

## Accepted Manuscript

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Peidong Xue, Lei Yang, Dongfeng Diao



PII: S0257-8972(17)31102-7  
DOI: [doi:10.1016/j.surfcoat.2017.10.061](https://doi.org/10.1016/j.surfcoat.2017.10.061)  
Reference: SCT 22826  
To appear in: *Surface & Coatings Technology*  
Received date: 21 June 2017  
Revised date: 18 October 2017  
Accepted date: 23 October 2017

Please cite this article as: Peidong Xue, Lei Yang, Dongfeng Diao , Nanocrystalline/amorphous biphasic enhanced mechanical properties in multilayer carbon films. The address for the corresponding author was captured as affiliation for all authors. Please check if appropriate. Sct(2017), doi:[10.1016/j.surfcoat.2017.10.061](https://doi.org/10.1016/j.surfcoat.2017.10.061)

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**Nanocrystalline/amorphous Biphasic Enhanced Mechanical Properties in  
Multilayer Carbon Films**

**Peidong Xue<sup>1,2</sup>, Lei Yang<sup>1</sup> and Dongfeng Diao<sup>2,\*</sup>**

<sup>1</sup>Key Laboratory of Education Ministry for Modern Design and Rotor-Bearing System, School of Mechanical Engineering, Xi'an Jiaotong University, Xi'an 710049, China

<sup>2</sup>Institute of Nanosurface Science and Engineering, Guangdong Provincial Key Laboratory of Micro/Nano Optomechanics Engineering, Shenzhen University, Shenzhen 518060, China

\*Corresponding author: dfdiao@szu.edu.cn. Tel: +86-0755-26902415

**Abstract**

This study reports the nanostructure evolution and mechanical properties improvement in the nanocrystalline/amorphous multilayer carbon films. Electron cyclotron resonance sputtering and electron/ion alternative irradiation techniques were used to deposit the multilayer carbon films with the total film thicknesses ranging from 130 to 10 nm and the single layer thicknesses ranging from 4 to 1 nm. The high resolution transmission electron microscopy observation showed that the interface between nanocrystalline layer and amorphous layer evolved from an original toothed structure to a mixed biphasic structure, and the nanocrystallite size in nanocrystalline layer decreased when layer thickness was reduced from 4 to 1 nm. The nano-indenter tests showed a significant improvement in hardness of multilayer film when single layer thickness was reduced from 4 to 1 nm. The scratch tests revealed that good scratch resistance could be preserved in the multilayer film with 1 nm single layer thickness when total film thickness was only 10 nm. This work may shed light on the ultrathin multilayered coating technology.

**Keywords:** multilayer carbon film; ultrathin single layer; interface structure; mechanical properties

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