3 Post-doc positions at Polifab within the NFFA-DI infrastructure

2 years contract (renewable) – net monthly salary of 2000€ - beginning in summer/autumn 2023

Polifab, the micro and nanofabrication facility of Politecnico di Milano (www.polifab.polimi.it), participates in the recently funded research infrastructure NFFA-DI (Nano Foundries and Fine Analysis Digital Infrastructure; https://nffa-di.it) which represents the Italian branch of the well-established ESFRI infrastructure NFFA (https://www.nffa.eu).

NFFA-DI is the NFFA upgrade proposal for realizing a Full-Spectrum Research Infrastructure for nanoscience and nanotechnology, capable of enhancing the Italian research competitiveness on the fundamental interactions of multi-atomic matter to explore the origins of materials behavior at all relevant dimensional and temporal scales, to describe, understand and design material solutions for engineering innovation. The rationale of NFFA-DI is to integrate nano-foundry laboratories, i.e. facilities for atomically controlled growth, structural characterization of nano-objects and nano-structured materials, including upscaling the most promising systems to the level of intermediate TRL developments, and the national facilities for the fine analysis of matter delivering synchrotron and FEL radiation (Elettra and FERMI), therefore raising the quality, reproducibility and overall competitiveness of Italian research in nanoscience, fully integrated into the European RI ESFRI landscape.

Within NFFA-DI, Polifab will potentiate its capabilities in the synthesis and fine analysis of advanced materials thanks to the installation of new experimental stations:

a) **Atomic layer and pulsed layer deposition (ALD and PLD)** systems for wafer-scale deposition of advanced functional materials (PIs: Claudio Somaschini and Andrea Cattoni)
b) **Combined molecular beam epitaxy and angular resolved photoemission spectroscopy (MBE+ARPES)** for the state-of-art growth of chalcogenides and in-situ investigation of the band-structure of quantum materials (PIs: Matteo Cantoni and Christian Rinaldi)
c) **RF probe station** for broadband spectroscopy measurements and **Time-Resolved MOKE microscope** for the analysis of magnetization dynamics (PIs: Daniela Petti, Edoardo Albisetti, Riccardo Bertacco)

For each of them, we are hiring a post-doc with a contract as a Technologist for 2 years (renewable) with a net monthly salary of about 2000 €, starting in summer/autumn 2023.

The tasks of the three post-docs will be:

- To contribute to the procurement, installation and commissioning of said instrumentation.
- To carry out an original research activity exploiting the new/upgraded instrumentation through in-house experiments, to become fully operational as research infrastructure providers.
- To contribute to the implementation of the digital infrastructure of NFFA-DI for the management of fair data as well as to the commissioning of access of users.

The post-docs will work in a stimulating environment for basic nanoscience and advanced technologies, with continuous exchange of know-how from the different nodes of the infrastructure and participation in the research activities of users.
They will have the opportunity to participate in the creation of a unique infrastructure, with the perspective of an activity beyond the two years of the initial contract, as the expected duration of NFFA-DI is at least 10 years.

The specific research themes for the in-house research are detailed here below for each post-doc.

Activity a. ALD/PVD growth of functional oxides and "Defect-Tolerant" materials for Photovoltaics (Claudio Somaschini, Andrea Cattoni)

The ALD/PLD systems will be dedicated to the growth of different materials ranging from metal oxides, 2D materials and Sulfide/Selenide-based materials for emerging applications. In particular, driven by the success of recently discovered hybrid lead- halide perovskite absorber materials for photovoltaic (PV), we will conduct a material-screening of "defect-tolerant" PV absorbers [1], with electronic structures similar to those of perovskites, but composed of earth-abundant non-toxic elements. In the project, we will initially focus our research on chalcogenide compounds (A)BX2 (A=Ag/Cu, B=Bi/Sb, X=S/Se), being a particularly promising class of semiconductor materials [2][3], that can cover a large spectrum of bandgaps addressing multiple applications such as Power-by-Light systems, automotive and indoor PV, and the challenging and urgent problem of identifying a stable and scalable wide-bandgap semiconductor partner for Silicon tandem solar cells.

The post-doctoral researcher will participate in the commissioning of the ALD/PLD tools. He/she will be involved in the growth of metal oxides thin films, chalcogenides thin films, their optoelectronic characterization and selection using selection metrics based on detailed-balance analysis [4]. Eventually, he/she will be involved in synthesis of new functional materials proposed by the users of the NFFA-DI infrastructure.

[1] L. Yu, A. Zunger, Phys. Rev. Lett. 108, 068701 (2012).
[2] Y. Wang, S.R. Kavanag, et al., Nature Photonics 16, 235 (2022).
[3] R. Tang, X. Wang et al., Nature Energy 5, 587 (2020).
[4] B. Blank, T. Kirchartz et al., Phys. Rev. Appl. 8, 024032 (2017).

Activity b. Ultrafine growth and advanced spectroscopy of chalcogenides and 2D materials for spin-orbitronics (PIs Matteo Cantoni and Christian Rinaldi)

Chalcogenides are of large interest nowadays in the scientific community as new substrates to keep the Moore's law alive. Exemplarily, compounds belonging to the class of ferroelectric Rashba semiconductors, such as GeTe [1], are widely investigated thanks to their unique ability to control the band structure and therefore the transport properties with the ferroelectric polarization [2]. In the project, a rather unique laboratory cluster tool for molecular beam epitaxy (MBE) and in-situ angle-resolved photoemission spectroscopy (ARPES), will be exploited to map the band dispersion of high-quality crystalline films of advanced spin-orbit s (as in [3, 4]) and quantum material, with a significant impact expected on the scientific community.

The post-doctoral researcher will be involved in the commissioning of the cluster tool. He/she will be responsible for the growth of thin and ultrathin films of chalcogenides (e.g., germanium telluride and its alloys), with fine control of the growth conditions. The post-doc will contribute to ARPES experiments for band structure analysis in those high-quality chalcogenides and other relevant materials, to be compared with supportive density functional theory calculations performed in the NFFA-NI network.

[1] D. Di Sante, R. Bertacco *et al.*, Adv. Mater. 25, 509 (2013).
[2] S. Varotto, C. Rinaldi *et al.*, Nature Electronics 4, 740 (2021).
[3] R. Rinaldi *et al.*, Nano Letters 18, 2751 (2018).
[4] M. Liebmann, C. Rinaldi *et al.*, Adv. Mater. 28, 560 (2016).

Activity c. Broadband spectroscopy and Time Resolved MOKE investigation of magnonic devices fabricated on YIG and CoFeB for unconventional computing (PIs Daniela Petti, Edoardo Albisetti, Riccardo Bertacco)

In this project, we will setup a RF station for broadband spectroscopy and develop temporal and spatial resolved microscopy with the aim of study different dynamic effects in magnetism. We will exploit Time-resolved Magneto-Optical Kerr Effect for the study of the magnetization and the propagation of spin waves in thin films and nanostructured systems.[1,2] In particular, we will focus on the dynamics of spin textures and topological structures, the effect of spin orbit torques in different ferromagnetic, ferrimagnetic materials and heterostructures. We will investigate spin waves in patterned systems with the aim of demonstrating Boolean and non-Boolean novel computing approaches. The post-doctoral researcher will be responsible of the development of the measurement apparatus and will be involved in the design of the experiments, possible materials growth, and in the nanofabrication with conventional and unconventional techniques.[3] The design and understanding of the experiments will require also the use of micromagnetic simulations via different platforms, such as **MuMax3** or OOMMF.

[1] E. Albisetti et al.,Adv. Mater. 32(9), 1906439 (2020)
[2] E. Albisetti et al., Communications Physics, 1(1), 1-8 (2018)
[3] E. Albisetti et al., Nature Nanotechnology 11, 545–551 (2016)

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