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Effect of residual water during deposition on the mechanical properties of Si-containing a-C:H Films

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Diamond like carbon (DLC) has widespread applications in many fields because of its high hardness, low friction, chemical inertness, and other excellent properties. Our group has developed MVP (Microwave sheath-Voltage combination Plasma), where high density plasma is generated by microwave propagation along plasma-sheath interface on metal surface, for increasing the deposition rate of DLC with PECVD. Then, an ultra-high deposition rate of 156 μm/h was achieved with a nano-indentation hardness of 20.8 GPa in Si-containing DLC (a-C:H:Si) coating. Such a high deposition rate can drastically decrease the coating time to obtain a required film thickness, typically 1□5 μm. However, for increasing the process throughput as an industrial coating instrument, not only coating time but also evacuation time before deposition should be decreased together. Note that this requirement is essential for achieving 1-by-1 coating line of DLC with MVP. Therefore, rough pumping only with rotary pump is desirable for ultra-high-speed DLC coating with MVP; however, the effect of degraded vacuum quality, or increased residual water during deposition on the properties of Si-DLC is not clear. In this work, we investigated the effect of residual gases, especially water, on the mechanical properties of Si-DLC property. As a result, with increasing water during deposition, O content in a-C:H:Si film increased from 1.0 to 2.4 at% accompanying the decrease of hardness from 21.3 to 18.9 GPa. However, the friction coefficient in the sliding against SUJ2 ball under dry conditions 10 % and 50 % in humidity showed almost the same level of 0.04□0.08 for all the a-C:H:Si films. In other words, low-friction coefficient of 0.04□0.08 were obtained with high robustness against humidity variation during sliding and chemical structure variation of a-C:H:Si film. (The authors gratefully acknowledge the funding by JST CREST, Japan.)

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