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Residual stress jumping with W concentration in the WC-C nanocomposite films

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Nanocomposite WC-C films were deposited by a novel hybrid ion beam deposition system combined with DC magnetron sputtering of W. W concentration in the film was varied in the range of 2.7~12.5 at. % by controlling the Ar fraction in the gas mixture of Ar and C6H6. The evolution of structure and mechanical properties of the film were investigated as a function of W concentration. It was found that a significant phenomenon, the stress jumping with W concentration without changes of mechanical properties of film, was firstly observed. The significant reduction of the residual stress below the W concentration of 4.2 at.% was due to the relaxation of the atomic bond distortion by the replacement of C-C bonds by C-W bonds. Subsequently, the emergence of crystalline tungsten carbides with increasing W concentration increased the residual stress. Beyond the 5.1 at.%, the growth of crystal carbides released the distortion of the local carbon network with the increase of W concentration, which in turn decreased the residual stress again. The unchanged mechanical properties were discussed in terms of the atomic bond structure of carbon network.