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Ultra-high-speed coating of DLC at over 100 $\mu\text{m}/\text{h}$ without softening of low-temperature tempered steel substrateYasuyuki Takaoka¹, Hiroyuki Kousaka¹, Noritsugu Umehara¹¹Nagoya University, Nagoya, Japan

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Recently, with increasing demands for energy saving by friction reduction and lifetime extension by wear reduction in mechanical elements, the application of DLC (Diamond-Like Carbon) is spreading gradually and steadily. In this field, higher-speed coating method with applicability to 3-dimensional shapes is strongly desired. Thus, we have proposed a high-speed coating method of DLC with a novel plasma CVD employing high-density plasma ($n_e \sim 10^{11} - 10^{13} \text{ cm}^{-3}$), which is sustained by microwave propagation along plasma-sheath interface on metal surface. In our previous work, a considerably high deposition rate of 188 $\mu\text{m}/\text{h}$, which is about 180 times larger than that of conventional method, and hardness of 12 GPa was obtained. However, during coating at such high rates, substrate temperature increased up to around 500 °C, which is larger than the tempering temperature 200 °C of many steels typically used for mechanical elements. If such a high temperature induces the softening of low-temperature tempered steels during coating, our ultra-high-speed coating method cannot be applied to a lot of mechanical elements. Therefore, in this work, we tried to check whether low-temperature tempered steel substrate is softened during ultra-high-speed DLC coating, in order to derive the guideline for avoiding substrate softening. DLC were deposited to alloy steel substrate (SCM415), which had been tempered at 200 °C to get Vickers hardness of 750 Hv, for different deposition times of 30, 60, 90, 120 sec. Substrate temperature was measured by radiation thermometer. Substrate hardness after deposition was measured by micro Vickers hardness tester at an indentation load of 0.3 kgf. Hardness test showed that the decrease of substrate hardness did not occur in coatings for 30 and 60 sec, though maximum substrate temperature exceeded 300 °C during coating. It was considered that higher temperature than 200 °C does not induce substrate softening if the time of high temperature is enough short.

Keywords

CVD

DLC

High-density plasma

Annealing

Microwave