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Modified Four Ball Tester as a Quick Verifying Tribometer for Different PECVD-DLC – Coatings in Extremely High Load Applications

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For extremely high load applications, a quick test method for evaluating hard coatings is necessary. We present the development of a tribometer being able to test hard coatings exposed to high loads above 2 GPa without lubricant. A four ball tester was modified for testing coated metal surfaces with one ball. Only one rotating ball is pressed on the coated surface with a high pressure. The ball and the coated surface are analyzed microscopically after some minutes and give clear results on the wear resistance and tribological effects of the interface. DLC multilayers and DLC layers with a hardness gradient were deposited on a 100Cr6 steel substrate with roughness $R_a = 0.31 \mu\text{m}$ and $R_z = 1.5 \mu\text{m}$. a) DLC 9 fold Multilayer Hard/Soft ($d=9.5 \mu\text{m}$) b) DLC Multilayer Hard/Soft ($d=2.2 \mu\text{m}$) c) DLC Gradient Hard - Soft ($d=3.0 \mu\text{m}$) d) DLC Gradient Soft - Hard ($d= 2.4 \mu\text{m}$). Coated samples were exposed to a dry test with this modified ball tester at four different Hertzian loads: 1037 N/mm², 1565 N/mm², 2126 N/mm², 3206 N/mm². For understanding failure mechanism and wear behavior, SEM with FIB, Nanoindentation, Nano-Scratch test, Optical microscope and XPS were used. Wear behavior of these DLC – coatings could be proven clearly. Best results were obtained with a DLC gradient layer starting with a hard DLC-layer on the steel substrate and ending with a soft carbon layer on top (thickness 3.0 μm). The formation of a carbon tribolayer at the interface coating/ball leading to a dry lubricant effect could be clearly observed. At a load of 1037 N/mm² the diameter of the calotte was approximately 250 μm , slowly increasing to 300 μm (@1565 N/mm²), 390 μm (@2126 N/mm²) and finally 610 μm (@3206 N/mm²). The other coatings showed significantly higher damage. Further evaluation of this method in comparison with other tribometers is in progress.

Keywords

DLC diamond like carbon
wear resistance
tribometer
hard coating