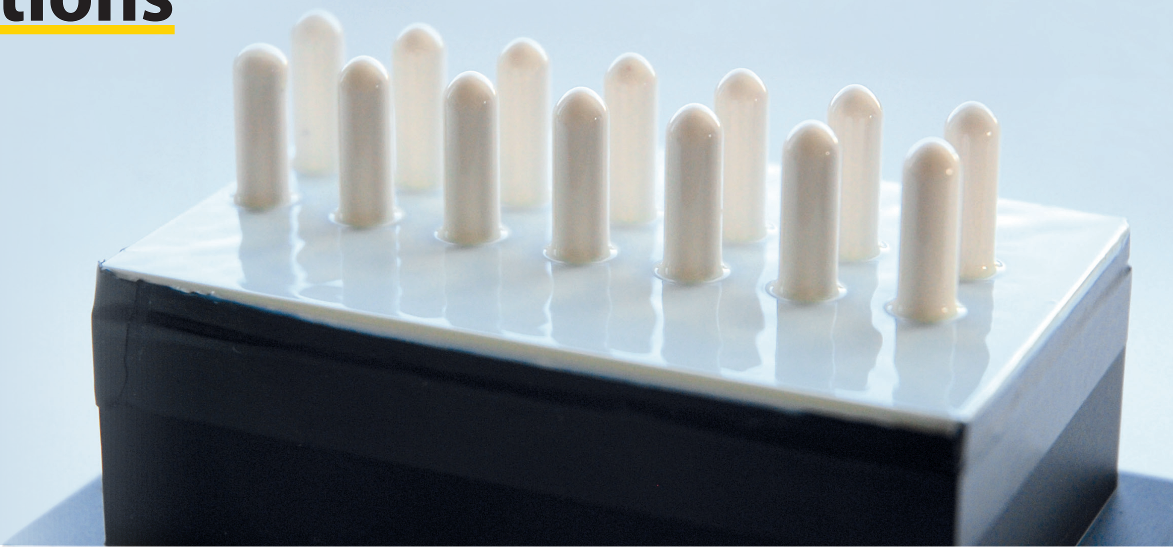
3D Printing Parts for Cold Plasma Applications

LITHOZ®

We are ceramic 3D printing.



Opportunity

Cold, non-thermal plasmas operating at atmospheric pressures have huge potential in applications for the decontamination of air, water, or for example in the healthcare industry. When the plasma is generated via electric discharge, the decontaminating effect is based on the thereby-generated chemical reactive species, such as ozone. These reactive species can be directly generated in water or air without addition of further chemicals. Moreover, cold plasma can also be used for thermosensitive materials or products, where thermal decontamination procedures are not suitable.

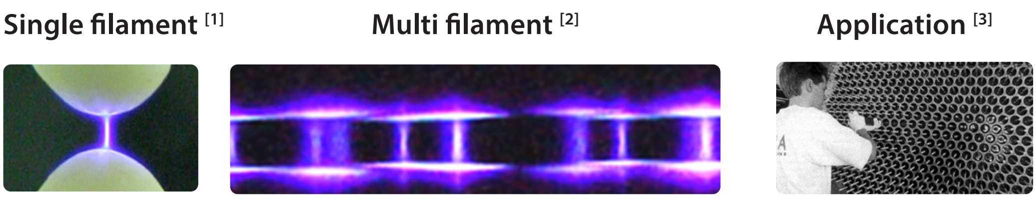


Figure 1: From single filaments to large area applications through multifilament arrangements

Challenge

Non-thermal plasmas still represent a challenge as they are usually small-scale due to the Paschen law, which describes the voltage necessary to initiate an electric discharge between two electrodes in a gas as a function of pressure and gap length. To enable large area applications, the INP Greifswald in Germany investigated a new approach: instead of increasing the area, the number of filaments was increased. However, in order to ultimately obtain a controllable plasma source, the filaments must be reproducible in terms of material properties and geometrical precision.

Technical ceramics are the material of choice, as a dielectric is required to limit the current and some metals cannot withstand the plasma. Another important factor is that technical ceramics are available in high purity, as any contaminations introduce the risk of unwanted electric breakdown. This is where new shaping technologies, such as 3D printing, offer the possibility of manufacturing the filaments with the high levels of reproducible precision needed for a stable and consistent creation of plasma while opening up the degree of freedom to deviate from zylindric geometries.

Project

Leibniz-Institut für Plasmaforschung und Technologie e.V. (INP) Greifswald led an investigation with the German DFG-funded "MultiFil" project, using individual discharges in dielectric barrier discharges (DBDs) in multi-filament arrangements. The aim was to compare single and multi-filament arrangements with similar dimensions to clarify whether the existing knowledge from the single filament can be transferred to arrangements *(Figure 1)*.

DBD describes the electrical discharge between two electrodes separated by an insulating dielectric barrier. Therefore, half-spherical alumina shells were produced. These shells represent the dielectric barrier, within which the metal electrodes were placed. A spatially-fixed single filament was created via placing two of the components opposing each other with a gap of 1 mm between them *(Figure 2)*.

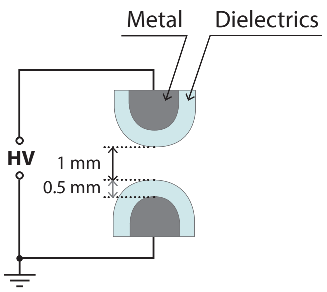


Figure 2: Setup for a spatially-fixed single filament via placing two DBD components opposite each other [5]

The challenge is that conventional shaping technologies are not able to meet the required part properties (evident from the appearance of cracks and spalling as shown in *Figure 3*) and geometrical precision.

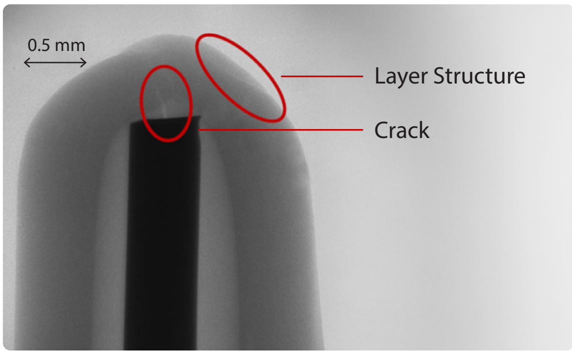


Figure 3: Conventional shaping technology resulted in the appearance of cracks and spalling [4]

Therefore, INP decided to produce the half-spherical alumina shells via lithography-based ceramic manufacturing *(Figure 4)*. Using this process, it was possible to produce parts with high accuracy and repeatability, which is necessary for the stable and consistent creation of plasma. In addition to further advancing plasma technology, 3D printing allows for even more complex and calculated geometries to increase the efficiency of plasma generation, combined with the possibility for fast adaption as well as upscaling.

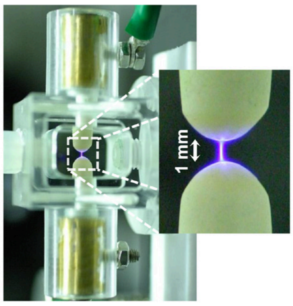


Figure 4: 3D printing of dielectric barriers for application as filaments in dielectric barrier discharges (DBDs) in plasma applications [1]

References:

[1] H Höft et al. (05.02.2013). The influence of O2 content on the spatio-temporal development of pulsed driven dielectric barrier discharges in O2/N2 gas mixtures. 2013 J. Phys. D: Appl. Phys. 46 095202. https://doi.org/10.1088/0022-3727/46/9/095202

[2] R. Brandenburg. (11.11.2004). Räumlich und zeitlich aufgelöste spektroskopische Untersuchungen an filamentierten und diffusen Barrierenentladungen. Ernst-Moritz-Arndt-Universität Greifswald, Mathematisch-Naturwissenschaftlichen Fakultät. http://www1.physik.uni-greifswald.de/download/dissertationen/dr-brandenburg.pdf

[3] U. Kogelschatz. (03.2003). Dielectric-barrier Discharges: Their History, Discharge Physics, and Industrial Applications. Plasma Chemistry and Plasma Processing 23, 1-46. https://doi.org/10.1023/A:1022470901385

[4] P. Turski, T. Gerling, J. Winter, K.D. Weltmann. (09.-10.10.2018). Vision for AM Ceramic Applications in Plasma Technology. AM Ceramics, Vienna.

[5] H. Höft. (16.06.2015). Characteristics of pulsed operated dielectric barrier discharges in molecular gas mixtures. Ernst-Moritz-Arndt-Universität, Mathematisch-Naturwissenschaftliche Fakultät. https://nbn-resolving.org/urn:nbn:de:gbv:9-002262-6

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