ti/Ni films embedded in DLC.

Experiment and Characterization

Case Study 1: Targets with different concentration of Zn (1, 5, 10 & 15at%) were mixed with carbon.

Carbon-based ZnO nanocomposite films were deposited using 248nm KrF pulsed excimer laser system (20Hz, 30J/cm^2) under 40sccm O_2 flow rate.



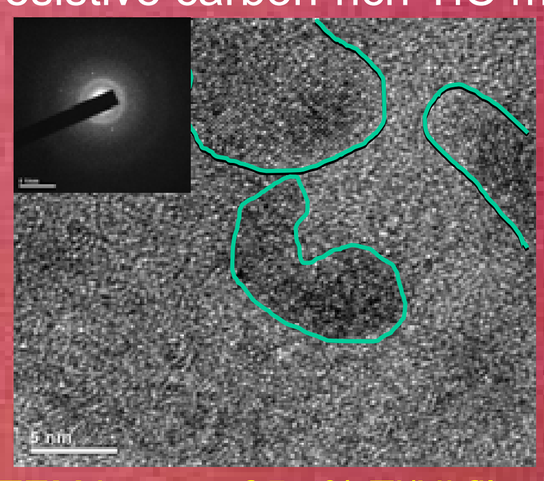
PLD setup and Plasma Plume

Case Study 2: Targets with different concentration of Ti/Ni (2.5/2.5, 5.0/5.0, 7.5/7.5 & 10/10at%) were mixed with carbon. PLD deposition similar to above except no gas flow.

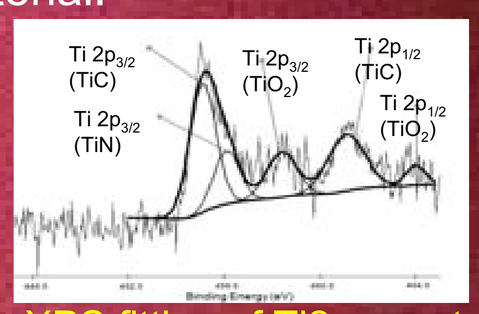
XPS Analysis – Shimadzu Kratos Ultra DLD with Monochromatic Al Kα @ 250W, CAE 10eV
TEM Analysis – Joel 2010F @ 200keV

Case Study 2: Ti/Ni incorporated into DLC

TEM analysis showed nanosized Ni clusters (~5nm) in carbon matrix. XPS analysis confirmed Ti was bonded with carbon to form ultrahard yet less electrically resistive carbon-rich TiC material.

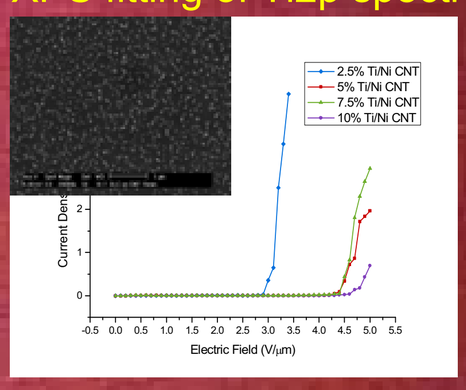


TEM image of 5at% Ti/Ni films



XPS fitting of Ti2p spectrum

Nanocomposite film can be used as a template to grow carbon nanotubes with good electron emission properties



SEM and FE properties

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Liverpool, England
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