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High energetic but low temperature DLC coating deposition obtained by kilo-volts pulsed bias

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Introduction: Diamond-like carbon(DLC) films are known as a metastable form of amorphous carbon which has exhibited high mechanical hardness, high chemical inertness and low friction and wear[1-3]. High ion energy induced by bias has been reported to be essential to improve the sp^3 content and adhesion between DLC coatings and substrates[4]. However, excess energy transforms into heat and results in the transformation from sp^3 to sp^2, inducing the decreased mechanical properties. Depositing DLC films with a superior condition may balance the sp^3 contents and phase transformations.

Materials and Methods: In this paper, kilo-volts pulsed biases are used to increase the C^+ ion energy to form high sp^3 content and adhesion of the DLC coatings, and simultaneously to avoid temperature rising that usually occurs when DC bias is applied. The high ionized C^+ is obtained by anode layer ion source with C_2H_2 gas and Cr/CrCx/CrC interlayers are introduced between DLC coating and the high-speed steel (HSS) substrate by high-power impulse magnetron sputtering (HPIMS). The microstructures and mechanical characteristics of DLC films were exhibited by scanning electron microscopy (SEM), X-ray photoelectron spectroscopy (XPS), nano-indentation, ball-on-disk wear test machine and scratch test, etc.

Results and Discussion: The results show that the prepared DLC coating not only has a large sp^3 content and the consequent high hardness of 18.5 GPa and excellent tribology performance with a low friction coefficient of 0.12 and wear rate of 0.87 ×10-15m^3/N·m for 4h, but also exhibits an outstanding adhesion (Lc=76N) with the HSS substrate, even the thickness of the DLC coating is up to 13 μm.

Conclusion: With the controlling of ions energy, hard and excellent adhered DLC films have been deposited in this paper. It is essential to shift the balance point between sp^3 contents and phase transformations into an optimum state.

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