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Researchers coat spinal polymer implants with bioactive film to improve bonding with bone

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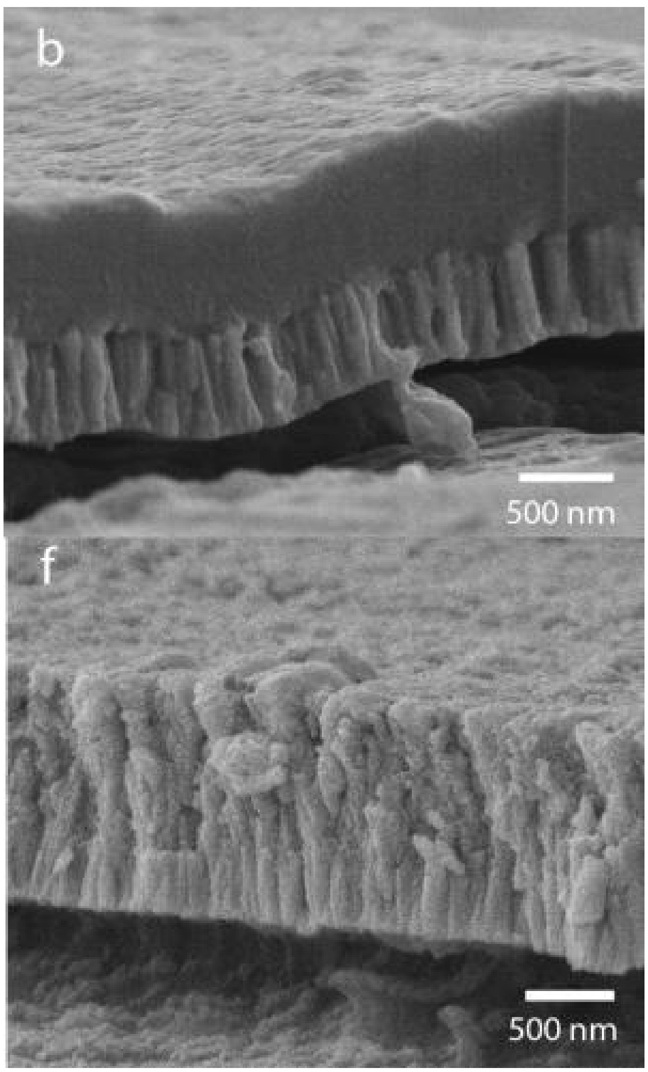

The top scanning electron microscope image (b) shows a cross section of the bioactive hydroxyapatite/YSZ coating without heat treatment. Note how the two layers are distinct. The bottom image (f) shows the coating after heat treatment. Note how the layers are now integrated.

Researchers from North Carolina State University have for the first time successfully coated polymer implants with a bioactive film. The discovery should improve the success rate of such implants – which are often used in spinal surgeries.

The polymer used in these implants, called PEEK, does not bond well with bone or other tissues in the body. This can result in the implant rubbing against surrounding tissues, which can lead to medical complications and the need for additional surgeries.

"We wanted to apply a bioactive coating that would allow the polymer implants to bond with surrounding tissues," says Dr. Afsaneh Rabiei, an associate professor of mechanical and aerospace engineering at NC State and lead author of a paper on the research. "The challenge was that these coatings need to be heated to 500 degrees Celsius, but the polymer melts at 300 C. We've finally solved the problem."

The first step in the new technique coats the implant with a thin film of yttria-stabilized zirconia (YSZ). The second step applies a coating of hydroxyapatite, which is a calcium phosphate that bonds well with bone. The researchers then heat the hydroxyapatite layer using microwaves. The YSZ layer acts as a heat shield, preventing the PEEK from melting. Meanwhile, the heat gives the hydroxyapatite a crystalline structure that makes it more stable in the body, meaning that the calcium phosphate will dissolve more slowly – promoting bonding with surrounding bone.

"We have received funding from the National Institutes of Health to proceed with animal testing to fine-tune this technique," Rabiei says.

"Then we will move on to clinical testing."

More information: "Processing and Evaluation of bioactive coatings on polymeric implants"

Authors: Afsaneh Rabiei and Stefan Sandukas, North Carolina State University

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Abstract: Polyetheretherketone (PEEK) is a high performance polymer with advantages over metallic biomaterials for application in spinal implants. In this study, hydroxyapatite (HA) coatings were deposited onto PEEK substrates using radio-frequency magnetron sputtering for the purpose of improving bioactivity. An intermediate coating layer of Yttria-Stabilized Zirconia (YSZ) was first deposited onto the PEEK substrates in order to provide heat shielding during subsequent postdeposition heat treatment to prevent degradation of PEEK substrates and coating/substrate interface. Plasma activation of the PEEK substrate surfaces before deposition resulted in a significant increase in coating adhesion strength. Post-deposition heat treatments of microwave and hydrothermal annealing were studied with the goal of forming crystalline HA without the use of high temperatures required in conventional annealing. Microstructural and compositional analysis by scanning electron microscopy and X-ray diffraction revealed that the YSZ layer exhibited a crystalline structure as-deposited, with columnar shaped grains oriented along the growth direction, while the HA layer was shown to be amorphous as-deposited. After microwave annealing, the HA coating exhibited a columnar crystalline microstructure, similar to that of the underlying YSZ crystalline layer; XRD analysis confirmed a crystalline HA phase in the coating. It is suggested that the existence of the crystalline YSZ layer aids in the formation of the HA layer upon

heating, possibly lowering the activation energy for crystallization by providing nucleation sites for HA grain formation. Cell culture tests showed a significant increase in initial cell attachment and growth on the microwave-annealed coatings, compared with uncoated PEEK and amorphous HA surfaces.

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