DAΦNE-Light Laboratory and Activity

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1 Summary

The scientific activity at the DAΦNE-Light laboratory, in 2019, was performed mainly using conventional sources and DAΦNE synchrotron radiation beam only for tests and some measurements. About 45 experimental teams got access to the DAΦNE-Light laboratory coming from Italian and European Universities and Research Institutions. As for the previous years two calls for proposals were opened in June and in October. In 2019 beamtime was given to experimental proposals submitted by European users within the EU CALIPSOplus Transnational Access program.
The facility was also involved in many different INFN-LNF educational activities (OPEN DAY, INSPYRE 2019 International School, Incontri di Fisica).
For the first time four mini workshops were organised in 2019. The first one was on the DAΦNE-Light facility describing the beamlines and the different scientific activities being performed (`https://agenda.infn.it/event/19025/`), the second one was on the projects involving Cultural Heritage studies (`https://agenda.infn.it/event/19026/`), the third one on the MICA CSN5 project and its implications in the studies of future colliders (`https://agenda.infn.it/event/19027/`) and the fourth one on THz sources and studies on graphene (`https://agenda.infn.it/event/19028/`).
Concerning the beamlines, a deflecting mirror was installed on the XUV High Energy Beamline (HEB) to go on with the realisation of the WINDY (White light liNe for Desorption Yields) branch line for the experiments related to a MoU between CERN and INFN-LNF. Other experimental activities, performed in 2019, included also some upgrades of the other beamlines, and the installation of new instrumentation.

2 Activity

2.1 SINBAD IR beamline - *Resp. Mariangela Cestelli Guidi*

The SINBAD IR beamline is dedicated to FTIR (Fourier Transform InfraRed) micro imaging and spectroscopy in different research fields, including material science, biology, radiobiology, live cell imaging, cultural heritage and geophysics. All these studies are possible owing to the imaging capabilities of the IR microscope coupled to the synchrotron source. The beamline is open to all users coming from Italian and International Institutions and also to EU and non EU experimental teams through the CALIPSOplus EU project, that will end in 2021.

The laboratory setup in 2019 was upgraded with the following instrumentation:

1. MicrostatN cryostat (Oxford Instrument) for Hyperion 300 microscope to perform reflection and transmission analyses at low temperature (77 K).

2. Laboratory for sample preparation (optical microscopes, cutting machine, preparation of

stratigraphic sections) dedicated to cultural heritage diagnostics and biological samples analysis.

3. NIR converted camera Nikon D750, 400-1000 nm for multispectral imaging
4. SWIR reflectography system: Hamamatsu InGaAs Camera C12741-03, 640x512 pixel, 900-1700 nm
5. UV lamp 365 nm filtered 3000mW for UV imaging

In 2019 the SINBAD-IR beamline has been involved in the following projects:

1. ***ADAMO-DTC, Lazio***

   As part of the District Technology of Culture supported by the Lazio region, the **ADAMO** project (**A**nalysis technologies, **D**iagnostics **A**nd **MO**nitoring for the Preservation and Restoration of Cultural Property) is aimed at transferring technologies from the DTC partners (ENEA, Roma Sapienza, Roma Tor Vergata, Roma Tre, Tuscia University, CNR and INFN) to industries operating in the area (Fig. 1). A detailed description of the ADAMO project can be found at this link: `http://progettoadamo.enea.it/`.

Figure 1: DAΦNE-Light Laboratory in the field of ADAMO project and DTC Lazio.

The DAΦNE-Light laboratory was involved in several measurements campaigns both in-situ and in laboratory:

(a) *Laboratory analysis:*

In the area of the former Centocelle airport, the Capitoline Superintendency of Cultural Heritage has coordinated the excavation of a large suburban Roman villa called "Villa della Piscina", where numerous fragments of frescoes realised in different phases were found. The aim of the IR spectroscopic analyses carried out at DAΦNE-Light was to support both the reconstruction of the frescoes and their dating with experimental data related to the composition of the materials, constituting both the painted surface and the substrate, and the realisation technologies (WP3).

(b) *In-situ measurements:*

i. Palazzo Chigi of Ariccia (Rome): characterisation of the mural paintings St. Joseph with the Child by Gian Lorenzo Bernini, a detailed analysis of the unique artworks signed by Bernini itself (WP4).

ii. Villa della Piscina Centocelle (Rome): characterisations of Roman fresco fragments (WP4).

iii. Basilica of S. Nicola in Carcere (Rome): characterisation of the fresco realised by Vincenzo Pasqualoni in 1850 (WP4).

Concerning the ADAMO project the laboratory was involved in the organisation of the two following events:

(a) Workshop for the discussion of the results obtained in the ADAMO site of S. Nicola in Carcere, organised by M. Cestelli Guidi, M. Romani, L. Pronti; 09/07/2019 Laboratori Nazionali di Frascati (`https://agenda.infn.it/event/19516/`)

(b) International School of Cultural Heritage organised by M. Cestelli Guidi, M. Romani, L. Pronti, V. Virgili, D. Ferrucci, R. Fantoni, F. Colao, 12/12/2019 Laboratori Nazionali di Frascati (`https://agenda.infn.it/event/21078/`)

2. ***Graphene 3D- Italian-Chinese Collaborative Research Projects between the Ministry of Foreign Affairs and International Cooperation (MAECI) and the National Natural Science Foundation of China (NSFC)***

   Graphene is the first thermodynamically stable two-dimensional material discovered in nature. Its properties are extraordinary: from the very high electric mobility based on linear dispersion electrons (Dirac electrons), to the strong interaction with the electromagnetic field, to the high thermal conductivity, to the remarkable mechanical hardness. In recent years research has focused on providing a third dimension to graphene. Recently three-dimensional (3D) graphene-like materials have been discovered with micro and nano-porous structures, or made by mesoscopic filaments that are distributed on macroscopic spatial scales. These topological structures allow preserving the extraordinary electrical and thermodynamic properties of 2D graphene extending them in 3D. The porous or filamentous nature, and the high surface/volume ratio of these 3D architectures open interesting application scenarios and opportunities for fundamental physics researches: batteries and super-capacitors, flexible electronics, IR and THz photonics, plasmonics and finally, the manufacture of novel highly-efficient devices capable of transduce light into sound.

3. ***TERA - INFN CSN5***

   The aim of the TERA project is to build a synergic interdisciplinary collaboration among different INFN sections with the final goal to push forward a strong R&D activity on THz technology with particular regard to THz acceleration. LNF is contributing to WP2 (Acceleration Beam Dynamics and Cavities) and WP3 (Detectors).

More than 23 experimental teams submitted proposals for beam time at the SINBAD-IR beamline. A selection of some scientific studies performed in 2019 is here summarized:

1. *High and Low temperature behaviour of confined H_2O and CO_2 in natural opaline silica.*

   B. Rondeau, Laboratoire de Planetologie et Geodynamique, University of Nantes, France

2. *FTIR imaging of cancerous neck tissues.*

   C. Paluszkiewicz, Istitute of Nuclear Physics PAN, Krakow, Poland

3. *Infrared spectroscopy of biomolecules: fibril assembly and protein-membrane interaction. Study on Cytochrome C fibril assembly.*

   A. Nucara, University La Sapienza (Rome), Dep. of Physics.

4. *Magnesiowüstite/hematite inclusions associated with residual carbonate reveal the origin of super-deep diamonds.*

   G. Della Ventura, Dep. of Science, University Roma Tre (Rome)

5. *Garnets, archetypal cubic minerals, do not grow cubic.*

   G. Della Ventura, Dep. of Science, University Roma Tre (Rome)

6. *Raman and ATR FT-IR investigations of innovative silica nanocontaniers loaded with a biocide for stone conservation treatments.*

   L. Ruggero and A. Sodo , Dep. of Science, University Roma Tre (Rome)

The SINBAD-IR beamline in 2019 was also involved in activities on behalf of third parties like:

1. Davide Rigaglia, Alpha Restauri, Chiesa di Santa Lucia alle Malve (Matera), Characterization of stratigraphic sections of mural paintings and Raman characterization of mural paintings.

2. (Collaboration) Biblioteca Marucelliana characterization of Ottavio Leoni drawings by Raman spectroscopy

3. (Collaboration) Biblioteca Marucelliana characterization of Raffaello drawing by Raman spectroscopy

4. Artelab s.r.l. Company: Characterization of stratigraphic sections of oil paintings of the '600.

Between the different activities, the SINBAD beamline is also routinely hosting different students performing their thesis or PhDs:

1. Alessia Damiani, *Spectroscopic analysis on photographic material: Characterisation of photographic material dating back to the last century and development of suitable cleaning methods.* Bachelor Degree (Chemistry), University of Tor Vergata (Rome)

2. S. Macis, *Deposition and characterisation of thin MoO_3 films on Cu for technological applications.*, PhD Thesis, University of Tor Vergata (Rome)

3. F. Coletti, *I tessuti di Pompei: materiali, tecniche e lavorazione e contesti*, PhD Thesis (Archeology), University La Sapienza (Rome).

4. C. Cicero, *Hydrothermal stability evaluation for parchment deterioration assessment: a novel opto-thermal method by Light Transmission Analysis (LTA)*, PhD Thesis, Industrial Engineering, University of Tor Vergata (Rome)

5. E. Bonaventura, *Optical properties of "stanene-like" thin films on Sapphire*, Master Thesis (Physics)

6. E. Fardelli, *Characterization of Chroococcidiopsis, irradiated with Mars-like conditions, using different spectroscopic techniques: Raman, FTIR and THz-TDs*, Master Thesis (Physics)

7. F. Galdenzi, *Dynamics of dehydrogenation processes in amphiboles.* PhD Thesis, University of Roma Tre (Rome)

2.2 DXR1 Soft X-ray Beamline - *Resp. Antonella Balerna*

The DAΦNE soft X-ray beamline, DXR-1, is mainly dedicated to soft X-ray absorption spectroscopy. The X-ray source of this beamline is one of the 6-poles equivalent planar wiggler devices installed on the DAΦNE electron ring (0.51 GeV) for the vertical beam compaction. The 6 wiggler poles and the high storage ring current (higher then 1 Ampere) give a useful X-ray flux for measurements well beyond ten times the critical energy. The useful soft X-ray energy range is 900 eV - 3000eV where the lower limit is given by the Beryl crystals used in the double-crystal monochromator and the higher limit is given by the wiggler working conditions.
In 2019, one of the two SDD ARDESIA detectors was installed in the experimental chamber that can be used with the X-ray conventional source. Some test and measurements were performed to check its performance. As soon as possible it will be installed on the XAFS experimental chamber to be used for measurements in fluorescence mode.
An upgrade of the second detector was performed by the group of the Politecnico of Milan, substituting the 0.45 mm SDD 4 channel detector with a 0.8 mm one (see Fig.2) with a great increase of the efficiency at higher energies. A new multichannel SDD detector was also developed redefining the cooling system and moving from 4 to 16 SDDs.

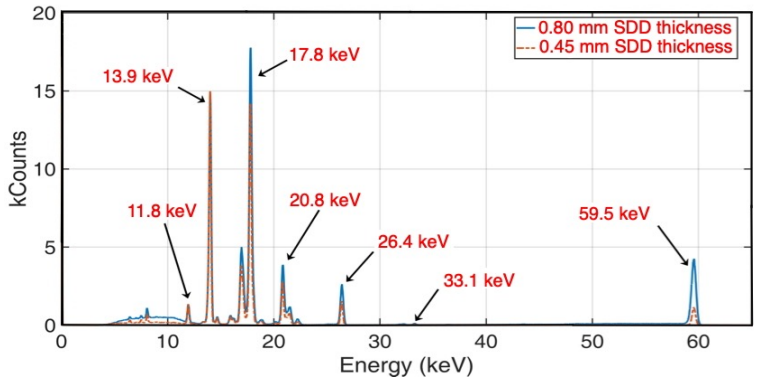

Figure 2: Comparison of two different SDDs: one with 800 μm thickness and one 450 μm thickness. A source of ^{241}Am was used for the measurements and the peaking time was of 2 μs.

Using the conventional x-ray source and the ARDESIA detector, XRF measurements and tests were performed on different samples also including fragments of frescoes related to cultural heritage studies.
The realisation of the software to connect the monochromator of the DXR1 XAFS beamline to ARDESIA started and will be tested in the near future. Also the program to measure XAFS spectra in fluorescence mode is under development.

2.3 DXR2 UV branch Line - *Resp. Marco Angelucci*

The DXR2 beamline at DAΦNE- Light operates with UV radiation on an extended spectral range from 120 nm to 650 nm. The UV radiation can be used in a wide range of experiments such as reflectance/transmittance, ageing and response of optical systems and detectors. The UV light has been used at the DXR2 branch-line in many and different research fields from biological to high energy physics experiments, to study solar-blind UV diamond-based detectors or FOAM for space missions. Furthermore, coupling the UV radiation and IR spectroscopy it is possible to study in real time the evolution of analysed samples, measuring the variation of IR spectra during UV exposure. The facility operates with UV radiation obtained as synchrotron radiation (SR) or standard sources (HgXe lamp in the 200-650 nm range and Deuterium lamp for the Deep UV 120-250 nm).
In 2019 a biggest part of the activity, more than twelve users, was related to the use of the Scanning Electron Microscope (SEM) and of the Energy Dispersive X-ray spectroscopy (EDX) analysis. The SEM and EDX measurements were preformed on different kind of samples like graphene with nano-porous structure, lignin and barks of trees, ancient photographic materials, polymers with impurities and many samples related to cultural heritage studies. In the second part of the year beamtime was given to an experimental proposal submitted in the first call for proposals 2019 and accepted after some preliminary tests:

1. *VUV reflectivity measurements of detector components of the LEGEND-200 experiment (LNGS)*
   G. Salamanna, University Roma Tre (Rome), Dep. of Mathematics and Physics.

   The aim of proposed measurements was the determination of the reflectivity (at various incidence angle) of samples of Ge, Si and Cu in the vacuum ultraviolet (VUV) range, around 128 nm. These data are essential in the project of a shield for liquid Argon, whose scintillation peak is centred at 128 nm, that will be utilised as background veto in an experiment (LEGEND), planned at LNGS, devoted to the measurement of the hypothesised neutrino-less double beta decay.

Since the initial results achieved with the deuterium lamp were very encouraging a new proposal was submitted in the second call for proposals 2019 asking to explore other energy ranges using the synchrotron radiation beam.

2.4 XUV beamlines and laboratory - *Resp. Roberto Cimino*

Aim of this laboratory is to host three bending magnet beamlines. Two will offer monochromatic light with a photon energy range from 30 eV to 1000 eV while the third one will provide non-monochromatized SR light. The Low Energy Beamline, (LEB) will cover the energy range from 30 eV to 200 eV and the High Energy Beamline (HEB) will offer monochromatic photons from 60 eV to 1000 eV. The third beamline, *WINDY* (White lIght liNe for Desorption Yields) offers collimated SR for photo-desorption studies. The three beamlines need some extensive use of SR delivered by DAΦNE to be finally commissioned. This will start in 2020 along with the restart of DAΦNE. In 2019, even if no SR was available, all the three beamlines and their experimental stations were consolidated in order to host and promote some mainstream projects and also some other smaller activities, in the spirit of opening the resources also to external users. Some issues are here listed:

1. ***EuroCirCol***

   In 2019, the XUV laboratory has hosted the last year of experimental activities of the Work Package 4.4 of the European Project EuroCirCol, focused on issues related to cryogenic

vacuum and its stability upon photon, electron irradiation and thermal variation. In this framework, one of the most relevant result regards a detailed study on the compatibility of porous surfaces with cryogenic vacuum in future high-energy particle accelerators. Recently, pulsed laser processing of Cu samples has been demonstrated to produce rough surfaces whose structuring at the nanoscale ensures an impressive reduction of the secondary electron yield, which has an undoubted appealing for applications in future high energy particle accelerators. However, in 2018 [L. Spallino et al.] we experimentally demonstrated, by Ar adsorption/desorption studies, that the effective use of such laser treated surfaces in this context requires a rigorous evaluation of the consequences on vacuum stability, that may arise when exploiting porous surfaces as cryogenic components. Our results, put into evidence that the sponge-like structural features confer to the laser treated sample non-negligible effects on the gas-substrate interaction, resulting in a vaster and higher desorption temperature with respect to what observed from a flat substrate. The Ar data call for a vaster analysis of the process specially studying gasses that can indeed be part of the accelerator residual composition. The TPD measurements shown in Fig.3, carried out dosing on flat and LASE-Cu typical gas species composing the residual vacuum in accelerators (CH_4 and CO), have confirmed the Ar data. Gas desorption occurs at a temperature higher than expected and spreads over a broad range in all cases. This means that, while the use and optimisation of LASE surfaces to mitigate SEY is quite advanced, a significant additional experimental campaign is necessary to validate their use in future accelerators. This additional work has been presented in various conferences and will be argument of a forthcoming publication.

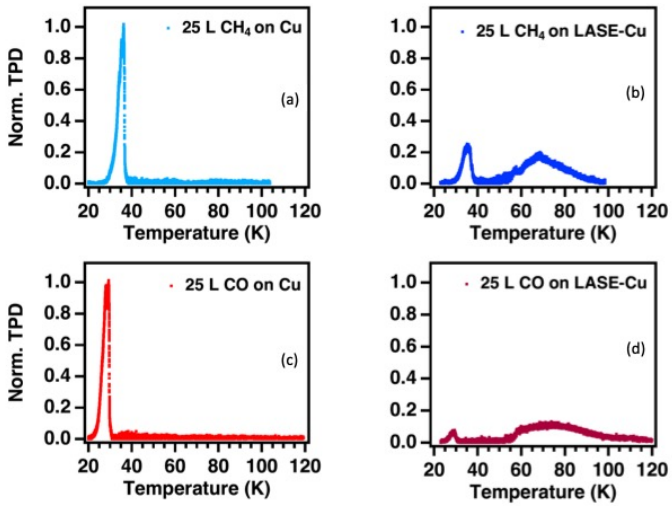

Figure 3: Normalized TPD measurements obtained from 25 L of CH_4 and CO dosed on clean poly-Cu (a,c) and on LASE-Cu sample (b, d).

2. ***MICA***

The laboratory hosted the INFN CSN5 funded activity MICA, at its last year. MICA has an affinity with EuroCirCol and these projects are complementary for many different aspects. Various research activities went on within this project, spanning from desorption studies, secondary electron yield (SEY) characterisations, photo yield and reflectivity studies etc. In this framework, for instance, one of the important questions successfully addressed in 2019 was to establish the minimum thickness of an amorphous carbon (a-C) coating on copper

to obtain the full reduction of the Secondary Electron Yield. a-C is a well-known coating apt to reduce SEY to values as low as below 1.1. Such low SEY is compliant to most of the demanding requirements for e-cloud mitigation. Unfortunately, a-C is known to have a quite high resistivity and a thick coating is known to affect machine impedance to unacceptable levels. The aim of a work package of the MICA project was to provide a reasonable estimate of the minimum amount of amorphous carbon that should be deposited on a polycrystalline copper sample to reduce the secondary electron yield (SEY, δ) to avoid any electron cloud phenomena in accelerators. The carbon has been deposited via electron bombardment. Its thickness has been derived by an X-Ray Photoelectron Spectroscopy investigation. Secondary Electron Yield analysis has been performed as a function of a-C thickness. The data reported in Fig.4, shows that the coating dominance on substrate is already reachable after 15-20 ML (i.e. $\sim$ 5 -7 nm) and it shows a maximum SEY of a-C deposited comparable with a thick a-C sample ($\delta < 1$). This result, implies that a surprisingly thin a-C coating is required to obtain minimum surface SEY. Provided that one can use a coating technique which allows to control and to produce clean and good quality a-C coatings, a quite thin layer will be enough to reduce SEY without causing any impedance issue.

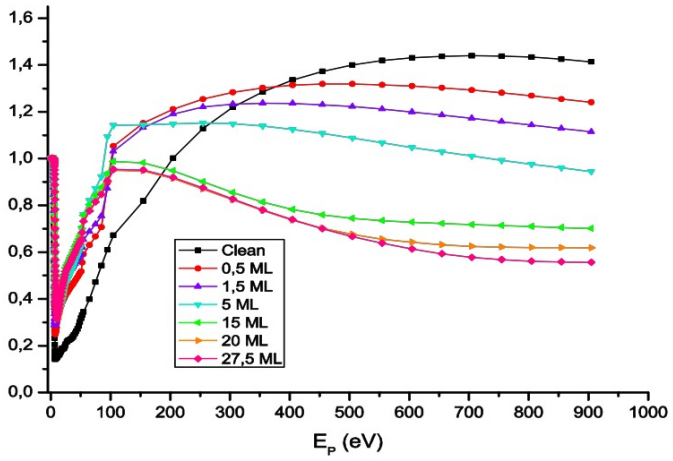

Figure 4: SEY evolution of a clean Cu surface after various thicknesses of an a-C coatings.

Within MICA, an intense experimental campaign has been continued to study as a function of wavelength the synchrotron radiation reflectivity and photo yield of interest as input parameters to simulations validating instabilities issues in highest performance accelerators. This work has been used by E. La Francesca for her PhD thesis work presented and approved in Roma "la Sapienza" in 2019.

3. ***CERN-LNF MoU: WINDY***

In 2017 a Memorandum of Understanding (MoU) between CERN and INFN-LNF has been signed. The general purpose of the MoU is the achievement of quantitative information on the reflectivity, photo-yield and photo induced desorption of small samples and of real 2-3 meters beam-pipes, using the Synchrotron Radiation White Light (WL) of DAΦNE. These parameters have a fundamental role in the optimisation of existing particle accelerators, like LHC and its upgrade (HL-LHC and HE-LHC), and in the realisation of the Future Circular Collider (FCC). A new beamline WINDY (White lIght liNe for Desorption Yields) is ready to take data once SR will become available.

4. ***Collaboration with BNL***

   Later during the year a collaborative effort started, based on a service contract, with the Brookhaven National Laboratory (BNL) to address material properties of interest for the construction of the newly approved Electron Ion Collider (EIC). This project will last 2 years and could represent an interesting initial step towards a closer collaboration in view of the design and construction of the vacuum chambers for EIC.

5. ***Characterization of MXenes doped perovskite for application in solar cell devices***

   The recent development of metal halide perovskite (PV) solar cells (PSCs) offers glimpses of a competition with traditional inorganic devices and/or of a synergy with established silicon technology. Perovskites (PV) are ABX_3 crystals, where A is an organic or inorganic cation (e.g. CH_3NH_3), B a metal cation (e.g. Pb) and X a halide anion (e.g: I, Br). Usually, a typical PSC is composed by a PV active layer, sandwiched between two selective contacts for negative and positive charge extraction. The need to improve the charge injectioncollection at the interface PVcharge transporting layer asks for improved chemicalphysical properties which can be obtained also by changing composition andor morphology of the involved materials. In this context, the exploration of a possible synergy between of metal halide PVs and transition metal carbides, nitrides and carbonitrides (MXenes) is a challenge to face. MXenes have a general formula $M_{n+1}X_nT_x$ (n = 1, 2, 3), where M represents an early transition metal, X is carbon and/or nitrogen, and T_x stands for surface terminations (such as –OH, =O, and –F). Their peculiarity resides in the possibility to tune work function as well thermal, mechanical, and chemical stabilities by choosing the proper transition metal.
   PCSs are currently successfully developed at the *CHOSE* (Center for Hybrid and Organic Solar Energy, Department of Electronics Engineering, University Tor Vergata of Rome) laboratory. In collaboration with this research group we have investigated by conventional X-ray (XPS) and ultraviolet (UPS) photoemission spectroscopy undoped and $Ti_3C_2T_x$-doped multi cation perovskite $CsFAMAPb(Br_xI_{1-x})_3$ (MA=CH_3NH_3, FA=CH_5N_1) thin films spin coated on TiO_2 substrates. In particular we focused on work function (WF) measurements, in order to establish if the MXene flakes could be exploited to finely control the energy level alignment between the PV absorber layer and the charge transport layer in PSC devices [Agresti et al.]. We found that the WF of pristine PV of 4.72 eV, as determined from the secondary electron onset, was shifted to 4.37 eV after the addition of MXene (see Fig. 5a), whereas the valence band spectrum and the energy gap measured remained nearly identical in the two samples (see Fig. 5b). The diagram in Fig. 5c schematises the WF and ionisation energy reduction in the MXene-doped PV sample.

   DFT calculations [L. Spallino et al.] related the observed behaviour to the OH and O terminations of the MXene flakes and demonstrated that the charge transfer at the PV/$Ti_3C_2(OH)_2$ interface induces the formation of an interface dipole, which reduces the WF and modifies the band alignment of the system, without affecting other electronic properties of the materials. This possibility is of fundamental importance to envisage new interface architectures. Therefore the results of this study can inspire innovative interface designs for PSCs and other PV-based devices such as LEDs and detectors also of interest of INFN.

6. ***Nanostructured catalysts based oh graphene/Ni interfaces for hydrogen production and storage.***

   The most diffused methods for hydrogen storage are based on the use of transition metal alloys capable to absorb the gas as solid sponges and to release it in controlled and reversible ways. But, due to the high metal density, such approach results extremely inconvenient in terms of stored energy per weight unit. A strategy to advance both hydrogen production and

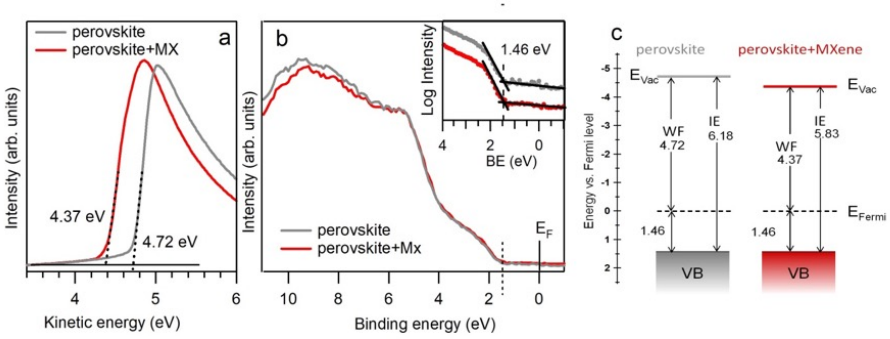

Figure 5: UPS curves measured on pristine and MXene-doped perovskite films a) around the secondary electron cut-off and b) in the valence band region . c) Energy scheme for undoped and MXene-doped perovskite with respect to E_{Fermi}.

storage is to design suitable nano-materials in which the peculiar morphology and the large specific surface provide innovative potentialities with respect to their massive counterpart. Promising candidates are hybrid catalysts based on graphene coupled with nano-structured transition metals, to obtain highly reactive interfaces, able to rise the efficiency of reactions functional for hydrogen production and/or storage. In this scenario graphene covered Ni polycrystalline substrates and even more Ni foams are becoming attracting since they combine the a inhomogeneous surface with a large defect density, or even a porous morphology of the metal scaffold in the case of the foams, with the catalytic activity of the graphene/Ni interface, which has been shown to be effective for water splitting. In order to produce nano-structured Gr/Ni catalysts we have investigated the chemical vapour deposition (CVD) growth of graphene on Ni polycrystalline substrates in ultra-high vacuum and in high pressure regimes. In the first case ethylene is used as gas precursor at a pressure in the 10^{-8}-10^{-7} mbar range, whereas the sample is held at about 600 °C. In the second case methane, mixed with Ar and H2 is fluxed in a furnace where the sample is heated at 900 °C. In both case we obtained monolayers and multilayers graphene by varying the growth conditions. The samples grown in UHV were characterised in situ by XPS and UPS spectroscopy. We could detect the graphene formation by revealing the C1s peak in the XPS spectrum and observe the characteristic features of the graphitic lattice in the valence band. Raman spectroscopy was used to evaluate the thickness of both classes of samples. Typical spectra exhibit a different ratio between the characteristics G and 2D band, indispensable to distinguish the monolayer (2D/G>1) from the multilayer (2D/G < 1) graphene. In both cases the complete absence of the D band around 1350 cm^{-1} indicates the high crystalline quality of the graphene layers.

The Laboratory is also routinely hosting students to perform their thesis or PhDs getting a direct experience with some *state of the art* experimental activity:

1. Armando Novelli - *Coverage Dependence of Secondary Electron Yield for Amorphous and Graphitised Carbon on Cu Samples for Multipactor Effect Mitigation inside Traveling Wave Tubes Amplifier* - University La Sapienza, Rome, Master Thesis in Aerospace Engineering (July 2019).

2. Eliana La Francesca - *Material science and accelerator R&D: Reflectivity and Photo Yield*

measurements of vacuum chamber technical Surfaces - PhD School of Accelerator Physics, XXXI edition - University La Sapienza, Rome (September 2019).

3 List of Talks and Posters

1. M. Cestelli Guidi, *SINBAD-IR Beamline*, First DAΦNE-Light mini-workshop, LNF (Frascati (RM)), 14th March 2019

2. L. Pronti, M. Romani, G. Verona-Rinati, M. Cestelli-Guidi, M. Marinelli, F. Colao, *In situ investigation and non-invasive diagnostics to support material analyses and restoration activities within the ADAMO project of the Technological District of Cultural Heritage-DTC Lazio*, Convegno Tematico AIAR 2019,Reggio Calabria, 27-29 March 2019

3. M. Romani, *INFN Beni culturali e CHNET*, Second DAΦNE-Light mini-workshop, LNF (Frascati (RM)), 11th April 2019

4. L. Pronti, *INFN Beni culturali e Progetto ADAMO*, Second DAΦNE-Light mini-workshop, LNF (Frascati (RM)), 11th April 2019

5. F. Benetti, *INFN Beni culturali e Progetto MACHINA*, Second DAΦNE-Light mini-workshop, LNF (Frascati (RM)), 11th April 2019

6. M.Sbroscia, M. Cestelli-Guidi, S. Falzone, C. Gioia, D. Mirabile-Gattia, M. Missori, L. Pronti, M. Romani, A. Sodo, M.A. Ricci, R. Fantoni, *Raman and FT-IR spectroscopy for the reconstruction of the decorative motives of Villa della Piscina, Rome*, TECHNART 2019, Bruges (Belgium), 7-10 May 2019

7. M. Romani, M. Marinelli, G. Verona-Rinati, A. Ciccola, M. Cestelli-Guidi, *FT-IR microspectroscopy for in-situ monitoring the laser induced degradation of organic binders in artworks*, TECHNART 2019, Bruges (Belgium), 7-10 May 2019

8. L. Ruggiero, A. Sodo, M. Cestelli Guidi, M. Romani, A. Sarra, P. Postorino, M. A. Ricci, *Raman and ATR FT-IR Investigations of innovative silica nano-containers loaded with a biocide for stone conservation treatements*, TECHNART 2019, Bruges (Belgium), 7-10 May 2019

9. J. Rezvani, D. Di Gioacchino , N. Poccia, C. Ligi, S.Tocci, M. Cestelli Guidi, S. Lupi, C. Gatti, A. Marcelli. *A novel detector based on the vortex Mott insulator-to-metal transition*, LIV Zakopane School of Physics, Breaking frontiers; submicron structures in physics and biology. Institute of Nuclear Physics PAN, Zakopane (Poland), 21-25 May 2019.

10. J. Rezvani, *The TERA experiment*, Fourth DAΦNE-Light mini-workshop, LNF (Frascati (RM)), 13th June 2019

11. S. Lupi, *Low-energy electrodynamics of Dirac particles in graphene and topological matter*, Fourth DAΦNE-Light mini-workshop, LNF (Frascati (RM)), 13th June 2019

12. M. Romani, A. Grottoli, *Il Cantiere di Restauro della Basilica di S. Nicola in Carcere*, Un anno di DTC Lazio. 1° Convegno annuale del distretto tecnologico beni e attività culturali della Regione Lazio, Aula Magna Sapienza, Roma, 30 September 2019

13. M. F. Caso, L. Pronti, L. Caneve, S. Ceccarelli, M. Cestelli Guidi, M. Colapietro, M. Marinelli, F. Mercuri, N. Orazi, S. Paoloni, A. Pifferi, A. Puiu, G. Verona Rinati, M. Romani, V. Spizzichino, O. Tarquini, U. Zammit, *Indagini diagnostiche sui dipinti e sui busti*

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15. S. Macis, *THz to UV transmission of 3D Graphene micro structures.* 2nd Bilateral Workshop 3D Graphene, Hefei (China), 12-13 October 2019

16. M. Cestelli Guidi, M. Romani, L. Pronti, *FTIR Synchrotron Radiation analyses on cultural heritage*, Forum Italia-Argentina 2019: ″Tecnologie nucleari e digitali per i beni culturali e la fisica applicata″ Buenos Aires, 20-21 November 2019,

17. S.J. Rezvani, *THz detectors based on tunable vortex dynamics in proximity junction arrays: Spectroscopy and Imaging with THz Radiation using Ultimate Radiation Sources*, Sapienza University of Rome (Italy), 10-12 December 2019

18. A. Balerna, *DAΦNE-Light and the DXR1 Soft X-ray beamline*, First DAΦNE-Light mini-workshop, LNF (Frascati (RM)), 14th March 2019

19. A. Balerna, *The DAFNE-Light Synchrotron Radiation Facility: main features and some applications*, 10th Young Researcher Meeting in Rome- LNF, 20th June 2019.

20. C. Fiorini, G. Utica, M. Gugiatti, I. Hafizh, M. Carminati, A. Capsoni, S. Coelli, A. Balerna, V. Tullio, G. Borghi, F. Ficorella, N. Zorzi, L. Bombelli, G.O. Lepore, *ARDESIA: A Fast SDD X-ray Spectrometer for Synchrotron Applications*, ICXOM-25, USA August 5-9, 2019

21. G. Utica, E. Fabbrica, M. Gugiatti, I. Hafizh, M. Carminati, A. Balerna, G. Borghi, F. Ficorella, N Zorzi, A. Capsoni, S. Coelli and C. Fiorini, *Towards Efficiency and Count-Rate Enhancement of X-ray ARDESIA Spectrometer*, IIEEE NSS-MIC 2019, Manchester (UK) October 26th - November 2nd, 2019

22. A. Balerna *The DAFNE-Light Synchrotron Radiation Facility Soft-X ray Beamline for Applications in Many Different Fields from Material to Life Science*, Extreme Rays, Istituto Svizzero Roma, 6 - 7 November 2019

23. A. Balerna, *1983 XAFS and nanomaterials: early beginning*, X-ray Spectroscopy and Synchrotron Radiation in materials physics: past, present and future. University Roma Tre, 29th November 2019.

24. R. Cimino, *XUV Laboratory*, First DAΦNE-Light mini-workshop, LNF (Frascati (RM)), 14th March 2019

25. L. Spallino, *Vacuum stability at cryogenic temperature - WP4 - Activity at LNF*, EuroCirCol Meeting, Barcellona (Spain), 18th March 2019.

26. R. Dupuy, M. Bertin, G. Féraud, X. Michaut, T. Putaud, L. Philippe, P. Jeseck, R. Cimino, V. Baglin, C. Romanzin and J.-H. Fillion, *Water ice photodesorption by VUV photons and X-rays investigated with synchrotron radiation*, The First International Astronomical Union Symposium on Laboratory Astrophysics, IAUS 350: ″Laboratory Astrophysics: from Observations to Interpretation″, Cambridge, UK, 14 -19 April 2019.

27. D. Alesini, M. Angelucci, S. Bini, R. Cimino, A. Liedl, V. Lollo, L. Sabbatini, L. Spallino, *Opportunities of tests, thermal treatments and brazing of vacuum material at the open Research Infrastructure LATINO*, Giardini Naxos, 24° Congress of the Italian Vacuum Society (AIV), 7 - 10 May 2019

28. L. Spallino, M. Angelucci ,R. Larciprete, and R. Cimino, *Material properties of impact to accelerator's performances in cryogenic vacuum*, Giardini Naxos, 24° Congress of the Italian Vacuum Society (AIV), 7 - 10 May 2019

29. A. Liedl, M. Angelucci, E. La Francesca, F. Siewert, M.G. Sertsu, A. Sokolov, F. Schäfers and R. Cimino, *Photo Reflectivity and Photo Electron Yield of Technical Materials for High Energy Accelerators*, Giardini Naxos, 24° Congress of the Italian Vacuum Society (AIV), 7 - 10 May 2019

30. M. Angelucci, M. Pietropaoli , G. Viviani, A. Grilli, A Raco, V. Sciarra, V. Tullio, L. Spallino, and R. Cimino, *New WINDY beamline for photon induced desorption with DAΦNE synchrotron radiation at LNF*, Giardini Naxos, 24° Congress of the Italian Vacuum Society (AIV), 7 - 10 May 2019

31. R. Cimino, *MICA: un progetto di Gr V per la scienza dei materiali applicata agli acceleratori*, Third DAΦNE-Light mini-workshop, LNF (Frascati (RM)), 16th May 2019

32. L. Spallino, *Proprietà dei materiali e loro potenziale impatto sulle prestazioni degli acceleratori in vuoto criogenico*, Third DAΦNE-Light mini-workshop, LNF (Frascati (RM)), 16th May 2019

33. A. Liedl, *Importanza della Luce di Sincrotrone sulle prestazioni degli acceleratori: riflettività e Photo-Yield*, Third DAΦNE-Light mini-workshop, LNF (Frascati (RM)), 16th May 2019

34. M. Angelucci, *Desorbimento indotto da Luce di Sincrotrone: impatto sulle prestazioni degli acceleratori e sua importanza nello studio dello spazio interstellare*, Third DAΦNE-Light mini-workshop, LNF (Frascati (RM)), 16th May 2019

35. R. Cimino, E. La Francesca, M. Angelucci, A. Liedl, L. Spallino, L. A. Gonzalez, I. Bellafont, F. Siewert, M.G. Sertsu, A. Sokolov, and F. Schäfers, *R and PY from candidate materials for the FCC-hh Vacuum system*, The fifth International Future Circular Collider (FCC) Conference, Brussels, Belgium, 24 - 28 June 2019

36. L. Spallino, M. Angelucci, R. Larciprete and R. Cimino, *Material properties of relevance to cryogenic vacuum systems*, The fifth International Future Circular Collider (FCC) Conference, Brussels, Belgium, 24 - 28 June 2019

37. M. Angelucci, R. Kersevan, P. Chiggiato, V. Baglin and R. Cimino, *Photo desorption studies at the WINDY set-up at LNF*, The fifth International Future Circular Collider (FCC) Conference, Brussels, Belgium, 24 - 28 June 2019

38. R. Cimino, *R&D for surface properties validation*, LHC-spin kick-off meeting, 15th July 2019

39. R. Cimino, *Surface effects for electron cloud*, ICFA mini-workshop on Mitigation of Coherent Beam Instabilities in Particle Accelerators, Zermatt (Switzerland), 23 - 27 September 2019

40. L. Spallino, M. Angelucci , and R. Cimino, *A new experimental method to study electron stimulated desorption yield of gas layers cryosorbed on a cold surface*, 105° Congresso Nazionale della Società Italiana di Fisica (SIF) L'Aquila, 23 - 27 September 2019.

41. L. Spallino, M. Angelucci, R. Larciprete, R. Cimino, *A cryogenic vacuum: new challenges for material science*, 105° Congresso Nazionale della Società Italiana di Fisica (SIF) L'Aquila, 23 - 27 September 2019.

42. R. Cimino, *ARYA: A Group V project for material science applied to accelerators*, ARYA kick-off Meeting, Napoli, 17th December 2019.

43. L. Spallino, *Material properties and their potential impact on cryogenic vacuum in accelerators*, ARYA kick-off Meeting, Napoli, 17th December 2019.

44. M. Angelucci, *SR induced desorption and its impact to accelerator's performances*, ARYA kick-off Meeting, Napoli, 17th December 2019.

4 Lectures and outreach

1. A. Balerna, *Acceleratori come sorgenti di luce.* Dip. Scienze Fisiche e Chimiche, Univ. degli Studi Dell'Aquila, March 6th, 2019

2. M. Romani, *Acceleratori e Beni Culturali*, Liceo Scientifico Tullio Levi Civita, 6th February 2019

3. M. Romani e L. Pronti, *"Luce di Sincrotrone e beni culturali*, Conferenza presso la Scuola di Alta Formazione e studio, Notte Europea della Ricerca, Matera (Italy), 26th September 2019

4. M. Cestelli Guidi, M. Romani, L. Pronti, *"Affreschi all'Infrarosso*, Laboratorio presso Chiesa Rupestre di S. Lucia alle Malve (in collaborazione con ISCR), Notte Europea della Ricerca, Matera (Italy), 27th September 2019

5. S. Pasquale, M. Romani, L. Pronti, A. Maria Gueli, F. Rizzo, M. Marinelli, G. Verona-Rinati ″Masterclass INFN Physics in Art 2019″: *La diagnostica per i beni culturali raccontata ai ragazzi delle scuole secondarie*, LUBEC 2019, Lucca , 4th October 2019

5 Publications

1. Agrosì, G., Tempesta, G., Mele, D., Caggiani, M.C., Mangone, A., Della Ventura, G., Cestelli-Guidi, M., Allegretta, I., Hutchison, M.T., Nimis, P., Nestola, F. , ″Multiphase inclusions associated with residual carbonate in a transition zone diamond from Juina (Brazil)″. Lithos, **350-351**, 105279 (2019). DOI: 10.1016/j.lithos.2019.105279

2. A. Del Vecchio, B. T. Poe, V. Misiti and M. Cestelli Guidi, ″High-Temperature Evolution of Point Defect Equilibria in Hydrous Forsterite Synthesized at 1100 °C and up to 4 GPa.″ Minerals **9**, 574 (2019) - DOI: 10.3390/min9100574

3. L. Pronti, M. Romani, G. Verona-Rinati, O. Tarquini, F. Colao, M. Colapietro, A. Pifferi, M. Cestelli-Guidi, M. Marinelli, ″Post-Processing of VIS, NIR, and SWIR Multispectral Images of Paintings. New Discovery on the The Drunkenness of Noah, Painted by Andrea Sacchi, Stored at Palazzo Chigi (Ariccia, Rome).″ Heritage, **2(3)** (2019) 2275-2286, DOI: 10.3390/heritage2030139

4. M. Marelli, A. Jouve, A.Villa, R. Psaro, A. Balerna, L. Prati, C. Evangelisti, ″Unraveling the Role of Hybrid Au-CuO Bimetallic Nanoparticles and their Structural Features for Selective Benzyl Alcohol Oxidation″, J. Phys. Chem. C **123**, 2864-2871 (2019) - DOI: 10.1021/acs.jpcc.8b09449

5. I. Hafizh, G. Bellotti, M. Carminati, G. Utica, M. Gugiatti, A. Balerna, V. Tullio, G. Borghi, A. Gola, N. Zorzi, A. Capsoni, S. Coelli, L. Bombelli, C. Fiorini, ″ARDESIA: A fast silicon drift detector X-ray spectrometer for synchrotron applications″, X-Ray Spectrometry **48**, 382-386 (2019) - DOI: 10.1002/xrs.3017

6. A. Balerna, ″DAFNE-Light DXR1 Soft X-Ray Synchrotron Radiation Beamline: Characteristics and XAFS Applications″, Condens. Matter **4**, 7 (2019) – DOI: 10.3390/condmat4010007

7. I. Hafizh, G. Bellotti, M. Carminati, G. Utica, M. Gugiatti, A. Balerna, V. Tullio, G. O. Lepore, G. Borghi, A. Gola, N. Zorzi, A. Capsoni, S. Coelli, L. Bombelli, C. Fiorini, ″Characterization of ARDESIA: A 4- Channel SDD X-ray Spectrometer for Synchrotron Measurements at High Count Rates″, JINST **14**, P06027 (2019)

8. M. Azzolini, M. Angelucci, R. Cimino, R. Larciprete, N. M. Pugno, S. Taioli and M. Dapor, ″Secondary electron emission and yield spectra of metals from Monte Carlo simulations and experiments″, J. Phys. Condens. Matter **31**, 055901 (2019) - DOI: 10.1088/1361-648X/aaf363

9. L. Spallino, M. Angelucci, R. Larciprete, and R. Cimino,″On the compatibility of porous surfaces with cryogenic vacuum in future high-energy particle accelerators″, Appl. Phys. Lett. **114**, 153103 (2019) - DOI:10.1063/1.5085754

10. A. Abada, M. A, S.S. AbdusSalam, et al., ″FCC Physics Opportunities: Future Circular Collider Conceptual Design Report Vol. 1″, Eur. Phys. J. C **79**: 474, (2019). DOI: 10.1140/epjc/s10052-019-6904-3

11. Abada, A., Abbrescia, M., AbdusSalam, S.S. et al ., ″FCC-ee: The Lepton Collider. Future Circular Collider Conceptual Design Report Vol. 2″, Eur. Phys. J. Spec. Top. **228**: 261-623, (2019). DOI: 10.1140/epjst/e2019-900045-4

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13. Abada, A., Abbrescia, M., AbdusSalam, S.S. et al ., ″HE-LHC: The High-Energy Large Hadron Collider. Future Circular Collider Conceptual Design Report Vol. 4″, Eur. Phys. J. Spec. Top. **228**: 1109-1382, (2019). DOI: 10.1140/epjst/e2019-900088-6

14. R. Cimino, M. Angelucci, L.A. Gonzalez, R. Larciprete, ″SEY and low-energy SEY of conductive surfaces″, J. of Electron Spectroscopy and Related Phenomena, online 21 June 2019. DOI: 10.1016/j.elspec.2019.06.008.

15. A. Agresti, A. Pazniak, S. Pescetelli, A. Di Vito, D. Rossi, A. Pecchia, M. Auf der Maur, A. Liedl, R. Larciprete, Denis V. Kuznetsov, D. Saranin and A. Di Carlo , ″Titanium-carbide MXenes for work function and interface engineering in perovskite solar cells.″, Nat. Mater. **18**, 1228–1234 (2019).DOI: 10.1038/s41563-019-0478-1

6 Other pubblications

1. LNF Highlights 2018: *ARDESIA- ARray of Detectors for Synchrotron RadIation Applications* , 12 (2019)

2. Highlight 3.6 in Activity Reports Italian CRG beamline at ESRF, M. Marelli, A. Jouve , A. Villa, R. Psaro, A. Balerna, L. Prati, C. Evangelisti *Hybrid Au/CuO Nanoparticles: Effect of Structural Features for Selective Benzyl Alcohol Oxidation*, **7** 16 (2019), ISSN 2553-9248