Oxide layers for applications in implantology

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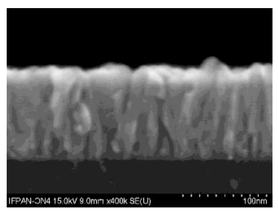
BACKGROUND

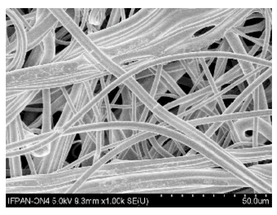
Implantology is a dynamically developing area of modern medicine. Currently, there is a wide range of implants made mainly of metals - implants used in fractures, knees, hips, implants in dentistry, cardiovascular devices and other. Unfortunately, to this day there is no perfect solution what material to use in these implants. In order to introduce a given foreign material into the human body, we must ensure its full biofunctionality and biocompatibility. Other properties of the selected materials should also be taken into account, such as corrosion resistance (physiological fluids are an aggressive environment), the role of oxides formed on their surface, time stability (if they remain in the body for a long time) and antimicrobial activity. Additional problems with metal implants relate to the body's reaction to metals (e.g. an allergic reaction).
In our work, we proposed new barrier layers for implants and a method of their preparation that can make implants more durable and safer.

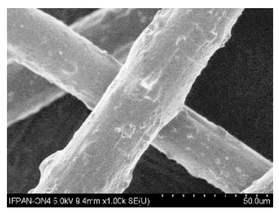
ATOMIC LAYER DEPOSITION TECHNOLOGY

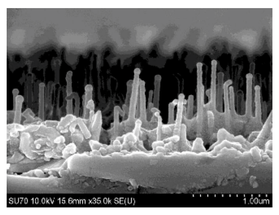
ALD technology consists in a sequential distribution of chemical compounds in a gas phase intoThe the reaction chamber. Each precursor pulse is separated with a purge phase of the chamber, whereby the precursors don't react with each other in the gas phase. The reaction occurs only on the substrate. One precursor pulse corresponds to the deposition of one atomic monolayer on the substrate. Therefore, the ALD is characterised by precise thickness control. ALD technology enables the deposition of homogeneous transition metal oxide thin films on the complex substrates.



Precise thickness control (ZnO film)

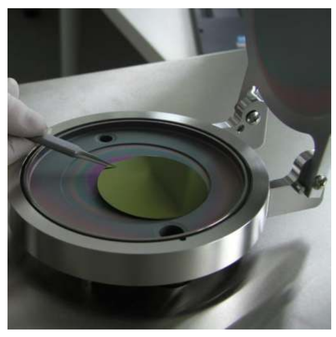


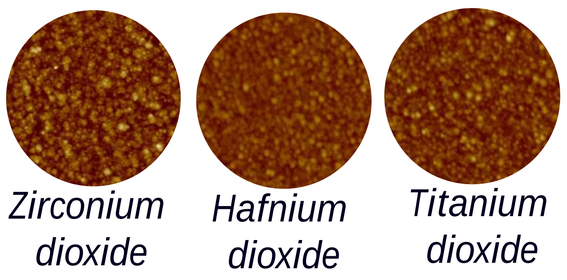




Deposition on the 3D surfaces (ZnO film on the cotton and nanorods.

EXPERIMENT

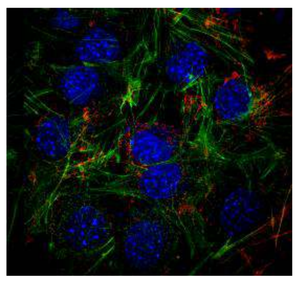




Zirconium dioxide *Hafnium dioxide* *Titanium dioxide* + *Cover slip*

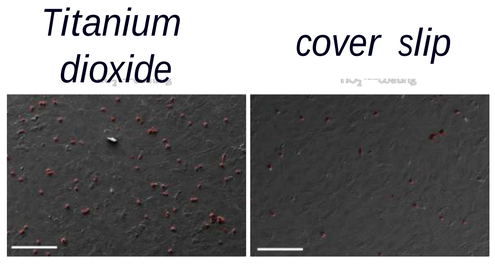
We test the oxides of transition metals for their biocompatibility with osteo-cells. We have investigated zirkonium dioxide, hafnium dioxide and titanium dioxide obtained by ALD technology. We studied the development of bone marrow stromal cells in contact with the ALD layers and observed different behaviour of such cells in relation to different oxides.

BIOCOMPATYBILITY OF THE ALD coatings

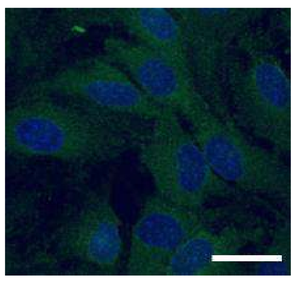


Zirconium dioxide improved mitochondrial metabolism of bone forming cells

Titanium dioxide *cover slip*

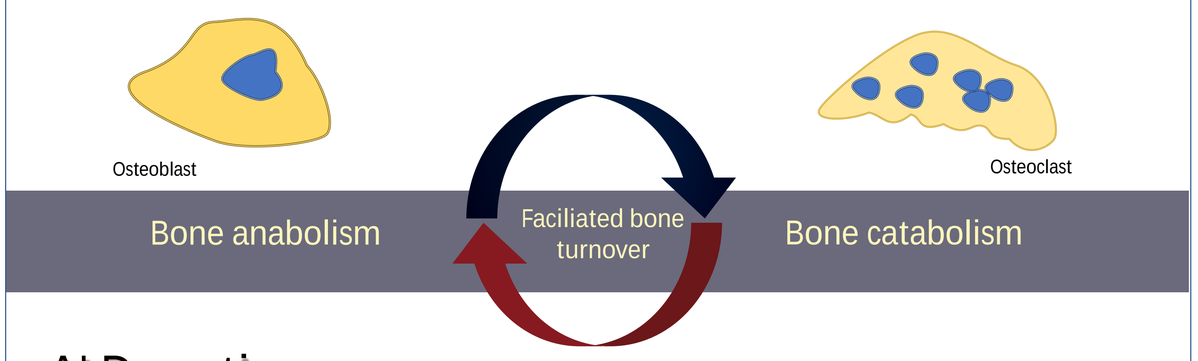


Titanium dioxide decreased invasion of osteoclast cells (red colour)



Hafnium dioxide increased expresion of bone markers, including transcription factor Runx-2 (green colour)

CONCLUSION



ALD coatings:

- Regulate interactions between bone cells
- Enhance expression and production prooosteogenic markers (mRNA, miRNA, proteins)
- Promote bone homeostasis

CONTACT

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