ED-ARCHMAT

SPECIFIC TARGETED WORKSHOP (STW1)
(ON LINE)

Nanotechnology in Archaeological and Cultural Heritage Material Science

14 – 15 October 2021

Politecnico di Torino

14 october 2021

10.00 - 10.10
Welcome

10.10 - 10.40
Leonardo Iannucci
Nanocomposites for Cultural heritage conservation

10.40 - 11.10
Luca Lombardo
Sensors for environmental monitoring

11.10-11.25
Break

11.25 -11.55
Leila Es Sebar
Analysis of the corroded surfaces by means of photogrammetry

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11.55 -12.25
Luisa Vigorelli
X-Rays imaging instruments and techniques in the Cultural Heritage field

12.25 - 12.55
Amina Vietti
Iron corrosion products examination at nanoscale

12.55 -13.10
Q&A session

Lunch time

14.30 -15.00
Emma Angelini
Nanolayers of metals as fast indicators of degradation

15.00 – 15.30
Sabrina Grassini
PECVD technologies for deposition of protective nanolayers

15.30 -16.00
Final Q&A session

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15 october 2021

10.00 -12.00

Angela Calia

Nanotechnologies applied to the Stone conservation

Lunch time

14.30 -16.30

Piero Baglioni

New methods and materials for the conservation of Cultural Heritage: from renaissance frescoes to modern and contemporary art

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CURRICULUM VITAE and ABSTRACTS of the SPEAKERS

CV – Leonardo IANNUCCI

Leonardo Iannucci received the M.D. in Materials Engineering in 2016 and then the PhD in Metrology in 2019 from Politecnico di Torino (Italy). From November 2020 to July 2021, he was visiting researcher at EPFL in the Integrated Circuit Laboratory (ICLAB).
Currently he is a research fellow with the Department of Applied Science and Technology (DISAT) at Politecnico di Torino. His main research fields are metals corrosion in industry and cultural heritage applications, development of innovative coatings for corrosion protection and electrochemical measurements.
He is member of IEEE (Institute of Electrical and Electronics Engineers), AIM (Associazione Italiana di Metallurgia) and GMEE (Gruppo Misure Elettriche ed Elettroniche).

ABSTRACT
The use of nanocomposites has spread in many applications in the last decades, thanks to the possibility of improving materials properties and combining different features of interest. This presentation will provide an overview about nanocomposites synthesis and applications; possible production routes will be discussed, as well as characterization techniques needed to assess their performance. Finally, case studies related to protection of metallic cultural heritage will be presented.

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CV Luca Lombardo

Luca Lombardo (Member, IEEE) was born in Italy in 1986. He received the B.D. and the M.D. in Electronic Engineering from the University of Messina (Messina, Italy) in 2014 and 2016, respectively. He received his Ph.D. Degree in Metrology from Politecnico di Torino (Torino, Italy) in 2019 and now he is research fellow in the field on electrical and electronic measurements with the Department of Electronics and Telecommunications at the Politecnico di Torino.
His research interests include the development of innovative sensors and systems for environmental monitoring and biomedical applications, embedded systems and instrumentation.

ABSTRACT
Environmental conditions significantly affect the conservation state of the cultural heritage artefacts. Temperature and relative humidity are directly related to the degradation of multimateric artefacts both stored in indoor sites and exposed to outdoor conditions. Furthermore, the presence of aggressive gases in the atmosphere can have harmful effects on the long-lasting preservation of cultural heritage assets. Therefore, an effective and flexible environmental monitoring system is often required in order to assess if the environmental conditions are suitable for the proper conservation of the artefacts or if some specific action has to be taken for their safeguard.
However, several constraints are involved in the design and deployment of environmental monitoring systems to be installed in cultural heritage sites, such as
reliability of the system and data quality, operative life, real-time operation, maintenance cost, sensor size and communication range. Recently, a monitoring system especially suitable for the cultural heritage field has been developed at Politecnico di Torino. The proposed monitoring solution tries to achieve a good trade-off among all of the required constraints. Nevertheless, its characteristics and flexibility make it suitable for many other applications. The proposed system has been employed in several monitoring campaigns in Italy and abroad. As an example of its application, data acquired during a campaign held recently in Colombia are here reported.

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CV – Leila ES SEBAR

Leila Es Sebar received her M.S. degree in Material Science for Cultural Heritage from the University of Torino, Italy, in 2018, and she is currently a Ph.D. student in Metrology at Politecnico di Torino (XXXIV cycle), Italy. She is lecturer for the course of Chemistry, Bachelor degree in Engineering at Politecnico di Torino from 2018.
Her main research topic is devoted to deepen the main aspects of the application of in situ diagnostic techniques (Raman, XRF, electrochemical measurements and photogrammetry) for the characterization of Cultural Heritage artefacts exposed to outdoor and indoor environments, such as museums and historical and archaeological excavation sites. She is member of the INFN-CHNet (Cultural Heritage Network), the network of the Italian National Institute for Nuclear Physics (INFN) devoted to Cultural Heritage. She collaborates also with the Centro Conservazione e Restauro "La Venaria Reale" in the field of multispectral photogrammetry.
She is member of the IEEE Instrumentation and Measurement Society, AIM (Associazione Italiana di Metallurgia) and GMEE (Gruppo Misure Elettriche ed Elettroniche). She is chair of the IEEE Women in Engineering Student Branch Affinity Group of Politecnico di Torino. She serves as reviewer for different journals, such as ACTA IMEKO and IEEE Transactions on Instrumentation and Measurement.

ABSTRACT
Photogrammetry is a non-destructive technique commonly employed in the cultural heritage field for recon- structing a 3D virtual replica of an artifact by simply taking several photos of the artifact itself from different points of view. The 3D model can be used either for documenting the artifact or for preserving its geometrical information and appearance. Moreover, by using a digital 3D model is extremely easy sharing information with the public and researchers without physically moving the artifact, and this represents a unique opportunity which cannot be achieved with traditional methods. Unfortunately most systems already present on the market are complex and costly both due to their hardware and software. This talk presents a novel acquisition system which is extremely cheap and can be easily arranged in any conservation laboratory. The solution is based on a simple acquisition system designed with the aim of providing researchers with a user-friendly and low- cost platform for the reconstruction of an artifact 3D model. The proposed system can be virtually interfaced to every commercial camera and can be integrated with several 3D reconstruction software. Finally, case studies related to application on metallic cultural heritage will be presented.

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CV – Luisa VIGORELLI

Luisa Vigorelli received her MS degree in Material Science for Cultural Heritage cum laude in 2015 from the University of Torino. After graduation, she attended different schools, such as the "IR and Raman Spectroscopy School for applications to Cultural Heritage" at the La Venaria Reale Conservation and Restoration Center, and then the Training Camp "Innovation and Archeology: the site and the finds of Monte Sannace" in Goia del Colle (BA), organized by E-RIHS.it (European Research Infrastructure for Heritage Science) with the collaboration of INFN and other local institutions and universities. She is currently enrolled in the PhD course in Metrology at the Politecnico of Torino, in collaboration with the Solid State Physics group of the University of Torino. Her research work is also part of the activities carried out by the INFN-CHNet (Cultural Heritage Network), the network for Cultural Heritage of the INFN. In particular, the activity is focused on the implementation and use of innovative x-ray imaging instruments and techniques (radiography and tomography) on different kind of objects and archaeological artefacts. She is member of the IEEE (Institute of Electrical and Electronics Engineers), GMEE (Gruppo Misure Elettriche ed Elettroniche) and AIAr (Associazione Italiana di Archeometria).

ABSTRACT

The study and development of different types of instruments based on X-ray emission gained increasing importance during the years. In particular, imaging techniques (digital radiography and computed tomography), born at first mainly for medical aims, are now widespread in many other field of application, including the Cultural Heritage one: thanks to the non-invasiveness and the strong penetrating power of X-rays, imaging analysis applied to objects of artistic and cultural interest are widely used. These techniques allow the visualization and the study of the internal structure in a non-invasive way (thanks to the different radiopacity of the materials), obtaining valuable information about the nature of constituent materials, constructive techniques and state of preservation. Due to the high heterogeneity of materials, shapes and sizes of the objects, different experimental set-ups have been developed over time, optimized for specific analytical needs, able to perform radiographs and tomographs of both large paintings, statues or furniture and smaller objects (installed at the Centro Conservazione e Restauro “La Venaria Reale” and at the Physics Department of the University of Torino). A recent upgrade of the set-ups consists in the possibility to realize higher resolution DR and CT measurements (micrometric level), thanks to a new flat panel X-ray detector, that allow to obtain good results on different kind of wooden and ceramic sherds and on natural materials. These analyses allowed to distinguish some features otherwise visible only with invasive techniques that require the cut of the samples. For example, in the case of wooden artefacts, valuable information about the techniques of assembly, execution and previous interventions were provided, whereas the so called “local tomography” on pottery sherds, allowed to obtain information on the internal structure and the distribution of inclusions. A recent project concerns the development of a new X-ray imaging apparatus, consisting of an innovative source, called Metal-jet, one of the latest innovations in the field of X-ray tubes. It employs a liquid-state metal anode technology for the production of radiation, able to reach higher fluxes than the other classic microfocus sources. The work concern, first of all, the characterization and evaluation of the performance of this source and, subsequently, of the

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entire instrumental set-up, aimed at carrying out high quality radiographic and tomographic measurements in the field of Cultural Heritage.

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CV – Amina VIETTI

Amina Vietti is currently PhD student at Politecnico di Torino (Department of Electronics and Telecommunications). She graduated in Technologies for Cultural Heritage (2013) and in Material Science for Cultural Heritage (2016) at University of Torino. Her research topics are mainly the study of corrosion products on archaeological iron by means of Raman spectroscopy and the development of conservation strategies to protect iron artefacts in museum contest.

ABSTRACT

When an archaeological metal object is buried in soil for long time, it will naturally corrode, modifying the structure and the stability of the artefact. Corrosion is a natural phenomenon whereby the original iron core is slowly transformed in a more stable form, as for example iron oxides and hydroxides, carbonates and sulfides. This process may occur both during burial time in soil and after the extraction from the archaeological site. The initial chemical composition of the artefact and the burial conditions plays an important role in the corrosion rate and in the typology of the degradation. The identification of the corrosion products allows the determination of the long-term degradation mechanisms during burial time, in order to plan consolidation treatments and protective strategies, also in preparation for musealization. And on the other hand, it allows the identification of the mineral species and provides information about the corrosion stratification at microscale and nanoscale. It will be presented a study where several iron nails from the archaeological site of Tharros (Sardinia, Italy) were analyzed by means of Raman spectroscopy.

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CV Emma ANGELINI

Emma ANGELINI, graduated in Chemistry at the University of Torino in 1975, she actually works in the Department of Materials Science and Chemical Engineering, as Full Professor of Applied Physical Chemistry. She has been member of the Academic Senate of Politechnic of Torino from november 2001 to november 2003. She teaches Chemistry in the courses of Electronic Engineering, and in the field of e-learning she recorded a course of Chemistry broadcasted by RAI NETTUNO SAT1 and RAI NETTUNO SAT2, by means of HotBird satellite of EUTELSAT.
She is responsible for national and international research projects in the following fields : i) protection of cultural heritage, ii) biomaterials to be employed in restorative dentistry, iii) innovative alloys for employments in electrocatalysis, iiii) surface modification of materials by low pressure plasmas.
She is responsible, among others, of European Project MATECO (New coatings deposited by PACVD for corrosion protection 2004-2007;(iii)European Project INCOMED EFESTUS (Tailored strategies for the conservation and restoration of archaeological value Cu-based artefacts from Mediterranean Countries 2003-2005), European INCO-MED Project PROMET (Innovative conservation approaches for monitoring and protecting ancient and historic metals collections from the Mediterranean basin 2004-2007, European Project MEDAL – INCOMED – SSA (Mediterranean Conservation Alliance 2007-2008).
She has been Member of Expert Evaluators Panel for the European Community.
She is President of the ICC-International Corrosion Council.
The scientific work carried out and the more than 250 papers published may be grouped according to the following themes:
1.Corrosion and protection of metallic materials - the research has been devoted to the study of the corrosion resistance of superficially treated steels, duplex stainless steels and sintered steels, amorphous and nanocrystalline alloys.
2. PECVD coatings for protection of metals, iron alloys, magnesium alloys, silver alloys
3.Analysis, corrosion processes and restoration problems on archaeological artifacts - studies of degradation processes on archaeological artifacts.
4.Studies on biomaterials - the research is carried out mainly on dental materials in environments simulating the oral cavity, in order to evaluate the corrosion resistance and release of ions.
She is member of AIM (Associazione Italiana di Metallurgia), SCI (Società Chimica Italiana), GMEE (Gruppo Misure Elettriche ed Elettroniche), EFC(European federation of Corrosion)

ABSTRACT
Conservation of ancient metallic artefact displayed inside museums is a complex problem due to the large number of constraints mainly related to the artefacts fruition by people. The development of a simple procedure for monitoring the artefact conservation state promptly highlighting risky conditions without impacting on the normal museum operations could be of interest in the cultural heritage world. This paper describes the interesting results obtained by using a highly sensitive and innovative methodology for evaluating the safety level of the museum indoor areas, and more specifically of the interior of the showcases, with respect to the metallic artefacts. The methodology is based on the use of an innovative smart sensors

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network and of copper reference samples. The smart sensors network was employed for the continuous monitoring of temperature and relative humidity close to the artefacts, i.e. inside the display showcases. The reference specimens were Cu coated with a 100 nm Cu nanostructured layer put for 1 year in the exhibition rooms inside and outside the showcases and characterised by means of normal imaging, colorimetric and FESEM techniques at regular intervals. The results of the monitoring evidenced the higher reactivity to the environmental aggressivity of the nanocoated copper specimen h respect to bulk artefacts and therefore the possibility to use them as alerts to possible corrosion phenomena that may occur to the real artefacts. A proper temperature and relative humidity monitoring inside the showcases and close to each group of artefacts is a powerful though economic and non-invasive way to highlight most of the possible critical display conditions.

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CV – Sabrina GRASSINI

Sabrina Grassini received the M.S. degree in Chemistry from the University of Turin and the PhD degree in Metallurgical Engineering from Polytechnic of Turin in 2004.
Currently she is assistant professor of Chemistry with the Department of Material Science and Chemical Engineering, Polytechnic of Turin.
Her research areas are:

- *Plasma Chemistry*: PECVD of organosilicon thin films, plasma sputtering; plasma etching; deposition of protective coatings on metals; innovative plasma processes for cleaning and protecting ancient metallic artefacts;
- *Corrosion and protection of metallic materials*: electrochemical characterization of innovative plasma protective coatings deposited on copper and silver alloys, steel and light alloys; corrosion inhibitors;
- *Cultural Heritage*: studies of chemical composition and degradation processes of metallic artefacts of archaeological and historic interest; study and development of innovative conservation strategies, in particular she works in the Villa della Regina in Turin for environmental monitoring.

She is member of AIM (Associazione Italiana di Metallurgia), SCI (Società Chimica Italiana), GMEE (Gruppo Misure Elettriche ed Elettroniche), SISM (società Italiana di Microscopia).

ABSTRACT
Surface engineering has been explored using plasma enhanced chemical vapur deposition (PECVD) of SiO2-like coatings on different metallic substrates in order to improve their resistance to corrosion. Specifically, the coatings have been deposited onto silver-based alloys which are prone to unaesthetic tarnishing, by means of PECVD in radio frequency (RF) plasma fed with tetraetoxysilane/oxygen/argon mixture.
Microchemical and microstructural characterization of the coatings has been carried out by means of X-ray photoelectron spectroscopy (XPS), Fourier transform infrared spectroscopy (FTIR), atomic force microscopy (AFM) and field emission scanning electron microscopy (FESEM). The protective effectiveness against tarnishing of SiO2-like layers has been evaluated by immersion tests in 0.1M Na2S aerated solution at room temperature.
It has been found that SiO2-like coatings deposited by increasing the oxygen-to-monomer ratio in the feeding-gas mixture and the input power density possess excellent barrier effects, and the coating adhesion increases if the deposition process is performed after a hydrogen plasma treatment. The protective effectiveness of PECVD coatings may be related to their barrier effect against the diffusion of water and other aggressive agents present in the environment and coming into contact with the metal surface.

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CV – Angela CALIA

Senior Scientist at CNR-ISPC (Italian National Research Council - Institute of Cultural Heritage Science) in Lecce (Italy).

Head of the Fixlab@ISPC-LECCE within the italian node of E-RIHS (European Research Infrastructure for Heritage Science)
Scientific coordinator of A.I.Te.C.H. (Applied Innovation Technologies for Diagnosis and Conservation of Built Heritage) - Public Research Network Plans, 2007-2013 FESR-FSE funds of Puglia region (Southern Italy).
Member of UNI (Italian Regulatory Body) - Normal Cultural Heritage Technical Commission.
She has been in charge for numerous competitive Research Projects in the field of Cultural Heritage study, dealing with:

- Mineralogical, petrographical and chemical study of quarry materials and artefacts, for the identification and determination of the provenance of stone materials used in the Cultural Heritage; archaeometric study of mortars, paintings and surface finishings for the identification of the constituent materials and knowledge of the execution techniques.
- Petrophysical and mechanical study of historical building materials; research on their durability and mechanisms of decay.
- Diagnosis of materials and artefacts and research of correlations between Destructive and Non-Destructive Tests.
- Study of products and methods for stone conservation.

Currently teacher in Mineralogy at ISCR (Istituto Superiore per la Conservazione ed il Restauro) – MIBACT, High Education School in Matera and in "Technologies and materials for restoration" Course - Interfaculty Degree Course "Technologies for Cultural Heritage", Salento University, from 2005 to 2011.
She has also held various teaching posts and given seminars in degree and post-graduate specialization courses, professional training courses for technicians and restoration workers.
She is the author of more than 140 publications on international and national journals, books and conference proceedings, and of about 60 technical reports concerning diagnostic activities for the Italian Ministry of Cultural Heritage, local bodies and restoration SMEs.

ABSTRACT

New coatings and nanomaterials for preserving Cultural Heritage stone surfaces: promising performances and basic approach to their evaluation.

Until recent years, the conservation practice of Cultural Heritage stone has been mainly based on the use of synthetic polymers or ethyl silicate based products. Compatibility and durability of the surface treatments with many of these products still are open issues and recent advances in material science are leading to the exploration of new materials for stone coating, which are promising to overcome the limits of the traditional products and, in addition, often introduce novel properties.
Starting from the main decay phenomena affecting the stones in outdoor conditions, some new coatings, which are receiving attention in the field of the stone conservation, will be pre-

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sented. The basic approach in evaluating their performance in terms of compatibility, effectiveness and durability through analyses and tests in laboratory conditions will be illustrated. Monitoring issues related to the assessment of long term stability and effectiveness of the stone treatments will be also presented, as key aspects for the evaluation of the performances in real conditions.

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CV - Piero BAGLIONI

Piero Baglioni is the chair of Physical Chemistry at the Department of Chemistry of the University of Florence since 1994. He was appointed as Visiting Scientist/Professor by the Department of Chemistry of the University of Houston, the Weizmann Institute, the Collège de France, and the M.I.T. He is the Director of the National Center for Colloid and Surface Science (CSGI) and he is in the Editorial/Advisory Board of several intentional Journals and member of several national and international Institutions and Societies.
Piero Baglioni is the author of more than 500 publications on books and largely diffused international journals. He is also the author of 27 patents. For his scientific activity he received several international recognitions, including the Rhodia Prize from the European Colloids and Interface Society (ECIS), 2002, the European Grand Prix for Innovation Awards; the 2011 Journal of Colloid and Interface Science award for Lifetime Achievement; “The Caballero Aguila” (from the INHA, Mexico), 2010; the "Catedra de Fisica, University of San Luis Potosi, Mexico, 2012; Chen Distinguished Lectureship on Neutron Science and Technology, Taiwan Ministry of Science and Technology and National Tsing Hua University, 2016, The Overbeek medal, 2016, The Japan Chemical Society Award, 2017, etc.
In the field of Conservation Science he pioneered methods and materials for the conservation of Cultural Heritage, as nanoparticles, in particular of calcium and magnesium hydroxide and carbonates, micellar systems and microemulsions, chemical hydrogels and organogels. These new systems are nowadays worldwide used.

ABSTRACT

New methods and materials for the conservation of Cultural Heritage: from renaissance frescoes to modern and contemporary art

P. Baglioni, Department of Chemistry and CSGI, University of Florence, Florence, Italy

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We pioneered one of the most exotic application of soft matter and materials science to conservation of cultural heritage. Art Conservation poses a formidable and exciting challenge to soft matter-colloid scientists in two respects. First, the majority of the most performing and environmentally safe cleaning and consolidation agents for artworks are soft matter systems. Second, the interaction of these agents with the artifact involves an exceptionally complicated range of interfacial interactions. Works of art surfaces interacting with the environment are the most prone to aging and decay; accordingly, soiling is a prime factor in the degradation of surfaces, chemical and mechanical degradation are often associated to soiling and lead to the disfigurement of a piece of art. The effects of these processes are usually strongly amplified in the presence of protective coatings (mainly acrylic and vinyl polymers), applied in previous restoration treatments. We pioneered the synthesis and the application of several advanced systems for the consolidation and the cleaning of works of art, as hydroxides nanoparticles, microemulsions and chemical gels (hydrogels and organogels). These

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systems mark a paradigm shift in modern conservation and have been used on classic, modern and contemporary artifacts as wall paintings of Beato Angelico, Piero della Francesca, or on modern and contemporary art paintings as paintings by Picasso, Lichtenstein, Pollock, de Chirico, etc.. I will give an overview of the progresses in the field from material and soft matter Sciences perspective, and I will summarize the main progresses and perspectives of the new gels recently developed, i.e. Twin-chain polymer hydrogels based on poly(vinyl alcohol) that constitute a new advanced tool for the cleaning of modern and contemporary art.

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