Template-assisted electrodeposition of zinc 3D microcomponents

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Abstract

Statement of the Problem: Surface modification of biomedical devices is recognized as one of the important and predominant techniques for improving their biocompatibility and bioactivity without altering their bulk properties. Implants require special mechanical, bioactive, and bioresorbable properties. The motivation of this paper is to present the potential of implant surface treatment with a 3D micro-architected zinc (Zn) coating synthesized using a template-assisted electrodeposition process. Zinc as a element is nowadays concerned as a 'next generation biodegradable materials', due to its ability to enhance bone repair. 3D structures' function is to improve tissue healing, osseointegration, and decrease the risk of infection. The key goal is to print a negative template made of photocurable resin and then fill it with metal via electrodeposition. The first step of the experiment is to optimize the 3D microprinting process to find the most effective parameters for template fabrication. This step requires preparing a CAD (Computer Aided Design) model and numerous tests of the printed structures. The next step is electrodeposition, which aims at producing the metal structure. To assess mechanical properties, we will use *in situ* micropillars compression. Template-assisted electrodeposition is an effective tool for fabricating standalone Zn micropillars instead of milling them in 2D electrodeposited coating using the Focused Ion Beam technique. It also eliminates any FIB-induced damage in the micropillars. Then, the template is removed by plasma etching and we have metallic structures with designed geometry. With this approach, we can assess process-microstructure-properties relations of Zn coatings for potential biomedical applications.

Conclusion & Significance: During the electrodeposition process of zinc, there is a possibility to adjust the fabricated mictrostucture, resulting in implementing the required mechanical properties. Production of the micropillars is the first step in improvement of electrodeposition parameters, which leads to the futher experiments with more complicated structures. Implant surface modification plays a crucial role in decreasing the risk of infections associated with medical implants. This research is the introduction to the advanced surface modification of biomedical implants and the results will be implemented for future experiments with intricate structures.

Image

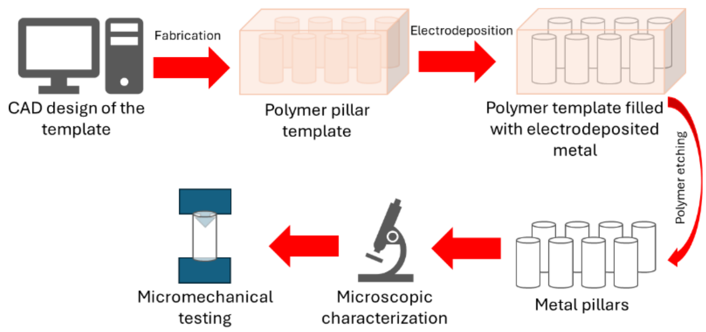
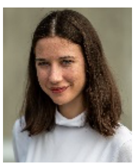


Figure 1. Schematic illustration of the template pillars' fabrication process using photon assisted lithography.

Recent Publications

1. Wang, Z. L., Guo, R., Ding, L. X., Tong, Y. X., & Li, G. R. (2013). Controllable Template-Assisted Electrodeposition of Single- and Multi-Walled Nanotube Arrays for Electrochemical Energy Storage. Scientific Reports 2013 3:1, 3(1), 1–8.
2. Nasirpouri, F., Alipour, K., Daneshvar, F., & Sanaeian, M.-R. (2020). Electrodeposition of anticorrosion nanocoatings. Corrosion Protection at the Nanoscale, 473–497.
3. Ohba, M., Scarazzato, T., Espinosa, D. C. R., & Panossian, Z. (2019). Study of metal electrodeposition by means of simulated and experimental polarization curves: Zinc deposition on steel electrodes. Electrochimica Acta, 309, 86–103.
4. Meier, E. L., & Jang, Y. (2023). Surface design strategies of polymeric biomedical implants for antibacterial properties. Current Opinion in Biomedical Engineering, 26, 100448.
5. Ritschdorff, E. T., Nielson, R., & Shear, J. B. (2012). Multi-focal multiphoton lithography. Lab on a Chip, 12(5), 867–871.
6. Saber, K., Koch, C., Fedkiw, P. (2003). Pulse current electrodeposition of nanocrystalline zinc. Materials Science and Engineering: A. 341. 174-181.

Photograph



Biography

Student intern at Swiss Federal Laboratories for Materials Science and Technology -EMPA, in Switzerland, Student of Mechanical Engineering in Specialization of Welding Technologies graduate of Materials Engineering from first study cycle, Silesian University of Technology. President of Light and Electron Microscopy Students Science Club, Co-author of science articles in Talent Detector Conference's materials.

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