IOCM 2025 Conference
The 4th International Online Conference on Materials
3–6 November 2025 | Online
MDPI

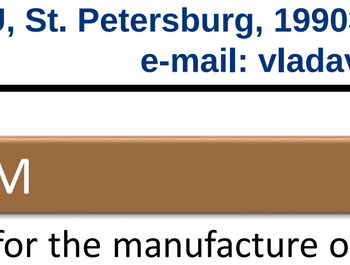
Regulation of the rate of biocorrosion and cytotoxicity of magnesium alloys by applying oxide nanocoatings using atomic layer deposition

V.V. Vartiajnen[1], L.A. Kozlova[1,2], M.A. Rytova[1], A.P. Godun[1], D.V. Nazarov[1,2]
[1]SPbPU, St. Petersburg, 195251, Polytechnicheskaya, 29
[2]SPbSU, St. Petersburg, 199034, Universitetskaya Embankment, 7-9
e-mail: vladavartiajnen@gmail.com

INTRODUCTION & AIM

Magnesium and its alloys are promising materials for the manufacture of bioresorbable implants due to a number of unique mechanical properties and biocompatibility. However, the widespread practical application of magnesium implants is limited by the release of excessive amounts of magnesium ions and gaseous hydrogen due to biocorrosion, as well as premature loss of mechanical properties, shape, and size of the implant. A relevant solution to these problems is to control the rate of biodegradation of magnesium alloys by applying protective nanocoatings.

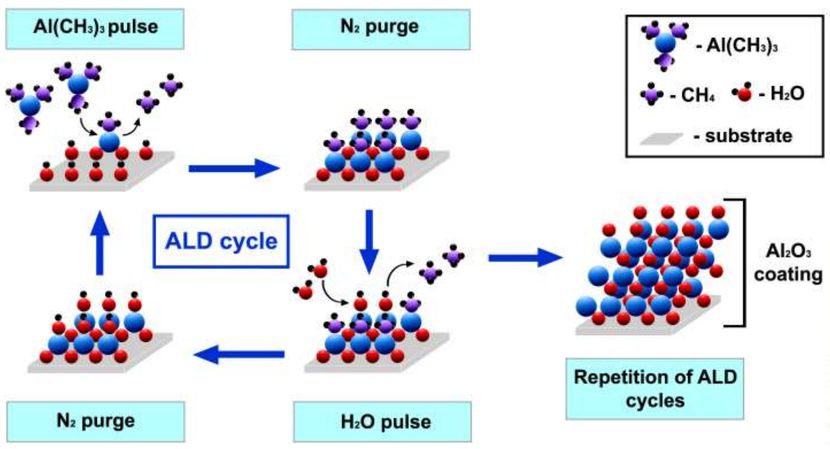
The most promising method for obtaining coatings is atomic layer deposition (ALD), which allows the synthesis of continuous, homogeneous, uniform coatings on surfaces with complex relief shapes.



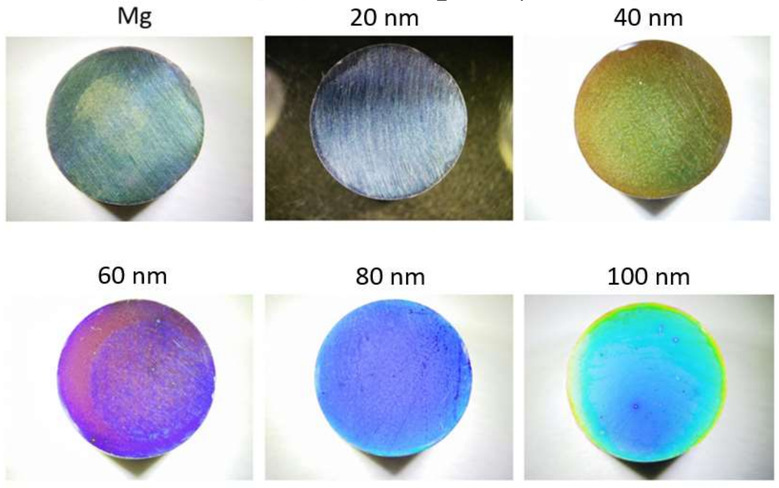
METHOD

Atomic Layer Deposition (ALD)

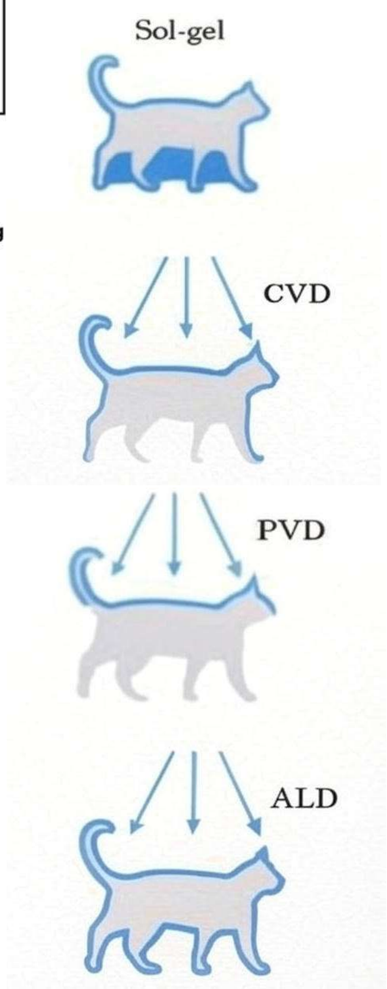
Scheme of Al_2O_3 synthesis by the ALD method



Photograph of TiO_2-$TiCl_4$ coating



Comparison of coating application methods

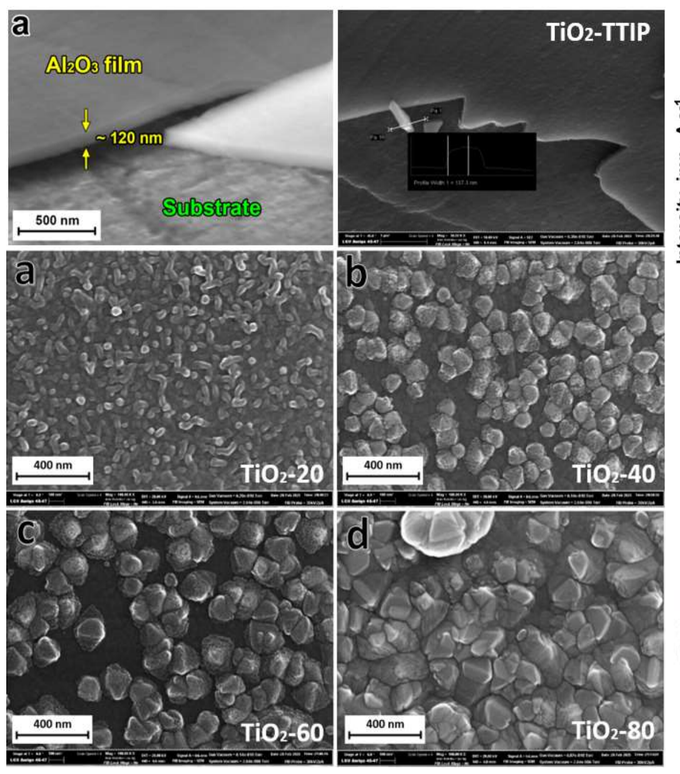


№	Coating	Precursor	Counter-reagent	Thickness, nm	Number of cycles	Synthesis t,˚C
1	Al_2O_3	$Al(CH_3)_3$	H_2O	20, 40, 60, 80, 100	160, 320, 480, 640, 800	200
2	TiO_2	$TiCl_4$			400, 800, 1100, 1400, 1900	
3		$Ti(OCH(CH_3)_2)_4$			650, 1200, 2050, 2650, 3020	

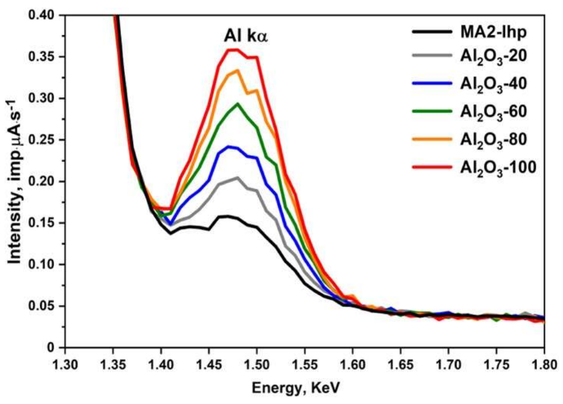
1) Violeta Tsakiris, et al. «Biodegradable Mg alloys for orthopedic implants», 2021
2) Peixuan Zhi «Advances in the Study of Magnesium Alloys and Their Use in Bone Implant Material», 2022
3) Martin Durisin «Bioabsorbable behaviour of magnesium alloys – an *in vivo* approach», 2015

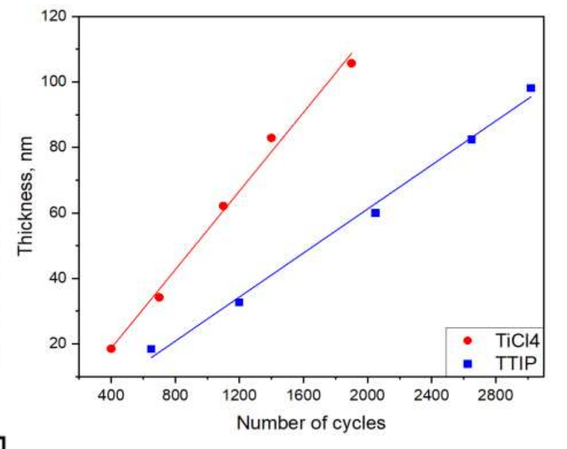
RESULTS & DISCUSSION

SEM micrographs

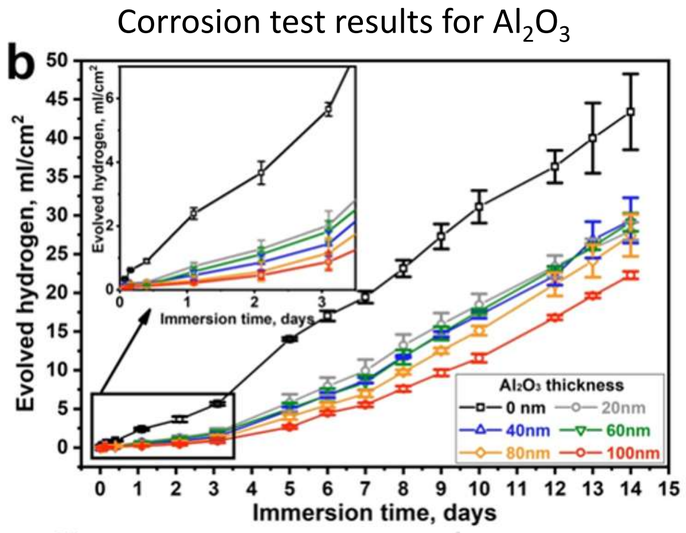


Elemental composition of surface and volume coatings (XPS)

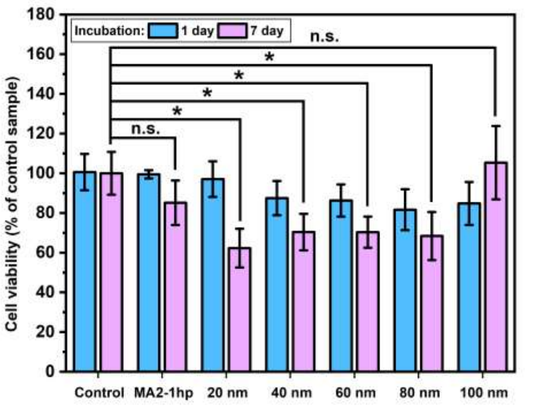


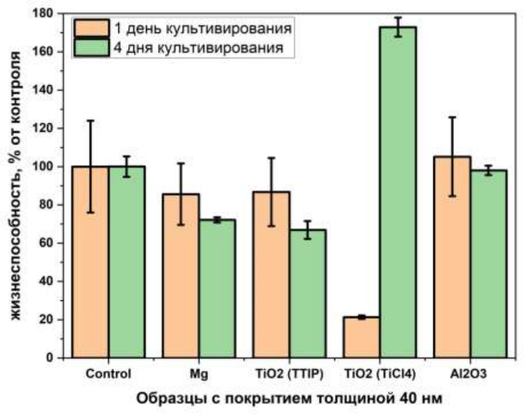


Corrosion test results for Al_2O_3



Cytological response of preosteoblasts MG-63 cells





CONCLUSION

- Using the ALD method, nanocoatings were successfully obtained: amorphous Al_2O_3 and TiO_2-TTIP, as well as crystalline TiO_2-$TiCl_4$ with thicknesses ranging from 20 to 100 nm on the surface of AZ31-type magnesium alloy.
- Amorphous coatings are characterized by a regular decrease in the rate of biocorrosion with increasing thickness, while crystalline TiO_2 coatings are characterized by extreme dependence with minimum biocorrosion at a thickness of 40 nm.
- Al_2O_3 coatings provided the best anti-corrosion properties and no cytotoxicity towards MG-63 osteoblast-like cells.

FUTURE WORK / REFERENCES

- In vivo testing,
- Coating application on implant (fixation screw)