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NEW PLASMA JETS FOR CLEANING SILVER

Silver surfaces that are exposed to open air will begin to tarnish, and after a while, the well-known brownish-black discoloration of silver sulfide appears. Removing these dark coatings is a task which must often be carried out, especially in restoration work. One way of doing this is to treat the affected areas with plasma jets, operating with the use of reducing gases. Conventional, previously established systems often use a hot discharge thus making them unsuitable for treating delicate objects locally. Pen-like jet systems developed at the Fraunhofer IST use dielectric barrier discharge (DBD), making gentle work possible at low temperatures up to 50 °C and allowing for the treatment of temperature-sensitive and fragile cultural objects.

Jet development for reduction and oxidation processes

The modification of surfaces via plasma jet in the protective atmosphere of a glove box has already been a standard procedure at the Fraunhofer IST for quite a long time. With the aid of the plasma jets, oxidation products and even organic contaminants can be removed efficiently in this way, employing reactive process gases and relatively high temperatures.

By using a pulsed DBD as well as a selection of specially designed material, jet development has been optimized to the point where treatment temperatures can be lowered almost to room temperature. In addition, the special arrangement of the DBD jet along with the use of certain process and reactive gases has enabled the hydrogen atoms forming in the discharge zone during reduction treatments, as well as the ozone molecules during oxidative treatments to hit the surface in sufficient quantities to remove corrosion products and organic impurities.

Furthermore, a specially arranged flow of inert gas has been successfully developed that makes it possible to work with the jets even outside of the glove box. The steady stream of inert gas ensures that reducing and oxidizing species in the vicinity are separated from each other and at the same time directing reduction products away from the surface. This opens up entirely new applications for the plasma jet function such as the restoration and treatment of immovable or large objects.

Cleaning textiles containing silver

The combination of metals and textiles often plays an important role in the restoration of textiles. One of the most common forms seen is silver thread, which is worked flat or spun as yarn around woven silk threads. The problem in this case is that the corrosion products of the metal are very damaging for the textile fibers since they promote their decomposition. Cleaning with conventional, mostly wet chemical or mechanical methods is however difficult to carry out on combined-material objects and often proves disadvantageous for the textile material.

The corrosion products present were reduced considerably by treating the silver with a plasma jet. Thanks to the low working temperatures and contactless treatment, this process resulted in very little damage to the silk. Investigations show

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that mechanical properties of the textiles, such as tensile strength and flexural strength, have hardly changed after the plasma treatment – less than two percent in the case of tensile strength.

Coatings of pure silver sulfide can be removed relatively easily with a reducing plasma. However, since corrosion coatings often involve a complex interplay of silver and copper compounds such as oxides, sulfides and sulfates, and even organic contaminants are present, a purely reductive treatment is inadequate in many cases. Much better cleaning results are obtained by using an oxidation treatment combined with a process gas containing oxygen, and then followed by a reduction step. In addition, preliminary results indicate that the damage to the silk caused by oxidation can be reversed by downstream reduction treatment.

Outlook

In the future, the plasma jets are to be further developed so that they may be moved by hand over objects using pinpoint precision, thus enabling the treatment of even more complex object geometries. In addition, ergonomic and safety aspects must be taken into consideration since high voltages and reactive gases are involved.

1 *Fragment of a stole (German Textile Museum Krefeld, Inv. No. 26071).*

2 *Detail of the stole with silver embroidery.*

3-4 *Flattened silver threads before (3) and after (4) a plasma treatment.*

CONTACT

Dr. Michael Thomas
Phone +49 531 2155-525
michael.thomas@ist.fraunhofer.de

Prof. Dr. Claus-Peter Klages
Phone +49 531 2155-510
claus-peter.klages@ist.fraunhofer.de