PO3031

Failure mechanisms of DLC coated joint replacements

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Diamond Like Carbon (DLC) is a very promising coating material to improve biomechanical properties of articulating implants due to its extreme hardness, chemical inertness, wear resistance and biocompatibility. One of the principal causes of failure of such implants is the delamintaion of the coating material.
To give a reliable adhesion lifetime prediction for DLC coated implants, a thorough estimation of all potential failure mechanisms is of particular importance. Beside mechanical failure, other delayed interface crack growth mechanisms also have to be considered, especially hydrogen embrittlement, galvanic, crevice, and pitting corrosion as well as stress corrosion cracking (SCC).
Here we present new methods to determine three pertinent failure mechanisms, in detail stress corrosion cracking, crevice corrosion (CC) and mechanical failure of coated implants, especially in respect to long term delamination. In addition to hip joint simulator testing, Focused Ion Beam cutting (FIB), Transmission Electron Microscopy (TEM), Scanning Electron Microscopy (SEM) and Energy Dispersive X-Ray analysis (EDX) were used to determine the failure mechanisms of the DLC coated implants. The correlations of the three mechanisms are discussed. We found testing in saline solutions to be insufficient, as proteins play an important role, especially as they may provide CC- conditions. Simulator testing shows that mechanical failure is mainly caused by third body wear involving wear particles.

Keywords
diamond-like carbon (DLC, a-C:H)
failure mechanism
stress corrosion cracking
crevice corrosion