VIII Congresso Nazionale di Archeometria
Scienze e Beni Culturali: stato dell'arte e prospettive
Bologna 5 - 7 Febbraio 2014

# PANNA PROJECT: ASSESSMENT OF A NOVEL METHODOLOGY FOR PLASMA CLEANING, COATING APPLICATION AND DIAGNOSTICS AND COATING REMOVAL

**S. Voltolina[1], C. Aibéo[2], M. Favaro[3], V. Goossens[4], L. Nodari[3], O. Schalm[5], A. Patelli[1], E. Egel[2], E. Verga Falzacappa[6], I. Pavlova[7], M. Stefanova[8], F. Mattiazzo[9]**

[1] Veneto Nanotech scpa (IT), stefano.voltolina@venetonanotech.it
[2] Stiftung Preussischer Kulturbesitz – Staatliche Museen zu Berlin (DE)
[3] Istituto di Energetica e delle Interfasi – CNR (IT)
[4] Chemstream bvba (BE)
[5] Conservation Studies – Universiteit Antwerpen (BE)
[6] Nadir srl (IT)
[7] Center for Restoration of Artworks ood (BG)
[8] Botega Z eood (BG)
[9] Lorenzon Costruzioni srl (IT)

Conservators and restorers have always been keeping an eye on technological innovation and, in fact, in the twentieth century, they have started to use new developed materials which had been in the market only since 5 to 15 years, such as synthetic polymers [1]. Nowadays, such products are still widely used in the field of conservation, thanks to their excellent qualities, although it is now well known that they decay with time and need therefore maintenance, that is, they have to be removed and reapplied from time to time.
At the same time, new cleaning procedures emerged, moving toward more selective and surface techniques. More than 30 years ago Nd:YAG laser was firstly used in a novel removal procedure for encrustations and superficial deposits on stone [2].

In the last decades the aim of the research in conservation was mainly focused on the development of new materials for preservation of surfaces and on the enhancement of the cleaning and removal procedures. Focusing on this challenging scenario, PANNA Project objective was the development of a full conservation methodology (*full-life protocol*) employing atmospheric plasma and introducing new concepts to protective coating technology.

Atmospheric plasma was proposed mainly for cleaning purposes, the first step of the proposed conservation methodology. Plasma is a highly ionized gas [3] full of reactive chemical species and Atmospheric Pressure Plasma Jets (*plasma torches*) are relatively compact devices able to let such species interact with surfaces. In industry plasma torches are used mainly for cleaning and activation of surfaces, even if hottest plasmas are used also in cutting and welding [4]. Nevertheless, the use of plasma for wounds disinfection and other medical applications evidenced the versatility of such technology and made it promising for an application in cleaning of works of art.

PANNA project proposed to improve protective coatings by adding functionalities which allow a rapid and easy determination of their presence and effectiveness (*self-diagnostic coatings*). Another main feature of the developed coatings is their removability by plasma, as once the product has lost its protective ability it should be removed and reapplied.

Resuming, PANNA Project is therefore proposing a new conservation methodology built up in the following steps:

i. Plasma cleaning of surfaces: Removing unwanted layers (e.g. soot and soiling, aged protectives, etc.)
ii. Application of self-diagnostic coatings: protect surface against future degradation
iii. Maintenance and diagnostics of the applied protective coatings
iv. Plasma removal of aged inefficient self-diagnostic coatings
v. Reapplication of self-diagnostic coatings

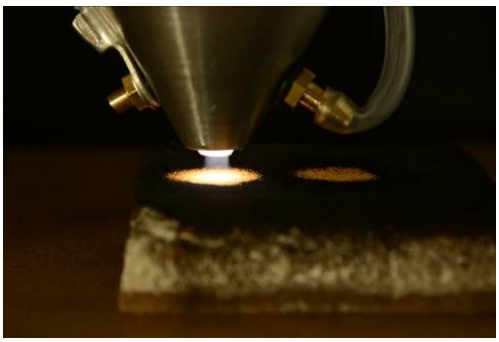
Fig. 1: Plasma cleaning of soot on ochre wall painting replica

The activity in the frame of PANNA Project started with the identification of advantages and drawbacks of plasma cleaning for conservation purposes. 5 different commercial plasma torches were tested in cleaning and removal of different dirt typologies (e.g. soot, tarnishing, graffiti, polymers) from stone, metal and wall painting materials by the conservators involved in the project. At the same time the technological development of a plasma torch prototype, dedicated to conservation purposes, was performed. Feedback from restorers testing plasma cleaning was fundamental in tuning the desired features of the new plasma torch prototype. Moreover, assessment of the plasma removability of protective polymers allowed selecting the most adequate matrix for the development of the plasma removable self-diagnostic coatings.

At the end of the first year of activity, PANNA Project consortium was able to determine the most promising applications of plasma cleaning for conservation, to produce the plasma torch prototype, overcoming the common drawbacks of commercial devices for such application and to develop plasma-removable super-hydrophobic protective coating formulations.

The second year of the project was devoted to the development of cleaning protocols using the prototype torch instead of commercial devices, to the protective properties assessment of the developed coatings on stone, metal and wall paintings and to the incorporation of the self-diagnostic moieties in the coating matrices.
Successful plasma cleaning protocols were identified for the following cases:

i. Cleaning of tarnished silver (reduction of sulphides)
ii. Graffiti removal from stone surfaces
iii. Removal of aged protective coatings (epoxy and acrylic)
iv. Cleaning of soot on wall paintings
v. Removal of aged varnishes from icons

The best performing coating for each considered material was identified and, with the introduction of fluorescent moieties in the formulations, a quick diagnostic methodology was developed. By illuminating these coatings with a common UV light source, it's possible to detect their presence and homogeneity. A correlation between the spectral response of the coatings and their effectiveness is still under study.

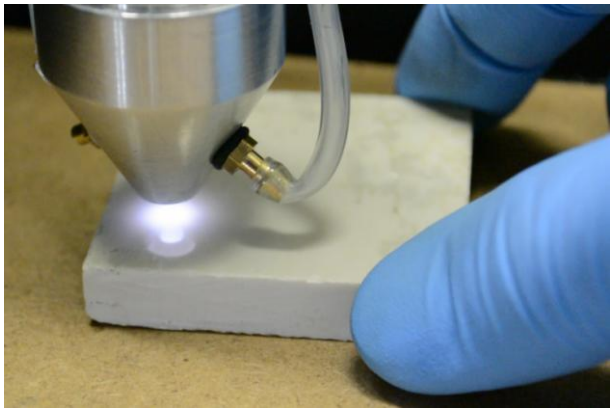

Fig. 2: Plasma removal of the self-diagnostic coating on stone
Visible illumination

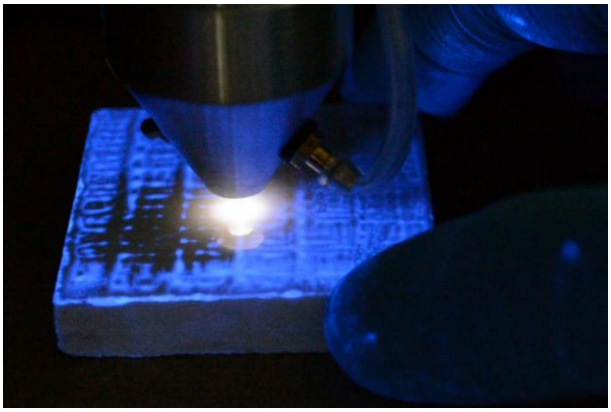

Fig. 3: Plasma removal of the self-diagnostic coating on stone
UV illumination

In these two years the knowledge on the efficiency of the atmospheric plasma on coating/dirt removal was deeply investigated and outputs turns in the development of an high efficient new plasma torch prototype. Moreover, a conservation protocol for plasma application was set up and well settled, new "tailor made" coating formulations were also produced and tested, showing new possibility on application of easy removing protective for Cultural Heritage assets.
At the present time the last year of PANNA Project is running and partners of the consortium are preparing for the dissemination of their results around Europe. A series of courses on the use of plasma cleaning and novel surface treatments for Cultural Heritage preservation is being organized for 2014. The courses will be in Italy, Belgium, Bulgaria and Germany.

**References/Bibliografia**

[1] Borgioli, L., 2002. *Polimeri di sintesi nella conservazione della pietra.* Edizioni il Prato. Padova

[2] Salimbeni, R., Pini, R., Siano, S., Calcagno, G., 2000. *Assessment of the state of conservation of stone artworks after laser cleaning: comparison with conventional cleaning results on a two-decade follow up*, Journal of Cultural Heritage, **1**, (2000), 385 – 391**.**

[3] Goldston, R. J., Rutherford, P.H., 1995. *Introduction to Plasma Physics*, IOP Publishing. London.

[4] Tendero, C. et al., 2006. *Atmospheric pressure plasmas: A review.* Spectrochimica Acta Part B 61 (2006) 2-30.