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Zirconia and thin zirconia-toughened-alumina films realized by pulsed plasma deposition technique for high-performance UHMWPE inserts

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At present, in the orthopaedic field, the main reason for implant failure is related to the UHMWPE insert wear debris that leads to osteolysis and aseptic loosening of the implant itself. Our hypothesis is that a hard ceramic thin film realized on the plastic component (i.e., UHMWPE) may reduce UHMWPE wear debris and deformation in a prosthetic coupling. 3% yttria-stabilized zirconia and zirconia-toughened-alumina (30/70%) thin films have been deposited by the Pulsed Plasma Deposition technique on medical-grade UHMWPE. The morphology and micro-structure have been characterized by SEM, AFM, EDX, XPS and XRD. Mechanical properties have been investigated by nanoindentation and scratch tests. Ball-on-disk tribological tests have been carried out in order to evaluate the validity of the proposed approach. Nanoindentation tests revealed very high hardness and Young's modulus values, while critical fracture tests revealed no radial cracks in the film. The very strong interface adhesion has been assessed by scratch tests. An indentation depth reduction of about 330% has been registered when the UHMWPE substrate was covered by a 1.5 micron thick film. Further, the material yielding under an applied constant load (creep) of coated UHMWPE was only the 19% of the creep of bare UHMWPE. Finally, preliminary tribological tests carried out in air against an alumina ball counterpart showed wear rate as low as $3.2\times10^{-6}mm^3N^{-1}m^{-1}$ after 500.000 cycles, showing an average friction coefficient evaluated on unpolished materials ranging from 0.15 to 0.3 in air, showing the feasibility of this novel approach to improve UHMWPE mechanical properties in arthroplasty.

Biography

Russo A got his Master degree in Medicine and Surgery in 2000 and PhD in 2009 at University of Bologna. From 2001, he has been carrying on numerous research regarding knee prosthesis fixation and polyethylene wear by means of Roentgen Stereophotogrammetric Analysis (RSA) technique. The main field of interest is the application of nanostructured materials in orthopaedic surgery. Presently, he is orthopaedic Surgeon and Researcher at the Laboratory of NanoBiotechnologies of the Rizzoli Orthopaedic Institute.

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