Innovative plasma generator in piezo technology: Applications in medicine and medical technology

PDD® technology means the launch of a new class of devices predestined for applications in medicine and medical technology. When applied, these devices combine a sterilizing effect with a highly efficient increase in surface energy.

Medical applications

In many fields of medicine and medical technology, atmospheric plasma technology is on the verge of broad application. Numerous and diverse scientific studies have proven the excellent effects of plasma treatment, especially when using non-thermal plasma sources. Systematic experimental approaches under laboratory conditions have shown cold plasma sources to be effective for treating wounds and accelerating the healing process as well as for treating a wide variety of inflammatory diseases both in dermatology and dental medicine. An excellent summary of the various therapies and methods can be found in the introductory abstract provided by "Plasma Medicine" [1]. In addition to direct therapeutical approaches, there is a wide range of possible application fields in biotechnology, pharmacology and medical technology; we would especially like to draw attention to the surface treatment of implants in order to improve wettability and sterilization as well as to control cell colonization.

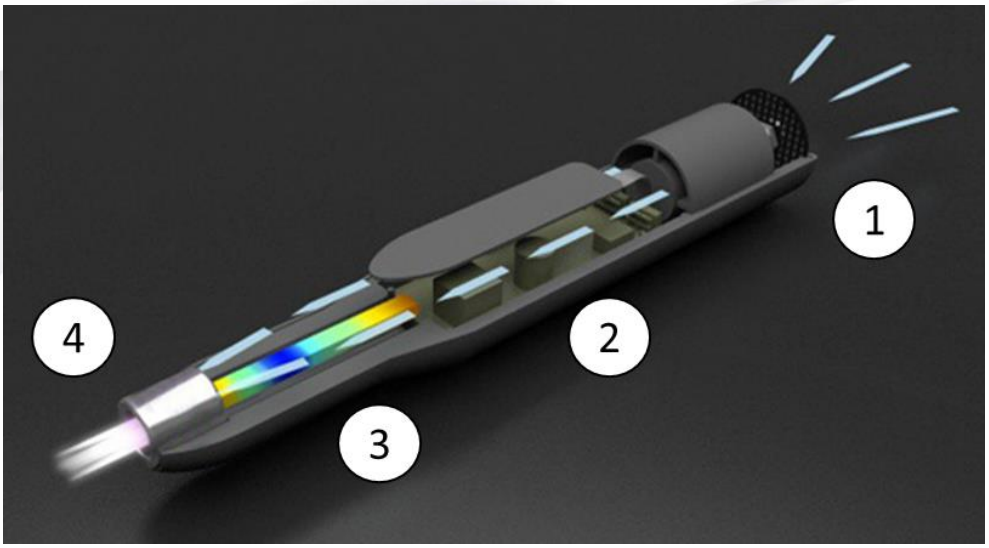
The important step now is to develop effective and cost-efficient technical devices in order to widen the radius from laboratory to broad application. It is therefore crucial to provide concrete evidence of effectiveness of the method as well as prove that the device used is entirely safe and creates reproducible results.

Two types of atmospheric plasma systems are predominantly used in medicine and medical technology. Dielectric barrier discharge (DBD) is characterized by low thermal stress and high effectiveness when treating larger surface areas such as skin tissue, wound treatment material or surfaces used in medical technology. Cold jets or point sources are especially suitable whenever limited areas or complex geometries, such as for example cavities, are being treated and the desired effect is that of excited species in the gas phase. Typically, the process gas here is excited through high frequency electric fields. By now, the development of application-oriented devices can draw from a wide scientific base for the classification of effect mechanisms. Any innovative device can thus be sufficiently analyzed for physiochemical properties - e. g. UV emission, thermal footprint, ROS (reactive oxygen species) and RNS (reactive nitrogen species) content, electron density, and electric field strength - to allow for an advance assessment of the effectiveness and possible side effects using conclusion by analogy.

With its PDD® technology (Piezoelectric Direct Discharge), ***relyon plasma*** GmbH has developed an innovative method of applying micro plasma jets as well as cold plasma sources of the dielectric barrier type.

Basic principle of generating piezoelectric plasma

PDD® (Piezoelectric Direct Discharge) is based on a piezoelectric transformer (PT) operated in open circuit mode. With high efficiency, low incoming voltage is transformed in order to build up high electric field strengths, thus dissociating and ionizing the ambient process gas, usually air. The gas temperature inside the plasma volume is typically only slightly higher than the ambient temperature. Electron densities of ca. 10^{14} to 10^{16} m^{-3} are achieved. PDD® thus provides a typical "cold" non-equilibrium plasma [2].



***Picture 1**: Basic principle of piezoelectric plasma generation. (1) air supply, (2) driver electronics, (3) piezoelectric transformer, (4) atmospheric volume discharge*

Device concept

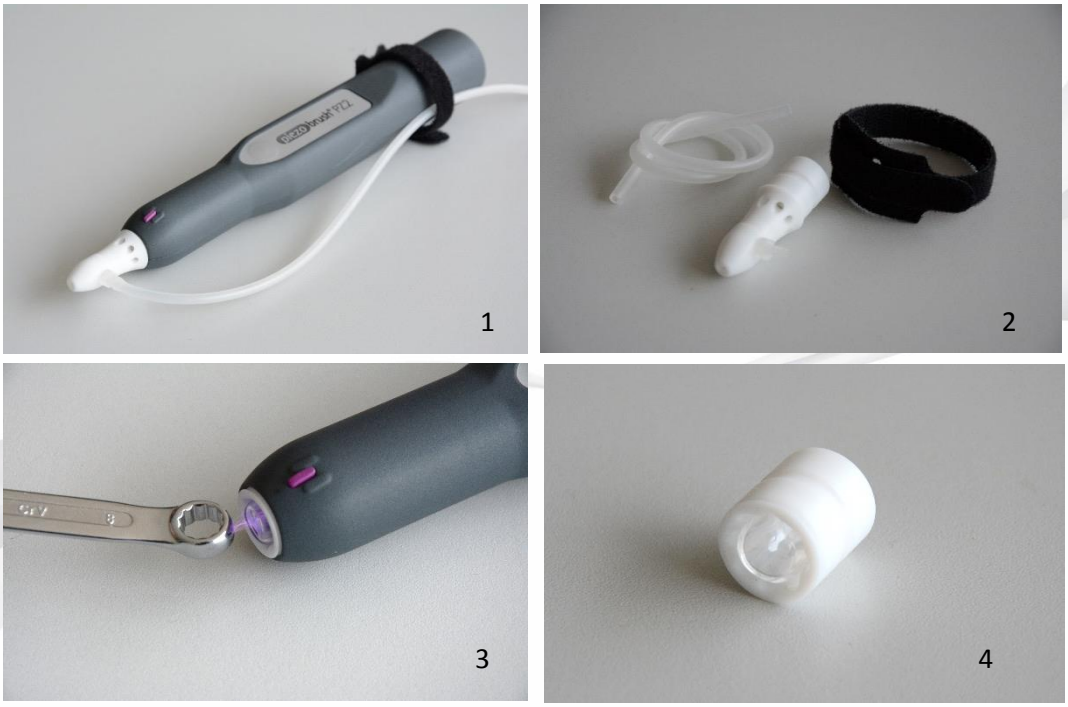
The device concept is characterized by maximum conversion efficiency and compact build. In medical device manufacturing, it is already in serial use both as a stationary as well as a handheld device.

Configurations

Using a variety of configurations, the system can be optimized for maximum yield of ozone or other reactive oxygen species (ROS) and in doing so reaches the highest grade of efficiency in its class, close to the theoretically possible yield limit value. For this purpose, nozzles for open systems are offered as well as adapters for closed systems (cf. picture 3). The system is thus fit to work with air, argon, helium, nitrogen, hydrogen as well as oxidizing or reducing gas mixtures.

For gentle treatment of larger surfaces, a dielectric barrier insert can be selected and discharge is extended to a widened area.

A modular push-fit system with various caps allows for a wide variety of applications. Depending on requirements, the device can be configured to work in DBD mode, as a cold plasma jet with variable process gases or air, or as an intensive point source ("plasma needle").



Picture 2: *Nozzle caps for various applications. (1,2) Needle nozzle for inside treatment of pocket holes, cavities and for using special gases. (3, 4) Nozzle insert for extensive treatment of sensitive or conductive surfaces.*

Picture 3: *PZ2 handheld device in laboratory use for the pretreatment of dental materials (inorganically filled synthetic resins, PEEK, titan).*

Conclusion

PDD® technology means the launch of a new class of devices predestined for applications in medicine and medical technology. Various implementations have proven a high disinfection rate for a multitude of microorganisms [3].

The wettability of medical-technical materials such as for example PEEK, teflon, silicon and highly-filled polymers can be optimized efficiently. This property is the base for a highly adhesive bond or for the biocompatibility with and therefore acceptance by surrounding living tissue. In application, the devices discussed combine a sterilizing effect with a highly efficient increase in surface energy.

Further information

[1] Plasma Medicine, Alexander Fridman und Gary Friedman, John Wiley & Sons 2013

[2] Wikipedia: http://en.wikipedia.org/wiki/Piezoelectric_direct_discharge_plasma

[3] ResearchGate.net: Effect of piezoelectric direct discharge plasma on microorganisms (**DOI:** 10.13140/RG.2.1.4750.4809) 2015

[4] K-Zeitung, Edition 5, Page 22: PEEK-Implantate funktionalisieren und Keime reduzieren