The application of Cold Atmospheric Plasma (CAP) for the sterilisation of spacecraft components

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Abstract:
The search for past or present extraterrestrial life is one main driver for space missions to habitable planets and moons in our solar system. Especially our neighbour planet Mars, but also Europa and Enceladus, icy moons in the outer solar system, are of high astrobiological interest. In order to find traces of life on another celestial body by in-situ measurements the instruments for life detection have to be very sensitive and the unintended contamination with organic compounds and microorganisms from Earth has to be avoided. The COSPAR’s Planetary Protection Policy and Guidelines specify the maximally allowed bioburden of spacecraft depending on the type of mission, the target and, in the case of Mars, of the landing site (Kminek et al., 2017). The bioburden reduction of spacecraft and instruments can be achieved by the application dry heat or hydrogen peroxide vapour as specified in international standards. A new approach is the use of Cold Atmospheric Plasma (CAP). Plasma, often called the fourth state of matter after solid, liquid and gas, is defined by its ionized state. The concentration and composition of reactive atoms and molecules produced in CAP depends on the gases used, the gas flow, the power applied, the humidity level etc.. In medicine, low-temperature plasma is already used for the sterilization of surgical instruments, implants and packaging materials as plasma works at the atomic level and is able to reach all surfaces, even the interior of small hollow items like needles. In the project PLASMA-DECON a prototype of a device for sterilising spacecraft material and components was built (Shimizu et al., 2014) and is now being further developed based on the surface micro-discharge (SMD) plasma technology (supported by the Bavarian Ministry of Economics, D). The produced plasma species are directed into a closed chamber which contains the parts that need to be sterilised. To test the inactivation efficiency of this new device bacterial spores were used as model organisms because in the COSPAR Planetary Protection Policy all bioburden constraints are defined with respect to the number of spores (and other heat-tolerant aerobic microorganisms). From the results obtained it can be concluded that the application of CAP proved to be a suitable method for bioburden reduction as part of the necessary planetary protection measures and the design of a larger plasma device is under development.

References:
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