NFFA-Europe integrated infrastructure for nanoscience

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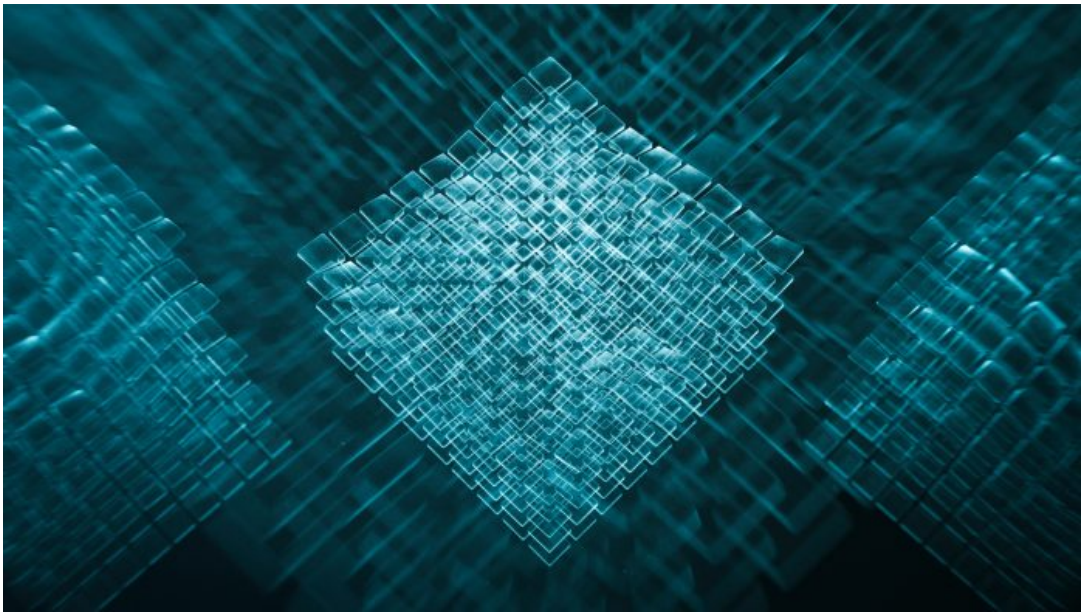

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Researchers in nanoscience, at the Nano Foundries and Fine Analysis, exploit the access to the most advanced combination of methods, tools and facilities.

Energy, information technology and the life sciences define global challenges to be addressed by a substantial research effort to better understand the properties of materials at the nanoscale and to learn how to design and fabricate novel functional systems at the cross-over to quantum behaviour.

Researchers in this broad field need to exploit the most advanced methods and tools for the production (such as growth and synthesis) of highly controlled nanoscale objects and systems, as well as to access the most advanced facilities for probing their local and extended electronic states, spin polarisation, and all quasi-particle excitations that characterise e.g. magnetism, multiferroicity, superconductivity.

Mayor research efforts are concentrated, for example, in studying low-power devices for information technology, to cope with the exponential growth of data traffic and analysis by drastically reducing the power consumption with respect to the current technology based

on conventional semiconductor approaches. The low-energy scale properties of various oxides and combinations of low dimensional oxide elements need to be understood and controlled, which requires state of the art facilities in growth, nano-probes, high-resolution spectroscopy and microscopy, time resolution probes, etc. that are not typically all available in the same laboratory or institution.

Figure 1

The NFFA catalogue of available tools

The Nano Foundries and Fine Analysis research infrastructure operates as a H2020 Integration Action Consortium of 19 Partners since 2015 and provides transnational access (TA) to about one hundred state-of-the-art facilities across Europe enabling nanoscience experiments and theory and computational science. The unique NFFA catalogue of nanoscience research tools is operated by governmental and academic laboratories co-located with synchrotron sources, free-electron lasers, neutron sources for scattering and spectroscopy (fine analysis of matter). Physical, hands-on, access to the facilities can be integrated or replaced by remote access in several cases, always with high-level scientific support by the TA provider.

The NFFA catalogue of available tools is organised into four ‘installations’ that represent homogeneous ensembles of methods to address:

1) Material synthesis and growth,

2) Lithography and nanofabrication,

3) Characterisation and fine analysis,

4) Theory and simulation.

Typical user projects span over at least two, or more, of these installations, structuring a work-plan that can cover a substantial part of the research programme. In this sense NFFA-Europe is unique, as the best offer in for instance, epitaxial growth and nano-structuring can be combined with the best options for synchrotron radiation spectroscopy, or electron microscopy, or neutron scattering. Similarly the best offer in scanning probe microscopy and spectroscopy can be combined with the best offer in Density Functional Theory based modelling and numerical simulation.

The 'Technical Liaison Network'

The partners who gave birth to the NFFA-Europe research infrastructure are mostly co-located with analytical large-scale facilities for fine analysis (ALSF), as this promotes the implementation of advanced research protocols and allows the exploitation of technical and logistic synergies among the different facilities and their owner and operator institutions.

A key element of the NFFA-Europe transnational access is the Technical Liaison Network (TLNet) that is centrally managed at the Coordinator headquarters (IOM-CNR in Trieste) and is composed by scientific and technical staff at all access providing sites. The TLNet can establish a dialogue with potential users on technical feasibility issues of a protocol or of an experiment.

Thanks to the effective integration of the partner facilities obtained by sharing knowledge of the characteristics of all the equipment made available at the various sites, the TLNet is capable of offering to each user proposal an optimised access work-plan, with one or multiple sites to be accessed for carrying out the research project in the best combined

conditions, after the selection is made, on a purely scientific merit, by the external Access Review Panel.

Joint Research Activities

Advanced research in nanoscience requires a constant upgrade of methods and tools, as well as the development of novel probes. NFFA-Europe has carried out four Joint Research Activities for:

1) Advanced X-ray optics,

2) Advanced fast Scanning Probe Microscopy,

3) Instrumentation for in-situ in–operando conditions, a unique method for nanometer-scale tagging and reproducible nano-positioning of samples in different instruments enabling the application of complementary probes and techniques on the very same individual nanostructure,

4) and, an integrated Information and Data Management Repository Platform – IDRP – for the nanoscience community.

424 proposals from 51 Countries have been collected in 13 calls yielding to 65% success and delivery of 769 laboratory access sessions to over 300 international researchers. Users are mostly from an academic institution, but 10% are from industry. SMEs enjoy favourable access conditions, IP protection, and the possibility to carry out short access sessions for testing the feasibility of specific experimental needs, for manufacturing new products or for improving quality and capabilities of services and technologies

Providing access to specialised instrumentation

The overall outcome in terms of access request, demonstrates the strategic value of NFFA-Europe that fulfils a clear need by the nanoscience community in terms of access to specialised and hardly-accessible instrumentation, as well as of test-access to ALSFs (e.g. neutron or X-ray sources) that would be otherwise in competition with pure-spectroscopy projects proposed by highly specialised users. Access to ALSF via NFFA-Europe is always in

combination with research work under other installations, and therefore is not in competition with the direct access to those facilities as managed by their own users programmes. It may actually represent an entry point to further direct usage of ALSF for nanoscience programmes.

In view of the development of the European Open Science Cloud (EOSC), NFFA-Europe is pioneering the first data repository for nanoscience. The testing phase with users is ongoing, but several laboratories and institutions, belonging to the Consortium or not, are already testing its implementation. This will be an asset in the future as highly diversified communities, as the nanoscience one, are ideal testbeds for the EOSC.

Networking activities have reached both the nanoscience and the industrial communities, with specific actions, as well as the young scientists through the biannual editions of the NFFA-Europe summer school, in Barcelona and Trieste.

'Integration Action' – reaching interdisciplinary and multidisciplinary goals

New models of Integration Actions are foreseen by the H2020 pilot call INFRAIA-03-2020 that will open on 28 november 2019. The one dedicated to Research infrastructures for research in micro-nano technologiesfor materials, reflects much of the potential of NFFA-Europe. NFFA-Europe will run until August 2020. Plans are being developed to extend and expand its services beyond that date. A renewed model of access is under study that could combine the access to perform an accepted proposal with a training offer of young researchers of the user group in the relevant facilities. Feedback from the nanoscience community will help in refining the new model.

As described in the Landscape Analysis of the ESFRI Roadmap 2018, advanced integrated communities, among which NFFA-Europe, currently provide key services for the European research competitiveness. Such services need to be consolidated at the level of a dedicated research infrastructure for long-term effectiveness and sustainability. Further integration with advanced electron microscopy and advanced laser facilities are part of a coherent development of the Consortium that shall also enforce a more direct interaction

with the nano-chemistry community at large, and in specialised key sectors like nano-toxicology and nanomedicine.

NFFA-Europe has developed the Integration Action concept reaching interdisciplinary and multidisciplinary goals. By further expanding its catalogue of offer and by continuously developing the synergies among methods and facilities, it plans to consolidate a very advanced infrastructure service for European competitiveness in academic and applied nanoscience research.

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