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Tribological assessment of multilayer micro/nanocrystalline CVD diamond coatings under physiological fluids

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Biotribological tests with FBS and HBSS fluids were conducted using seven different types of diamond coating architectures: monolayers of MCD and NCD and four types of two and four layer coatings. Reciprocating, flat pin-on-flat plate, sliding tests were conducted under 11 N and 98 N loads at 12 mm.s⁻¹ and 24 mm.s⁻¹, respectively, for a maximum length of 6000 m. Apparent contact stresses are in the range of those found in micro-separation experiments, from 30 MPa to 750 MPa. Wear occurs initially by truncation of microcrystalline pyramids or blunting of nanocrystalline agglomerates and then by a fine scale abrasive wear mechanism that ends in surfaces becoming fully polished for the 98 N loads. AFM derived wear volumes confirmed that, for the 11 N loads, wear coefficient values, k, are from one to two orders of magnitude smaller than for similar dry experiments and are in the range 10⁻⁹ to 10⁻⁸ mm³.N⁻¹.m⁻¹, corresponding to a very mild wear regime. These values increase by about one order of magnitude for the 98 N test, due to enhanced fatigue effects, with Bi- and Multi-layer films being less sensitive to the speed and load increment than the monolayers. For the 11 N tests, to larger steady state friction coefficient values correspond larger wear rates, for both fluids, although without a clear effect of the physiological liquids on the total wear rates. In these tests, μ_{ss} values vary from 0.015 to 0.081, with the larger values being obtained for the FBS lubrication, but still inside the range of values found for common hip-joint replacement materials.

Keywords

CVD diamond
multilayers
biotribology