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# Microstructure, Stress Gradients, and Mechanical Properties in Diamond Films Revealed by Cross-sectional X-ray Nanodiffraction and Microcantilever Testing

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Ultrananocrystalline diamond (UNCD) films consist of small randomly oriented diamond grains embedded in an amorphous C:H matrix. Usually, the grain size is determined by X-ray diffraction or transmission electron microscopy, revealing information only from the total UNCD film or only locally from selected areas with low statistics, respectively. In this work, we present the first cross-sectional X-ray nanodiffraction study of diamond multi-layers with varying grain size from microcrystalline diamond to UNCD. X-ray nanodiffraction was performed in transmission geometry at ESRF in Grenoble, using a beam diameter of 30 nm oriented parallel to the diamond-Si interface. The sample was scanned in equidistant steps from interface to substrate, revealing depth gradients of texture, grain size and residual stress across the film. Micro cantilevers fabricated by focused ion beam milling were used to access Young's modulus and fracture stess in both UNCD and microcrystalline sublayers. In addition, a nanoindenter-based mapping of Young's modulus was carried out on a cross section of the layer system prepared by FIB. The results show complex cross-sectional gradients of microstructure and stress state.

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