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Achieving Low Friction and Wear under Various Humidity Conditions by Co-doping Nitrogen and Silicon into Diamond-like carbon Films

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Abstract: Nitrogen and silicon co-incorporated DLC (N-Si-DLC) films were deposited by RF-CVD method, and the humidity effect on the tribological properties was investigated by a ball-on-disk type reciprocating tribometer in air environments at the relative humidity of 15, 45 and 75 %. The chemical state of the elements and the bonding configurations were determined by X-ray photoelectron spectroscopy (XPS), Raman spectroscopy, and Fourier transform infrared (FTIR) spectroscopy. Nano-indentation tests were performed to measure the hardness and modulus. The internal stress of the films was calculated by the Stoney equation. The characterization results showed that the N and Si contents were in the range of 4.4-10.3 at.% and 7.5-8.7 at.%, respectively. By co-doping N and Si, the internal stress of the films was reduced markedly, although with a slight reduction in the hardness and modulus. The N-Si-DLC films co-doped with a small amount of N exhibited lower friction and wear compared with the Si-DLC films without doping N. Also, these films showed low frictional sensitivity to the environmental humidity. The formation of C=N and C≡N groups with strong electron withdrawing ability is thought to contribute to reducing the friction and wear, since they are strong electron acceptors which can reduce the electron density and nucleophilic reactivity of the dangling bonds formed on the film surface during sliding.

Key words: Diamond-like carbon; Nitrogen co-incorporated; Si-DLC; Humidity; Electron acceptor

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