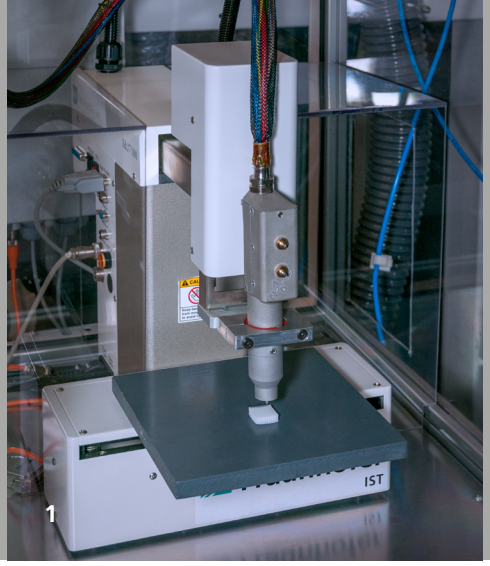

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Extract from the annual report 2017
To the website: www.ist.fraunhofer.de/en.html

PLASMA JET FOR COATINGS WITH FUNCTIONAL GROUPS

A new approach for the medical treatment of missing bone fragments is the implanting of 3D printed and biodegradable polymer frameworks, so-called scaffolds. These have the task of serving as a framework for new growing bone cells, and then over time to decompose within the body. For optimal growth of the new bone cells the surface of the polymer must be chemically treated by nucleophilic and electrophilic groups. One possibility that is being investigated at the Fraunhofer IST is the deposition of layers with suitable chemical groups via atmospheric pressure PECVD by a plasma jet during the 3D printing process.

Development of the technology

At the Fraunhofer IST a plasma jet mounted on a robot (see Fig. 1) is used for deposition of PECVD layers. A layer forming precursor is added to the argon plasma that is used, which results in a local layer deposition in front of the plasma nozzle. The directed gas flow should enable penetration of the film into the porous scaffold structure (see Fig. 2).

Through variation of different process parameters, such as precursor gas, gas flows, electrical power, oxygen supply, pulse pattern or substrate temperature, the influence of the individual parameters was more precisely investigated for the layer properties. The plasma jet used causes only a very low energy input of maximum 4 W on the substrate to be coated, so that substrate temperatures of 60 °C are not exceeded during the coating process. Thus, the test arrangement is also excellently suited for the coating of temperature-sensitive, porous polymer structures.

Results

With the approach described above it was possible to deposit layers with different precursors, such as HMDSO, TMS, APTMS, GMA, and MAA-VTMOS. In this regard, for nucleophilic pp-APTMS layers, in particular it became clear that the pulse pattern has a major influence on the density of the nucleophilic groups. If the layers are deposited with a minimal duty cycle, i. e. with a low ratio of pulse to period duration, then the molecular structure of the precursor remains better preserved and layers with higher group densities are generated (see the opposite graphs). A moderate increase in the substrate temperature to 70 °C during a deposition process also had a positive effect on the nucleophilic group densities of the pp-APTMS layers. Moreover, it was also possible to successfully transfer the layer deposition of planar substrates to 3D scaffold substrates.

Outlook

Current and future investigations of this topic are increasingly focused on layer stability relative to storage and sterilization processes. In addition, it is planned to conduct studies concerning cell growth on coated substrates.

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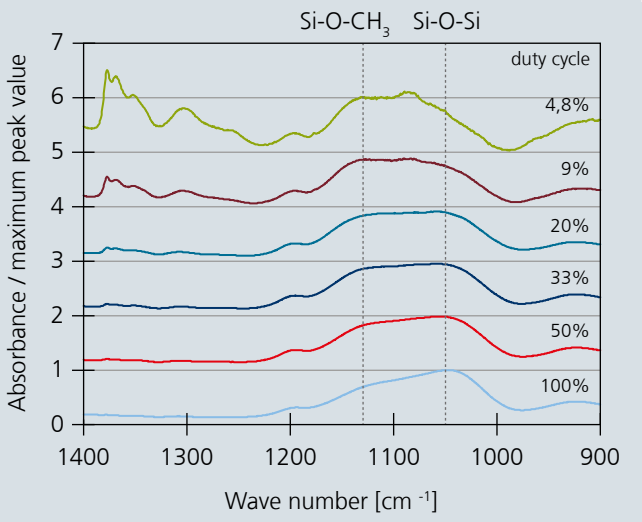
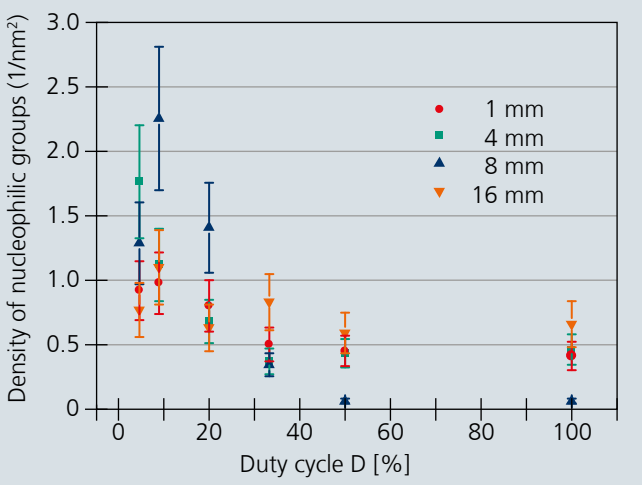
ATR-FTIR spectra of pp-APTMS layers for different duty cycles.



Density of nucleophilic groups as a function of the duty cycles.



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1 *Robot arm with plasma jet in operation.*

2 *Layer deposition by plasma jet.*

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