# HYDRO- AND SOLVOTHERMAL NANOPOWDER SYNTHESIS IN MICROWAVE REACTORS

**SYLWIA DĄBROWSKA[1,2]*, URSZULA SZAŁAJ[1,2], JACEK WOJNAROWICZ[1], TADEUSZ CHUDOBA[1], WITOLD ŁOJKOWSKI[1]**

[1] INSTITUTE OF HIGH PRESSURE PHYSICS PAS, WARSAW, POLAND
[2] WARSAW UNIVERSITY OF TECHNOLOGY, FACULTY OF MATERIALS SCIENCE AND ENGINEERING, WARSAW, POLAND
*E-MAIL: S.DABROWSKA@LABNANO.PL

***[ENGINEERING OF BIOMATERIALS 153 (2019) 75]***

**Introduction**
Nowadays more and more bioactive materials are used in medical applications, which can support osseointegration. Bioactive hydroxyapatite (HAP) is one of the inorganic component of hard tissues, which is manufactured in The Institute of High Pressure Physics (IHPP PAS) and it is called GoHAP™

**Materials and Methods**
Microwave solvothermal synthesis (MSS) is an example of microwave assisted wet chemical synthesis process and nowadays it is counted as one of the most popular chemical methods of obtaining nanomaterials, like HAP, ZnO, $ZrO_2$ and other. The morphology, grain size and specific surface area of the nanopowder can be controlled thanks to the microwave reactor and the high pressure consolidation technology for ceramic materials. Microwave heating enables better control of the reaction time, fast heating and reducing the thermal gradients. This results in a better crystallinity of the nanoparticles comparing to the precipitation process. An additional advantage is a reduced synthesis temperature, so no powder calcination is needed.

**Results and Discussion**
Nanohydroxyapatite was synthesized by precipitation method in room temperature and after heated by hydrothermal synthesis using microwave reactor MSS2. In the IHPP PAS we are able to synthesize and obtain six types of hydroxyapatite with different crystallinity degree and grain size [1].

**Conclusions**
At the Laboratory of Nanostructures, IHPP PAS, we have been developing new type microwave reactors for nanopowders synthesis for more than 15 years. The use of the microwave radiation and the unique design of the reactors permit precise pressure control during the quick synthesis processes, controlled with the accuracy of even one second. The reactors like MSS1 or MSS2 also present a control system which allows for automatic operation in the stop flow mode or use the batch (closed vessel) mode in bigger production scale than in other commercial equipment [2]. In the MSS2 reactor in the stop flow mode, the process chamber is emptied exactly upon finishing the heating, which results in a rapid cooldown and freezing of the reaction. The batch system brings inertial purity and repeatability of the process of medical purity nanopowders. And also the same concentration of the each batch of synthesized product [3].

**Acknowledgments**
The MSS2 reactor was constructed as a part of the CePT project, reference: POIG.02.02.00-14-024/08, financed by the European Regional Development Fund.

The research was supported by the Polish National Centre for Research and Development (NCBR) project: NANOLIGABOND (POIR.04.01.02-00-0016/16)

**References**
[1] S. Kuśnieruk, "Influence of hydrothermal synthesis parameters on the properties of hydroxyapatite nanoparticles", Beilstein Journal of Nanotechnology 7:1586-1601, November 2016.
[2] Dąbrowska, S.; Chudoba, T.; Wojnarowicz, J.; Łojkowski, W.; Current Trends in the Development of Microwave Reactors for the Synthesis of Nanomaterials in Laboratories and Industries: A Review. Crystals 2018, 8, 379.
[3] Dąbrowska, S.; Chudoba, T.; Leonelli, C.; Wojnarowicz, J.; Łojkowski, W.; Problems of exploitations of microwave reactors for nanoparticles synthesis. Journal of Machine Construction and Maintenance, 2018, 110(3), 41-47.