EMERGEMAT

4th International Conference on Emerging Technologies in Materials Engineering
4-5 November 2021 - Bucharest, Romania

PREDICTION OF MECHANICAL PERFORMANCE OF 3D PRINTED $CaMgSi_2O_6$ ARCHITECTURES

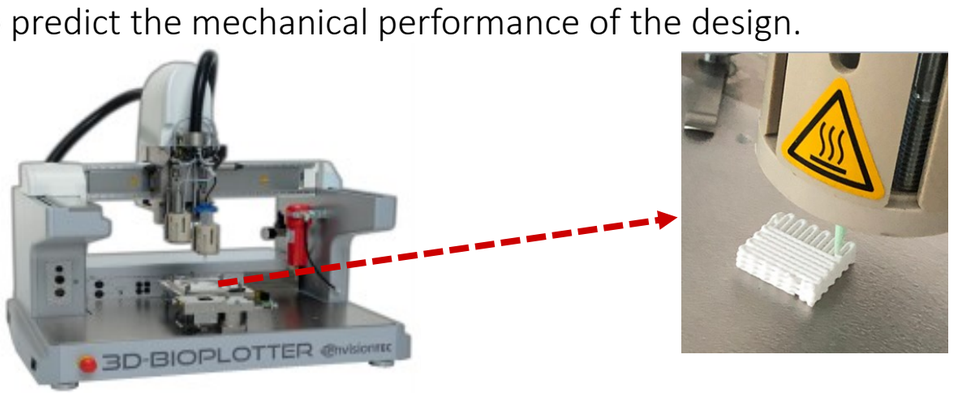
Maria Eliza PUȘCAȘU[1], Ștefania CHIRIAC[1], Laura-Mădălina CURSARU[1], Radu-Robert PITICESCU[1], Adrian-Ionuț NICOARĂ[2,3*]
[1]National Research & Development Institute for Non-ferrous and Rare Metals – IMNR, Blvd.Biruintei no.102, Pantelimon, Ilfov, Romania, epuscasu@imnr.ro
[2]National Research Center of Micro and Nanomaterials, University POLITEHNICA of Bucharest, Splaiul Independentei no. 313, Bucharest, Romania
[3]Academy of Romanian Scientists, Splaiul Independentei no. 54, Bucharest, Romania , Corresponding author: adrian.nicoara@upb.ro

ABSTRACT

In bone tissue engineering, 3D printing technology represents a promising means to obtain complex architectures with the possibility to control precisely the pore size [1].

Diopside ($CaMgSi_2O_6$) is a biomaterial which has the ability to induce *in vitro* apatite formation and *in vivo* growth and differentiation of the osteoblast. $CaMgSi_2O_6$ is a biocompatible material that possesses good bending strength and fracture toughness, bioactivity and slow degradation rate. Due to its outstanding properties diopside has tremendous potential in medical applications [2,3].

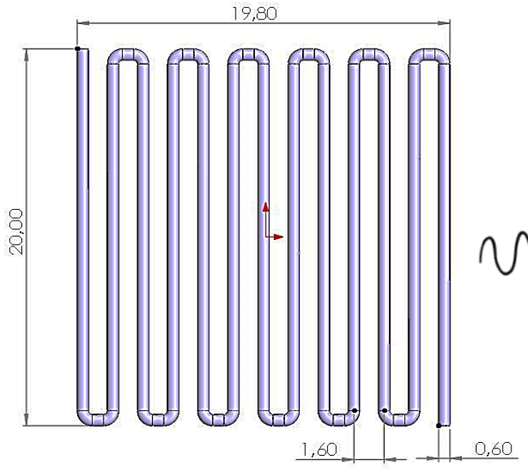
Using 3D-BIOPLOTTER EnvisionTEC Starter Series diopside based scaffolds were obtained via 3D printing technology. Considering the input parameters of the 3D printed architectures, CAD 3D structures can be obtained. The CAD models of the printed architectures can undergo computer simulation of their mechanical behavior in order to predict the mechanical performance of the design.



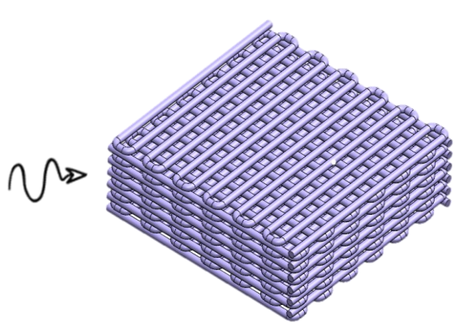
The aim of this study is to investigate the mechanical properties of previously 3D printed architecture using SolidWorks 2019 simulation tool. The CAD models of a 3D printed diopside scaffold is generated according to the printing parameters. Considering the material characteristics, the static simulation of the mechanical resistance of the designed parts is performed.

METHODS AND RESULTS

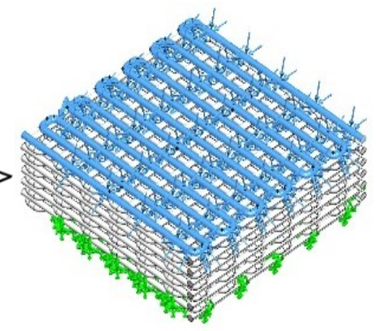
- Using SolidWorks 2019 the architecture of the 3D printed diopside structure was reproduced;
- In the designing process were considered parameters like: infill type, rotation angle, distance between strands, nozzle diameter, and 3D structure dimensions;
- The designed model was subjected to static simulation;
- In the simulation step the mechanical characteristics of the material and stress similar to the one that the trabecular bone withstands were taken into account.



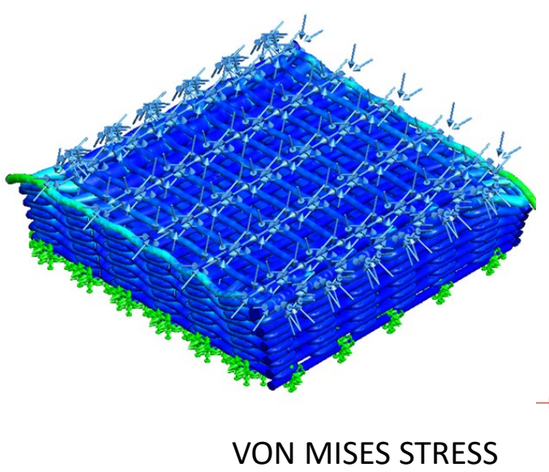
Designing of layer according to the printing parameters



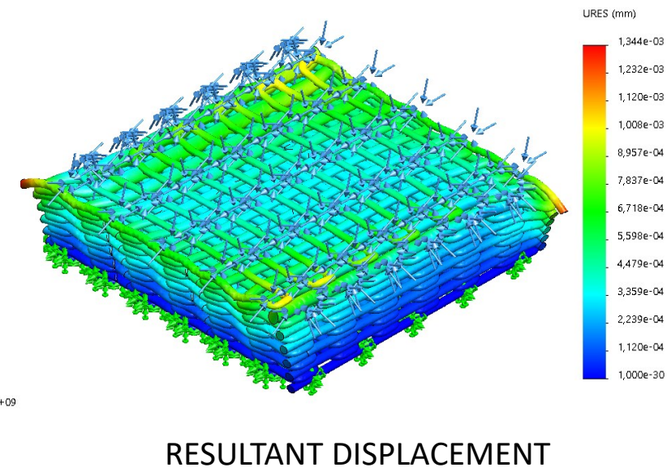
CAD model of the 3D printed part



Selected loads and fixtures point for the simulation process



VON MISES STRESS



RESULTANT DISPLACEMENT

- ✓ According to the simulation results the 3D structure will not yield or fracture because the maximum value of von Mises Stress doesn't exceed the yield strength of diopside [4]. Even so, the resultant displacement indicated that the 3D structure can undergo a significant deformation under the stress that the trabecular bone bears.

Type	Min	Max
VON: von Mises Stress	0,000e+00 N/m^2	1,141e+08 N/m^2
URES: Resultant Displacement	0,000e+00 mm	1,344e-03 mm

CONCLUSIONS

In this study a 3D structure was designed according to the printing parameters of the manufactured architecture.

The designed part was subjected to static simulation to a pressure value similar to the one that trabecular bone withstands. Promising results regarding the mechanical characteristics of the 3D part were obtained.

Static simulation could be an useful tool to predict the mechanical behavior of the 3D printed structures. This approach can provide a better design for the 3D architectures allowing the fabrication of structures with personalized characteristics.

A prospective for future studies could be to identify the differences in simulation result for different printing parameters.

REFERENCES AND ACKNOWLEDGEMENTS

1. C. Wang, W. Huang, Y. Zhou, L. He, Z. He, Z. Chen, X. He, S. Tian, J. Liao, B. Lu, Bioact. Mater. 5 (2020) 82.
2. C. Wu, Y. Ramaswamy, H. Zreiqat, *Acta Biomater. 6* (2010) 2237.
3. P. Srinath, P. Abdul Azeem, K. Venugopal Reddy, P. Chiranjeevi, M. Bramanandam, R. Prasada Rao, Adv. Powder Technol. 32 (2021) 875.
4. D. Dorner, B Stockhert, Technophysics 379 (2004) 227.

The authors very much appreciate the involvement of the colleagues from Advanced and Nanostructured Materials Laboratory from the National Research & Development Institute for Non-ferrous and Rare Metals – IMNR and the support of the research team from the National Research Center of Micro and Nanomaterials from University POLITENICA of Bucharest.