Surface Physics Applied to Cultural Heritage

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Abstract

In this contribution we will present some special innovative examples of surface analysis techniques applied to different areas of Cultural Heritage. In particular, we will discuss the study of surface of bronze ancient statues as well as of ancient paper by specific surface techniques as Atomic Force Microscopy (AFM). Obviously the Multivariate Analysis is necessary to elaborate the large data produced by this innovative techniques.

Introduction

Solids are the major part of artistic objects, which dimensions vary from the monoliths (i.e. obelisks) to the grains in the composition of pigments. Nevertheless there are some common characteristics, i.e. all the solids can be subdivided in an inner part (the volume) and a border (the surface), which includes the volume. In physics the surface represents the layer of atoms chemically homogeneous with those included inside the solid but with different properties: in fact while the inner atoms are totally surrounded by similar bonds, those located at the surface are unbalanced because on one side they have different interactions. This layer in contact with other gaseous, liquid or solid substances which constitute the external environment, represents the surface of a solid.

Then the surface is the zone in which the components of a solid have a different behaviour due to its direct interaction with the external environment. In theory only one atomic layer, i.e. some tenth of thousand millionth of a meter composes the thickness of the solid surface. In practice this thickness can be higher than this thin region because it could include the whole border zone where can exist compounds of different nature from that of the original solid volume. From above, it is evident that the knowledge of the chemical-physical properties of the surface allows to interpret the past history, to know the actual condition and to foresee the future evolution respect to the external environmental.

For this purpose there are developed techniques and methods able to give specific information on the properties of these border atoms. In particular, the surface study of an ancient piece reveals its deterioration state as well as the effects of eventual restoration or conservation techniques. In addition the surface study, improving the reading of a find, exalts its beauty or rareness.

In a handmade the surface is the expression of the artisan, often artist, who will transfer to the external images, symbols, and ideas. But it also evidences his skill and ability in the choice of tools and his technical knowledge so giving a complete view of the artist's work. In fact the observer of a masterpiece is unlikely attracted by the properties of its volume. At the contrary, the forms and colours of the surface capture his attention: the volume of the object is only the material support of the true artistic work. Of course we cannot generalize: in a building we appreciate also the interiors and we evaluate a precious object also in relation to his weight, which is a property of volume. But in the vast majority of cases the artistic message is impressed on the surface of the objects.

Results

The approach used in present work is to find out whether structure properties in a controlled degradation of a model system can be correlated with physical quantities measurable in a non-

destructive or micro-destructive way. As an other example of application of the surface technique, bronze patinas were studied.

Cellulose based object shows the author message on its surface so constituting its support; the interest on the monitoring of its degradation degree don't needs to be stressed.

Cellulose degradation occurs because of internal or external factors, such as intrinsic acidity of the paper or storage in an unsuited place. Degraded papers show an evident fragility and a yellowing, compromising in some cases the readability of the text [1].

At a merely qualitative comparison between images of samples at different ageing state showed appearance of fragmentation on fibers surface, involving all three fiber dimension (height, width and length), see Fig. 1.

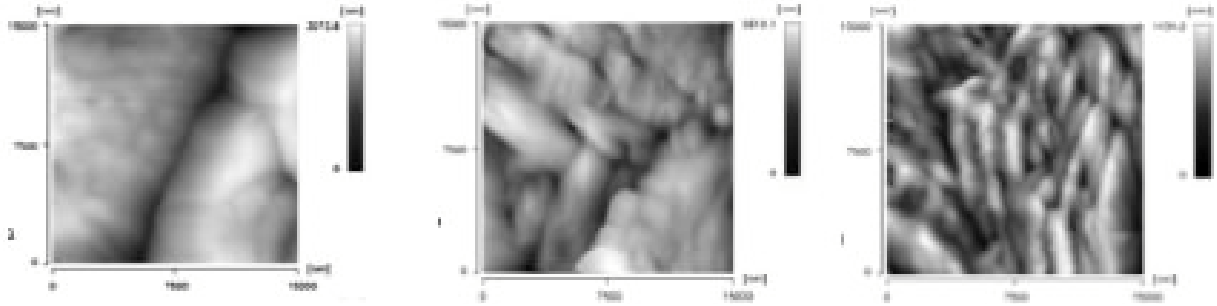

Fig. 1; AFM images concerning 0, 21, and 48 days of ageing treatment (laboratory climate chamber with light, temperature and water vapor changed)

Occurrence of such fragmentation increases with increasing ageing time, becoming a significant morphology after 21-28 days of treatment, and quite the ordinary appearance of the more aged sample.

The suggested interpretation is that the climate chamber treatment is likely to induce deterioration to the fiber cuticle, so to remove encapsulation of fibril bundles and unfasten the bundles themselves. Such a phenomena would imply an increment of disorder that is also reflected in the surface corrugation data, which are not, in this case, distributed around a specific value but spread towards the smaller dimensions including also values that never where found in unaged sample.

The surface methods supplied explanations to the treatments that Greeks and Romans applied to the surface of bronze statues as scratching and black patina.

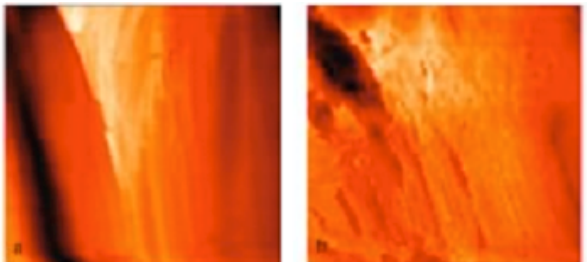

Fig. 2; AFM Images of black patina on bronze surfaces, artificial on the left, natural on the right

Interesting results where also obtained in the discrimination of artificial and natural structures (Fig. 2) you can find on the surface of prehistoric tooth: a crucial point to understand the ceremonies (artificial structures) and the health status (natural structures) of ancient populations.

Conclusion

Using surface methods we where able to study many aspects of the history of materials of interest in cultural heritage. In all of these studies it will be necessary a more accurate statistical analysis of results due to the strong unhomegeneity of local chemical-physical properties of natural materials used to realize artistic objects.

References

1) G. Piantanida, M. Bicchieri, C. Coluzza, Atomic force microscopy characterization of the ageing of pure cellulose paper, *Polymer*, 46(26), (2005) 2313-12321