UNIVERSITY OF HYDERABAD
Gachibowli, Hyderabad

Detailed Project Report for acquiring Equipment under HEFA Funding through

IOE PROJECT

EQUIPMENT IN THE ORDER OF PRIORITY

SNo	Equipment	Participating Schools *	Estimated Cost (in Rs. Crore)	Planned to be Purchased in the Financial Year
1	X-Ray Photoelectron Spectrometer (XPS) and accessories	SOC/SOP/ SEST	6	2020-21
2	Micro-X-Ray Diffractometer (micro-XRD)	SOC/SOL/ SEST/SOP	4	2020-21
3	High Resolution Mass Spectrometer	SOC/SOL/ SOP	5.5	2020-21
4	Cryogen-free Superconducting Magnet with Magnetic and Transport options	SOP/SOC/ SEST	4.5	2020-21
5	Integrated Confocal Raman microscopy System with FILM and TLM	SOC/SOL /SOP/SEST	3	2021-22
6	Dual–Focused Ion Beam system (FIB-SEM)	SEST/SOP/ SoC	6	2022-23
7	Analytical Transmission Electron Microscope	SOP/SOC/ SOL/SEST	14	2022-23
8	Nuclear Magnetic Resonance Spectrometer (800 MHz)	SOC/SOL	15	2022-23
TOTAL			**58 Cr**	

*[SOC: School of Chemistry; SOP: School of Physics, SOL: School of Lifesciences; SEST: School of Engineering Sciences and Technology]

1 Title of the Scheme: Establishment of X-ray photoelectron spectroscopy (XPS) facility at the Centre for Nanotechnology, University of Hyderabad

1.1. Total Cost of the proposed Scheme: Rs. 6 crore (Six crore only)

1.2. Proposed duration of the scheme: 2020-21

1.3. Detailed Proposal

1.3.1 Introduction

The properties of the bulk and the surface of any material are intrinsically different and, hence, it is important to probe beneath the surface. There are several tools available for analysis of bulk materials. In contrast, there are very few surface probes that provide quantifiable information about a surface and x-ray photoelectron spectroscopy (XPS) is one of the most important probes for such studies. XPS is a powerful tool to analyze elemental composition, empirical formula, chemical state and electronic state of the elements in the topmost layers of the material that constitute surfaces, bio and nanomaterials.

The basic phenomenon in XPS involves the irradiation of a solid surface with a beam of X-rays. This results in the emission of electrons from the top 1-10 nm of the surface with their kinetic energy being characteristic of the elements that comprise the material. The quantification is achieved by counting ejected electrons over a range of electron kinetic energies, which manifest as peaks in the spectrum from atoms emitting electrons of a particular characteristic energy. The energies and intensities of the photoelectron peaks enable identification and quantification of all surface elements (except hydrogen).

Thus, XPS is a tool that is central to all types of materials science and engineering and enables the understanding of many fundamental and applied aspects of physics, chemistry, life science and engineering by probing the physical and chemical interactions that occur at the surface or at the interfaces of different materials. It is well documented that surface chemistry influences a diverse range of factors such as corrosion rates, catalytic activity, adhesive properties, wettability, contact potential and failure mechanisms. XPS can be used to analyze the surface chemistry of a material after an applied treatment such as fracturing, cutting or scraping, thin-film electronics and bio-active surfaces.

1.3.2 Origin of the proposal

The University of Hyderabad has five Schools of study among the sciences (Physics, Chemistry, Life Sciences, Medical Sciences and Engineering Sciences and Technology) with several faculty members who are actively engaged in research and development related to a variety of materials. For example, in the School of Physics there is an active interest in magnetic, optical, electronic, semiconducting, multi-ferroic and superconducting materials in bulk and thin film form, sensors of different kinds, microelectronic and semiconductor devices, materials for energy storage, 2D materials and nanomaterials and devices. The School of Chemistry faculty are involved in R&D on advanced molecular materials, polymers, nanomaterials, catalysis, a new generation of photovoltaic cells and advanced inorganic-organic hybrids. In the School of Life Sciences, there is active interest in animal biology, plant sciences, biochemistry, biotechnology and the development of drugs, diagnostic tools and therapies for many life-threatening diseases. The School of Medical Sciences faculty are involved in optometry and vision sciences as well as fundamental aspects relating to public health, cognition and neurological issues. In the School of Engineering Sciences and Technology there is very major interest in high entropy alloys, piezo and ferro-ceramics, graphene based devices, steels, corrosion and micro electro-mechanical systems. This non-exhaustive list of research areas is an indicator of the wide variety of inter-disciplinary research being carried out. One of the common themes threading through these areas is the need to probe and analyze elemental composition, empirical formula, chemical state and electronic state of the elements of the materials and devices.

The University established the Centre for Nanotechnology (CFN) in 2007 through a project funded by the Department of Science and Technology (DST). Subsequent to the completion of the project in 2014, the University is supporting all research activities of the CFN from its own resources. The mandate of the Centre, initially, was to facilitate research in nanoscience and nanotechnology within the University. In the last few years, the Centre has become a hub for advanced materials characterization, which is accessible to users across the country. It facilitates research activities of users from many HEIs including IITs, NITs, Central and State Universities and colleges. Access is open and transparent and based on a nominal user charge.

The Centre is equipped with facilities such as Transmission Electron Microscope with sample preparation facility, Physical Property measurement systems, SQUID, Scanning Near field optical microscope with Raman spectrometer, micro/Nano fabrication facility with class 100 and class 1000 clean room, photolithography facility, electron beam lithography and vacuum deposition systems.

1.3.3 Justification

The major lacuna in the facilities of the **UoH is the absence of an x-ray photoelectron spectrometer.** A survey of the HEIs and national labs in Hyderabad shows that there are only two such facilities, both in the National labs. These are not easily accessible and even if they are accessible the user charges are too high for users from Central and State Universities. Users requiring access to XPS typically go to IISc. Bangalore or IIT Kharagpur or Anna University. There is a waiting time from a few weeks to several months. Clearly, the absence of the facility affects not only the University of Hyderabad but also users from across the region. There is, therefore, an urgent need to establish such a facility that will be beneficial to several hundred post-graduate and Ph.D. students and enable their institutions to carry out world-class research.

References:

1. D. Venkatakrishnarao, C. Sahoo, V. Radhika, M. Annadhasan, S. R. G. Naraharisetty, and R. Chandrasekar,_"2D Arrangement of Polymer Micro-Sphere Photonic Cavities Doped with Novel N-Rich Carbon Quantum Dots Display Enhanced One- and Two-Photon Luminescence Driven by Optical Resonances" Adv. Opt. Mater. (2017), 5, 1700695. [XPS measurement done at Anna University].
2. Murali, B.; Dey, S.; Abdelhady, A. L.; Peng, W.; Alarousu, E.; Kirmani, A. R.; Cho, N.; Sarmah, S. P.; Parida, M. R.; Saidaminov, M. I.; Zhumekenov, A. A.; Sun, J.; Alias, M. S.; Yengel, E.; Ooi, B. S.; Amassian, A.; Bakr, O. M.; Mohammed, O. F., Surface Restructuring of Hybrid Perovskite Crystals. ACS Energy Letters **2016,** 1 (6), 1119-1126.
3. Shaheen, B. S.; Hafez, A. M.; Murali, B.; Kirmani, A. R.; Amassian, A.; Mohammed, O. F.; Allam, N. K., 10-fold enhancement in light-driven water splitting using niobium oxynitride microcone array films. Solar Energy Materials and Solar Cells **2016,** 151, 149-153.
4. Murali, B.; Madhuri, M.; Krupanidhi, S. B., Near-infrared photoactive Cu3BiS3 thin films by co-evaporation. **2014,** 115 (17), 173109.
5. Pan, J.; Quan, L. N.; Zhao, Y.; Peng, W.; Murali, B.; Sarmah, S. P.; Yuan, M.; Sinatra, L.; Alyami, N. M.; Liu, J.; Yassitepe, E.; Yang, Z.; Voznyy, O.; Comin, R.; Hedhili, M. N.; Mohammed, O. F.; Lu, Z. H.; Kim, D. H.; Sargent, E. H.; Bakr, O. M., Highly Efficient Perovskite-Quantum-Dot Light-Emitting Diodes by Surface Engineering. **2016,** 28 (39), 8718-8725.
6. Abdelhady, A. L.; Saidaminov, M. I.; Murali, B.; Adinolfi, V.; Voznyy, O.; Katsiev, K.; Alarousu, E.; Comin, R.; Dursun, I.; Sinatra, L.; Sargent, E. H.; Mohammed, O. F.; Bakr, O. M., Heterovalent Dopant Incorporation for Bandgap and Type Engineering of Perovskite Crystals. The Journal of Physical Chemistry Letters **2016,** 7 (2), 295-301.

1.4. Outcomes and Deliverables

Stated aims and objectives of the scheme

1. Establishment of an X-ray Photoelectron spectrometer facility at the University of Hyderabad.
2. Enable students and faculty of UoH and HEIs' across the country to access this facility which, in turn, will result in higher quality research output in areas spanning Physics, Chemistry, Life Sciences, Medical Sciences and Engineering.
3. Publications in high impact factor journals
4. Better quality PhD theses in advanced materials, nanomaterials and devices, biomaterials and allied areas.

1.4.1 Outcomes of the Scheme in the form of measurable indicators:

1. Publications in high impact factor journals.
2. More international collaborations
3. Project proposals submitted for funding, based on this facility
4. PG and Ph.D. theses based on this facility.
5. Trained human resource in XPS.

1.4.2 Target Beneficiaries:

1. Students and faculty of UoH and HEIs' across the country with special focus on marginalized sections and other vulnerable groups.
2. Scientists from various national labs under DST, DRDO, CSIR etc.
3. Materials, Electronics and Pharma Industries in the Hyderabad area.

2. Title of the Scheme: Establishment of a Multipurpose Micro XRD facility at the Centre for Nanotechnology, University of Hyderabad

2.1 Total Cost of the proposed Scheme: Rs. 4 crore (Four crore only)

2.2. Proposed duration of the scheme: 2020-21

2.3. Detailed Proposal

2.3.1 Introduction

X-ray diffraction is ~~a tool that is~~ the first probe which most materials scientists and engineers to characterize the developed materials. It is a non-destructive technique that enables characterization of structure of materials i.e. whether they are amorphous, polycrystalline or single-crystalline. In addition, the lattice parameters of crystals, crystallite size and residual stress information can be extracted from x-ray diffraction measurements. When equipped with high-temperature stage information regarding phase purity and phase transitions can also be extracted. By changing the angle of x-ray incidence, crystallographic texture of thin film surfaces can be investigated thereby eliminating contribution from substrates on which these films are deposited. With the emergence of nanomaterials, x-ray diffraction and small-angle x-ray scattering have been particularly important characterization tools. Since it is a non-destructive technique, samples can be re-used which is not possible in electron microscopy. Developments in x-ray diffraction technologies have enabled probing of soft materials which was not possible for many years. One of the main constraints in conventional x-ray diffraction techniques is the fairly large volume of samples required to obtain reliable and good quality data. This problem has been overcome recently with the development of laboratory-based micro- x-ray diffraction instruments which now eliminates the need for synchrotron radiation.

2.3.2 Origin of the proposal

Several faculty members of schools of Physics, Chemistry, Life Sciences, Medical Sciences and Engineering Sciences and Technology in the University of Hyderabad are actively engaged in the research and development related to a variety of materials. For example, in the School of Physics there is active interest in magnetic, optical, electronic, semiconducting, multi-ferroic and superconducting materials in bulk and thin film form, sensors of different kinds, microelectronic and semiconductor devices, materials for energy storage, 2D materials and nanomaterials and devices. The School of Chemistry faculty are involved in R&D on advanced molecular materials, polymers, nanomaterials, catalysis, new generation of photovoltaic cells and advanced inorganic-organic hybrids. In the School of Life Sciences there is active interest in animal biology, plant sciences, biochemistry, biotechnology and the development of drugs, diagnostic tools and therapies for many life-threatening diseases. In the School of Engineering Sciences and Technology there is major interest in high entropy alloys, piezo and ferro-ceramics, graphene based devices, steels, corrosion and micro electro-mechanical systems. This non-exhaustive list of research areas is an indicator of the rich variety of interdisciplinary research being carried out in the University. One of the common themes threading through these areas is the need to probe and analyze crystal structure and related information of the materials and devices.

2.3.3 Justification

The major lacuna in the facilities of the **UoH is the absence of micro-XRD.** As stated earlier, microdiffraction experiments, in contrast to very conventional powder x-ray diffraction, irradiate very small areas of samples. The development of large 2D area fast detector technologies as well as the accompanying data analysis software, it is possible to scan samples under a submicron x-ray beam and obtain spatial maps of grain orientation, strain/stress and/or micro-topographical information of materials. More importantly, a spatial map of the diffraction pattern can be taken and analysed at each point. The ability to scan can enable resolution of parameters linked to the atomic structure and provide information in the range of 10– 1000 nm depending on the minimum beam size achievable.

It can be used to carry out experiments on powders, bulk, thin film, coating, biological/pharma samples .

A summary of typical technical specs is given below

- Micro diffraction beam size 30-100 microns
- Analysis of localized Residual stress
- Crystallographic Texture
- Grazing angle /thin films
- Crystal structure

OPTIONAL

- Small angle x-ray scattering
- In-situ heating stage
- Cu / Co/Mo “dual wavelength”

It is thus expected that, with the above-mentioned capabilities the micro-xray diffraction facility will be a central facility with large number of users. It should be noted that no such facility exists within the University or any University in Telangana. It is also expected to be useful to materials and pharma based industries in and around Hyderabad.

For example, the following references describe molecular packing changes of flexible photonic single micro-crystal after deformation studied by spectroscopy methods. Micro-XRD would have provided clear picture of the molecular packing changes and improved the quality of publications further.

1. M. Annadhasan, A. Agrawal, S. Bhunia, V. V. Pradeep, S. S. Zade,* C. M. Reddy,* R. Chandrasekar* " Mechano-Photonics: Flexible Single-Crystal Organic Waveguides and Circuits" Angew. Chem. Int. Ed. (2020), 10.102/anie202003820. [VERY IMPORTANT ARTICLE, TOP 10%]
2. M. Annadhasan, D. P. Karothu, R. Chinnasamy, L. Catalano, E. Ahmed, S. Ghosh,* P. Naumov,* R. Chandrasekar*"Micromanipulation of Mechanically Compliant Organic Single-Crystal Optical Microwaveguides, Angew. Chem. Int. Ed. (2020), 10.1002/anie.202002627.

Relevant Publications: Micro XRD Facility used in ARCI Hyderabad.

3. Praveen Chapala, Pandu Sunil Kumar, Vasundhra Bhandari, Joydip Joardar, Swati Ghosh Acharyya, Effect of alloying elements on the microstructure, coefficient of friction, in-vitro corrosion and antibacterial nature of selected Ti-Nb alloys, Applied Surface Science Vol. 469, pp. 617-623, 2019.
4. S. Sravanthi, Swati Ghosh Acharyya, K.V. Phani Prabhakar, Joydip Joarder,Effect of varying weld speed on corrosion resistance and mechanical behavior of Aluminium - steel welds fabricated by cold metal transfer technique, Materials and Manufacturing Processes, In press, 2019

2.4. Outcomes and Deliverables

Stated aims and objectives of the scheme

1. Establishment of a Multipurpose Micro XRD facility at the University of Hyderabad.
2. Enable students and faculty of UoH and HEIs’ across the country to access this facility which, in turn, will result in higher quality research output in areas spanning Physics, Chemistry, Life Sciences, Medical Sciences and Engineering.
3. Publications in high impact factor journals

4. Better quality PhD theses in advanced materials, nanomaterials and devices, biomaterials and allied areas.

2.4.1 Outcomes of the Scheme in the form of measurable indicators:

1. Publications in high impact factor journals.
2. More international collaborations
3. Project proposals submitted for funding, based on this facility.
4. PG and Ph.D. theses based on this facility.
5. Trained human resource in XPS.

2.4.2 Target Beneficiaries:

1. Students and faculty of UoH and HEIs' across the country with special focus on marginalized sections and other vulnerable groups.
2. Scientists from various national labs under DST, DRDO, CSIR etc.
3. Materials, Electronics and Pharma Industries in the Hyderabad area.

3. Title of the Scheme: Establishment of a High Resolution Mass Spectrometry facility at Central Instrumental Laboratory, University of Hyderabad

3.1. Total Cost of the proposed Scheme: Rs. 5.5 Crore (Five and half crore only)

3.2. Proposed duration of the scheme: 2020-21

3.3. Detailed Proposal

3.3.1 Introduction

Mass spectrometry (MS) is an analytical technique in which chemical compounds are ionized into charged molecules and ratio of their mass to charge (m/z) is measured. Development of electron spray ionization (ESI) and matrix assisted laser desorption ionization (MALDI) increased the applicability of MS to synthetic macromolecules and large biomolecules like proteins. MALDI-TOF-TOF-MS has certain advantages over ESI-MS viz. (i) MALDI-TOF-TOF-MS produces singly charged ions, thus interpretation of data is easy as compared to ESI-MS, (ii) for analysis by ESI-MS, prior separation by chromatography is required which is not needed for MALDI-TOF-MS analysis. In addition, recent technological advancement of high throughput and speed associated with complete automation has made MALDI-TOF- TOF-MS the method of choice for proteomics work, which requires handling large number of proteins in a single sample and processing them in a fast time scale.

The sample for analysis by MALDI-MS is prepared by mixing or coating with solution of an energy-absorbent, organic compound called matrix. The sample within the matrix is ionized in an automated mode with a laser beam. Desorption and ionization with the laser beam generates singly protonated ions from analytes in the sample. The protonated ions are then accelerated at a fixed potential, where these separate from each other on the basis of their mass-to-charge ratio (m/z). The charged analytes are then detected and measured using different types of mass analyzers like quadrupole mass analyzers, ion trap analyzers, time of flight (TOF) analyzers etc. During MALDI-TOF analysis, the m/z ratio of an ion is measured by determining the time required for it to travel the length of the flight tube. TOF analysis is found to be most suitable for analysing synthetic and biological macromolecules.

Thus, MALDI-TOF- TOF-MS is a tool that is central to all types of macromolecular research and enables the detailed mass analysis of the macromolecules, and its modified counterparts and their fragments.

3.3.2 Origin of the proposal

The University of Hyderabad has five Schools of study among the sciences (Physics, Chemistry, Life Sciences, Medical Sciences and Engineering Sciences and Technology) with several faculty members who are actively engaged in research and development related to synthetic and biological macromolecules. For example, in the School of Life Science, there is active interest in large biological macromolecules like proteins, peptides and various other proteomics works. Both structural and mechanistic aspects are routinely studied by several faculty members. The School of Chemistry faculty are involved in R&D of synthetic macromolecules of various kinds, including polymer based materials as well as biomacromolecules such as proteins. The measurements of molecular weight this synthesized macromolecule is very important in order to understand the structure and composition very accurately. The School of Medical Sciences faculty are involved in optometry and vision sciences as well as fundamental aspects relating to public health, cognition and neurological issues. Faculty in the School of Engineering Sciences and Technology are involved in developing various kinds of materials utilizing polymers. In all these research, often it is necessary to determine the detailed structural and mass analysis of macromolecules and hence MALDI-TOF-MS would be very useful.

3.3.3 Justification

The major lacuna in the facilities of the **UoH is the absence of MALDI-TOF-TOF-MS.** Matrix-assisted laser desorption/ionization-time of flight (MALDI-TOF TOF-MS) is a soft ionization technique used in mass spectrometry, which permits to detect mass spectra of large organic molecules (polymers, dendrimers, porphyrinoids and other macromolecules) and to analyze mass spectral pattern of biomolecules (peptides, proteins, sugar etc.). The biggest advantage of this technique is that it provides accurate molecular weight of samples from few hundreds to the order of kilo-Daltons. Also another advantage of MALDI is it provides the isotopic distribution of the elements in the sample and hence of great use for transition metal complexes. Finally it needs very less quantity of sample (usually in the order of milimolar scale) and is also a very efficient technique (can measure large no of samples in a day). Several research groups in the University are actively working in the area of both synthetic and biological macromolecules, this facility will be immensely helpful for the characterization of their macromolecule samples. In addition, large number researchers both from academics and industries will be using this facility for analysing their samples mass in more precise way.

A survey of the HEIs and national labs in Hyderabad shows that there are only one-two such facilities, both in the National labs. These are not easily accessible and even if they are accessible the user charges are very high for users from Central and State Universities. Also, users requiring access to MALDI-TOF-TOF-MS facility need to wait few weeks to several months for analysis. Clearly, the absence of the facility affect not only the University of Hyderabad but also users from across the region. There is, therefore, an urgent need to establish such a facility that will be beneficial to several hundred post-graduate and Ph.D. students and enable their institutions to carry out world-class research. UoH has more than hundreads of polymer realted papers most of them are published without characterisation of molecular weight distribution pattern due to lack of MALDI-TOGF-TOF.

References:

1. Ferrocene grafted hydroxyl terminated polybutadiene: A binder for propellant with improved burn rate Billa Narasimha Rao, Kuruma Malkappa, Nagendra Kumar, Tushar Jana, Polymer, 163; 162; 2019.
2. V. Radhika, M. Annadhasan, J. Ravi, M. D. Durga Prasad, N. Mitetelo, K. Zhdanova, E. Mamonov, K. Muellen,* T. V. Murzina,* R. Chandrasekar, "Multifunctional Chiral pi -Conjugated Polymer Microspheres: Production and Confinement of NLO signal, Detection of Circularly Polarized Light and Display of Laser-Triggered NLO Emission Shifts."
   Adv. Opt. Mater. (2020), accepted.
3. R. Vattikunta, D. Venkatakrishnarao, C. Sahoo, S. R. G. Naraharisetty, D. Narayana Rao, K. Müllen*, and R. Chandrasekar* “Microresonators from Charge-Transfer in Polymer Particles - toward Enhanced and Tunable Two-Photon Emission” ACS. Appl. Mater & Interfaces (2018),10, 16723.
4. YSLV Narayana,D. Venkatakrishnarao, M. A. Mohiddon, A. Biswas, N. Viswanathan, and R. Chandrasekar*, "Near Infrared Range Whispering-Gallery-Resonance from Photonic micro-Sphere Cavities Self-Assembled from a Blend of Polystyrene and Poly[4,7-bis(3-octylthiophene-2-yl)benzothiadiazole-co-2,6-bis(pyrazolyl)pyridine] Coordinated to $Tb(acac)_3$” ACS. Appl. Mater & Interfaces (2016), 8, 952-958.
5. YSLV Narayana, S. Basak, M. Baumgarten, K. Muellen, and R. Chandrasekar,* "White - Emitting Polymer/Ino*rganic Hybrid Spheres: Phenylethynyl and 2,6-Bis(pyrazolyl)pyridine Copolymer Coordinated to Eu(tta)3"* Adv. Funct. Mater.(2013), 23, 5875-5880.
6. Gnanesh Kumar B.S.,Gottfried Pohlentzb, Mona Schulteb, Michael Mormannb, Siva Kumar Nadimpallia N-glycan analysis of mannose/glucose specific lectin from Dolichos lablab seeds International Journal of Biological Macromolecules (2014). 69, 400–407.
7. Debashree Sengupta • Monica Kannan, Attipalli R. Reddy, A root proteomics-based insight reveals dynamic regulation of root proteins under progressive drought stress and recovery in Vigna radiata (L.) Wilczek, Planta (2011) 233:1111–1127.
8. V. Yadavalli, S. Nellaepalli, and R. Subramanyam, Proteomic Analysis of Thylakoid Membranes, in Robert Carpentier (ed.), Photosynthesis Research Protocols, Methods in Molecular Biology, vol. 684, DOI 10.1007/978-1-60761-925-3_14, © Springer Science+Business Media, LLC 2011.

3.4. Outcomes and Deliverables

Stated aims and objectives of the scheme

1. Establishment of a Mass Spectrometry facility at the University of Hyderabad.
2. Enable students and faculty of UoH and HEIs’ across the country to access this facility which, in turn, will result in higher quality research output in areas spanning Chemistry, Life Sciences, Medical Sciences and Engineering.
3. Publications in high impact factor journals
4. Better quality PhD theses in Chemistry, advanced materials, nanomaterials, biomaterials, life science and allied areas.

3.4.1 Outcomes of the Scheme in the form of measurable indicators:

1. Publications in high impact factor journals.
2. More international collaborations.
3. Project proposals submitted for funding, based on this facility.
4. PG and Ph.D. theses based on this facility.
5. Trained human resource in Mass Spectrometry.

3.4.2 Target Beneficiaries:

1. Students and faculty of UoH and HEIs’ across the country with special focus on marginalized sections and other vulnerable groups.
2. Scientists from various national labs under DST, DRDO, CSIR etc.
3. Polymers, Materials, and Pharma Industries in the Hyderabad area.

4. Title of the Scheme: Establishment of Cryogen-free Superconducting magnet with Magnetic and transport measurement System at at Central Instrumental Laboratory, University of Hyderabad

4.1. Total Cost of the proposed Scheme: Rs. 4.5 crore (Four and half crore only)

4.2. Proposed duration of the scheme: 2020-21

4.3 Detailed Proposal

4.3.1 Introduction

A large number of faculty and research scholars working in the area of Physics, Chemistry and Engineering Sciences need to characterize the materials at low temperature and in the presence of Magnetic field. This is an active area of research as it provides not only the fundamental understanding to the basic interactions that govern various Physical properties but also for developing various sensors and devices.

Traditionally, magnetic and transport measurements over (1.6-400K) temperature range were made in systems that required the use of liquid helium. Recognizing the requirement, the University established a Liquid Helium generating plant in 2005 with funding from DST. Over the years, the University has found it difficult to run the facility 24x7 for several reasons including, the large power requirements, and increase in the cost of Helium gas, which is the basic raw material required, from Rs. 500 per m^3 to Rs. 2000 per m^3 and the gas is not available readily. The running of the plant costs Rs. 4 lakhs per month along with uninterrupted power and supply of chilled water and a minimum of two technical staff. The maintenance of the Helium plant is, therefore, becoming increasingly difficult in a university environment without adequate and guaranteed financial outlay.

The existing PPMS and VSM systems, purchased by the Centre for Nanotechnology in 2009, have several users from Schools of Physics, Chemistry and Engineering Sciences and Technology. They rely entirely on the continuous supply of LHe for operation. Typically, measurements over this temperature range takes several days per sample to generate world-class publication level data. However, due to limited supply of LHe even when the plant was operational most users were getting a maximum of 14 days of access every six months. As a consequence only 30-40 publications could be achieved. Obviously, this rate of data generation as in any other competitive research field, is sub-optimal and renders most of the research irrelevant by the time all experiments are completed.

Hence, there is an urgent need to establish a complementary facility that does not rely on continuous supply of LHe for its operation. It is important to note that, based on past experience and the duration of each measurement, there is need for two systems which will not only serve the needs of the University community but also sister institutions. This is evident from requests received from institutions such as Osmania University, NIT Warangal and Dr. Reddy's labs which could not be taken up due to lack of availability of slots.

4.3.2 Origin of the proposal

The University of Hyderabad has five Schools of study (Physics, Chemistry, Life Sciences, Medical Sciences and Engineering Sciences and Technology) with several faculty members who are actively engaged in research and development related to a variety of materials. For example, in the School of Physics there is active interest in magnetic, optical, electronic, semiconducting, multi-ferroic and superconducting materials in bulk and thin-film form, sensors of different kinds, microelectronic and semiconductor devices, materials for energy storage, 2D materials and nanomaterials and devices. The School of Chemistry faculty are involved in R&D on advanced molecular materials, polymers, nanomaterials, catalysis, the new generation of photovoltaic cells and advanced inorganic-organic hybrids. In the School of Engineering Sciences and Technology, there is a very major interest in high entropy alloys, piezo and Ferro-ceramics, graphene-based devices, steels, corrosion and micro-electro-mechanical systems. This non-exhaustive list of research areas is an indicator of the rich variety of inter-disciplinary research being carried out. One of the common themes threading through these areas is the need to probe and analyse chemical information, and physical properties such as magnetic, electrical and magneto-transport properties of materials.

4.3.3 Justification

The major lacuna in the facilities of the **UoH is the absence of a Cryo-free magnetometer.** This proposal presents the justification for establishing Cryogen Free Measurement Systems for the investigation of Electrical and Magnetic properties of materials at temperatures ranging from 1.6 K to 400 K and magnetic fields up to 9 Tesla **without the need for liquid Helium**.

Magnetism, Superconductivity and transport properties of functional materials, over the temperature range of 1.6 to 400 K, is a major interest of faculty members of the Schools of Physics, Chemistry and Engineering Sciences and Technology. Several PhD students rely on these measurements for their research.

In recent years, new technological developments have enabled the development of systems called “Cryogen free Magnets” that obviate the need for continuous supply of LHe. Such systems have been installed successfully in various institutions around India (feedback of users is given below).

The technical capabilities

- Magnetization measurements using VSM option in the temperature range of 1.6 – 400 K in the presence of a 9 T field.
- Ac susceptibility measurements from 1 Hz to 20 kHz with ac amplitude up to 5 mT
- DC electrical transport to measure the resistance, magneto resistance & Hall effect measurements
- 5 sample probe mount to perform simultaneous measurements of resistance or Hall voltage up to 5 samples.
- Up gradation for thermal properties is possible

These capabilities are similar to the existing systems. A Major advantage is the system can be used **24x7 in cryogen free mode**.

Two well-known companies namely Quantum Design, U.S.A and Cryogenics Ltd, UK are suppling these systems (both the brochures are attached along with this email). These are complete systems which can be used to measure the Magnetization and (Electrical) Transport properties of materials. In summary, the proposed system will be able to run 24 x7 and measure a larger number of samples and serve a large section of the academic community. It will also complement the existing system as and when the LHe plant is operational. The two systems together are expected to be a very important source of resource generation considering that such systems are not available in the University system in the entire Telangana state.

1. Swain, P.S. Anil Kumar, V. Gorige,* Electrical Conduction Mechanism for the Investigation of Charge Ordering in Pr0.5Ca0.5MnO3 Manganite System, J. Magn. Magn. Mater. 485, 358 (2019).
2. Swain and V. Gorige,* Irreversible Meta-Magnetic Transition in Charge Ordere Nd0.5Ca0.5MnO3 Manganite, Phys. Status Solidi (b) 256, 1800707 (2019).
3. P. Bongurala and V. Gorige,* Structural, magnetic and electric properties of multiferroic NiFe2O4-BaTiO3 composites, J. Magn. Magn. Mater. 477, 350 (2019).
4. Swain, K. Komatsu, M. Itoh, T. Taniyama and V. Gorige,* Strain –mediated magnetic response in La0.67Sr0.33MnO3/SrTiO3/La0.67Sr0.33MnO3/BaTiO3 structure, AIP Advances 8,
5. 055808 (2018).
6. V. Gorige,* A. Swain, K. Komatsu, M. Itoh, and T. Taniyama, Magnetization reversal in Fe/BaTiO3(110) heterostructured multiferroics, Phys. Status Solidi-RRL (Rapid Research
7. Letters) 11,1700294 (2017).
8. V. Gorige,* K. Raju, D. H. Yoon, and P. S. Anil Kumar, Strain mediated magnetoelectric coupling in NiFe2O4-BaTiO3 multiferroic composite, J. Phys. D: Appl. Phys. 49, 405001 (2016).
9. B. K. Hazra, S. N. Kaul, S. Srinath, M. M. Raja, R. Rawat, and A. Lakhani, Evidence for the absence of electron-electron Coulomb interaction quantum correction to the anomalous Hall effect in Co2FeSi Heusler-alloy thin films, Phys. Rev. B 96 (18), 184434 (2017).
10. B. Koteswararao, T. Chakrabarty, T. Basu, B. K. Hazra, P. V. Srinivasarao, S. Srinath Large spontaneous exchange bias in a weak ferromagnet Pb6Ni9(TeO6)5, Sci. Rep. 7, 8300, (2017).
11. B. K. Hazra, M. Raja, and S. Srinath, Correlation between structural, magnetic and transport properties of Co2FeSi thin films J. Phys. D: Appl. Phys. 49, 065007 (2016).

4.4. Outcomes and Deliverables

Stated aims and objectives of the scheme

5. Establishment of Cryogen-free 9T superconducting magnet with Magnetic and Transport measurement facility at the University of Hyderabad.
6. Enable students and faculty of UoH and HEIs' across the country to access this facility which, in turn, will result in higher quality research output in areas spanning Physics, Chemistry and Engineering.
7. Publications in high impact factor journals
8. Better quality PhD theses in advanced materials, nanomaterials and devices, and allied areas.

4.4.1 Outcomes of the Scheme in the form of measurable indicators:

6. Publications in high impact factor journals.
7. More National and international collaborations
8. Project proposals submitted for funding, based on this facility
9. This facility will enable the researchers from UoH to contribute to the field of Spintronics, Multiferroic materials/devices, Functional Materials, and low-temperature Science.
10. M.Sc Projects and PhD theses based on this facility.
11. Trained human resource in low temperatures and Materials characterisation

4.4.2 Target Beneficiaries:

9. Students and faculty of UoH and HEIs' across the country with special focus on marginalized sections and other vulnerable groups.
10. Scientists from various national labs under DST, DRDO, CSIR such as DMRL, TCIS-Hyderabad and faculty and research scholars from local state universities/Institutes such as Osmania University, NIT Warangal
11. Materials, Electronics and Pharma Industries in the Hyderabad area such as and Dr. Reddy's labs

5. Title of the Scheme: Establishment of an Integrated Confocal Raman Microscopy System with FLIM and TLM (iCRM-FLIM-TLM Facility) at CFN, University of Hyderabad

5.1. Total Cost of the proposed Scheme: Rs. 3 crore (Three crore only)

5.2. Proposed duration of the scheme: FY 2021-22

5.3. Detailed Proposal

5.3.1 Introduction

Confocal Raman microscopy is a powerful tool for analysing of the chemical composition of heterogeneous samples on the sub-micrometre scale. The Raman effect is based on inelastic scattering of excitation light by the molecules of gaseous, liquid or solid materials. The interaction of a molecule with photons causes vibrations of its chemical bonds, leading to specific energy shifts in the scattered light that can be identified in its Raman spectrum. Any given chemical compound produces a particular Raman spectrum when excited and can be easily identified by this individual "fingerprint." Raman spectroscopy is a well-established and non-destructive method for analysing the molecular composition of a sample.[1,2] When Raman spectra are collected at every measurement point using a confocal microscope combined with a spectrometer, a Raman image can be generated that visualises the distribution of the sample's compounds. Due to the high confocality of integrated Confocal Raman Microscopy coupled with time-correlated single-photon counting Module for FLIM and TLM Applications (**iCRM-FLIM-TLM**), volume scans and 3D images can also be generated from 2D images from different focal planes.

Confocal Raman Microscopy - 3D Chemical Imaging

A Raman spectrum shows the energy shift of the excitation light (laser) as a result of inelastic scattering by the molecules in a sample. The excitation light excites or annihilates vibrations of the chemical bonds within the molecules. Different chemical species consist of different atoms and bonds so that each molecule can be easily identified by its unique Raman spectrum. As only molecular vibrations are excited (or annihilated), Raman spectroscopy is a non-destructive technique. In Raman imaging, the Raman spectra are collected with a high-throughput confocal microscope/Raman spectrometer combination. A high-sensitivity CCD camera connected to a powerful computer and software system is used to detect the Raman signal. With specialized software tools, imaging capabilities can be expanded even further. For example, it is possible to generate images by integrating over selected spectral areas, determining the peak width, peak position or by even more sophisticated procedures such as the fitting of complete spectra or cluster analysis. Imaging results may include information on the distribution of chemical compounds, amorphous/crystallinity-analysis and material stress characterization. The Confocal Raman set-up offers the unique ability to acquire chemical information non-destructively with a resolution down to the optical diffraction limit (~ 250 nm). This allows to observe and analyze the distribution of different phases within a sample in ambient conditions without specialized sample preparation. Because of the confocal setup, it is not only possible to collect information from the sample surface, but also to look deep inside transparent samples and even obtain 3D information.

3D Raman Imaging and Depth Profiles

3D volume scans and depth profiles are valuable tools in providing information about the dimensions of objects or the distribution of a certain compound throughout the sample. iCRM-FLIM equipped with a confocal microscope can provide depth resolution and a strongly reduced background signal and facilitate the generation of depth profiles and 3D images with exceptional spectral and spatial resolution. Images are recorded point by point and line by line while scanning the sample through the excitation focus. With this technique, the specimen can be analyzed in segments along with the optical axis and depth profiles or 3D images can be generated. Near-field Raman imaging is an exceptional microscopy technique which links chemical Raman information to high-resolution Scanning Near-field Optical Microscopy (SNOM). Thus near-field Raman allows for the acquisition of complete high-resolution confocal Raman images. Typically, lateral resolutions of below 100 nm can be achieved. Through the unique combination of a high throughput spectroscopic system with the cantilever-based SNOM technique and an unrivalled sensitivity and imaging, quality can be provided by a single microscope setup.

Time-correlated single-photon counting (TCSPC):

TCSPC records the time-resolved luminescence or fluorescence decay after pulsed stimulation.[3,4] In Time-resolved Luminescence Microscopy (TLM), the intensity decay is recorded at each image pixel. Various parameters describing each decay can be determined, such as single- or even multi-exponential relaxation times. Images can then be colour-coded according to any of the extracted parameters, revealing local differences in the emission behaviour of a sample. For example, extracting the lifetime of fluorophores allows for Fluorescence Lifetime Imaging (FLIM).[5] Combining the time-resolved data with Raman, AFM or SNOM images yields additional information on the investigated materials.

Time-resolved Luminescence microscopy (TLM):

With Time-resolved Luminescence Microscopy (TLM), the luminescence properties of light-emitting devices, such as LEDs, can be investigated and spatial differences can be revealed. Light emission is stimulated by an electrical pulse generator and its intensity is recorded in a time-resolved manner. Thus, relaxation times or response times can be calculated for each image pixel and visualized. TLM can be used, for example for the quality control of LEDs.

Fluorescence Lifetime Imaging (FLIM):

Fluorescence Lifetime Imaging Microscopy (FLIM) determines the average fluorescence lifetime for each image pixel from the time-resolved fluorescence decay after excitation by a pulsed laser. The resulting FLIM image is colour-coded according to the lifetime, displaying its spatial distribution in a sample. In combination with other imaging techniques, such as Raman imaging or AFM, FLIM extends the amount of information gained from one sample

Thus, iCRM-FLIM is a central facility to all types of materials science and engineering and enables understanding of many fundamental and applied aspects of physics, chemistry, life science and engineering by probing the physical and chemical interactions.[6] The high demands on device quality and reliability make it increasingly important to have a detailed knowledge of the inherent strain and crystalline properties of such device structures. Moreover, such sophisticated iCRM-FLIM-TLM imaging techniques provide the opportunity to analyse the samples comprehensively regarding their chemical and physical characteristics. Importantly, iCRM-FLIM-TLM provides a wide range of imaging techniques which can be flexibly combined in one microscope to significantly increase the insight provided by measurement results. Confocal Raman imaging provides chemical information, AFM detects topography, structure, and physical properties such as stiffness, adhesion, etc. of the sample’s surface, and SNOM high-resolution measurements can optically reach beyond the diffraction limit.

References:

1. V. Radhika, M. Annadhasan, J. Ravi, M. D. Durga Prasad, N. Mitetelo, K. Zhdanova, E. Mamonov, K. Muellen,* T. V. Murzina,* R. Chandrasekar**"Multifunctional Chiral pi -Conjugated Polymer Microspheres: Production and Confinement of NLO signal, Detection of Circularly Polarized Light and Display of Laser-Triggered NLO Emission Shifts."* ***Adv. Opt. Mater.*** (2020), accepted.
2. Mitetelo, N.; Venkatakrishnarao, D.; Ravi, J.; Popov, M.; Mamonov, E.; Murzina, T. V.; Chandrasekar, R. Chirality-Controlled Multiphoton Luminescence and Second-Harmonic Generation from Enantiomeric Organic Micro-Optical Waveguides. *Advanced Optical Materials* **2019**, *7*, 1801775.
3. Venkatakrishnarao, D.; Narayana, Y. S. L. V.; Mohaiddon, M. A.; Mamonov, E. A.; Mitetelo, N.; Kolmychek, I. A.; Maydykovskiy, A. I.; Novikov, V. B.; Murzina, T. V.; Chandrasekar, R. Two-Photon Luminescence and Second-Harmonic Generation in Organic Nonlinear Surface Comprised of Self-Assembled Frustum Shaped Organic Microlasers. *Advanced Materials* **2017**, *29*, 1605260.
4. Pan, J.; Sarmah, S. P.; Murali, B.; Dursun, I.; Peng, W.; Parida, M. R.; Liu, J.; Sinatra, L.; Alyami, N.; Zhao, C.; Alarousu, E.; Ng, T. K.; Ooi, B. S.; Bakr, O. M.; Mohammed, O. F. Air-Stable Surface-Passivated Perovskite Quantum Dots for Ultra-Robust, Single- and Two-Photon-Induced Amplified Spontaneous Emission. *The Journal of Physical Chemistry Letters* **2015**, *6*, 5027-5033.
5. Paul, S.; Samanta, A. N-Bromosuccinimide as Bromide Precursor for Direct Synthesis of Stable and Highly Luminescent Green-Emitting Perovskite Nanocrystals. *ACS Energy Letters* **2020**, *5*, 64-69.
6. Ahmed, T.; Seth, S.; Samanta, A. Mechanistic Investigation of the Defect Activity Contributing to the Photoluminescence Blinking of CsPbBr3 Perovskite Nanocrystals. *ACS Nano* **2019**, *13*, 13537-13544.
7. Ketavath, R.; Katturi, N. K.; Ghugal, S. G.; Kolli, H. K.; Swetha, T.; Soma, V. R.; Murali, B. Deciphering the Ultrafast Nonlinear Optical Properties and Dynamics of Pristine and Ni-Doped CsPbBr3 Colloidal Two-Dimensional Nanocrystals. *The Journal of Physical Chemistry Letters* **2019**, *10*, 5577-5584.

8. Sanghamitra Debroy, Santhosh Sivasubramani, Gayatri Vaidya, Swati GhoshAcharyya and Acharyya, A., Temperature and Size Effect on the ElectricalProperties of Monolayer Graphene based Interconnects for Next Generation MQCA based Nanoelectronics, *Scientific Reports*, 2019. (Accepted)

9. S. Sravanthi, Swati Ghosh Acharyya, K.V. Phani Prabhakar, Joydip Joarder, Effect of varying weld speed on corrosion resistance and mechanical behavior of Aluminium - steel welds fabricated by cold metal transfer technique, *Materials and Manufacturing Processes*, Volume 34, 1627-1637, 2019.

5.3.2 Origin of the proposal

The University of Hyderabad has five Schools of study (Physics, Chemistry, Life Sciences, Medical Sciences and Engineering Sciences and Technology) with several faculty members who are actively engaged in research and development related to a variety of materials. For example, in the School of Physics there is active interest in magnetic, optical, electronic, semiconducting, multi-ferroic and superconducting materials in bulk and thin-film form, sensors of different kinds, microelectronic and semiconductor devices, materials for energy storage, 2D materials and nanomaterials and devices. The School of Chemistry faculty are involved in R&D on advanced molecular materials, polymers, nanomaterials, catalysis, the new generation of photovoltaic cells and advanced inorganic-organic hybrids. In the School of Life Sciences, there is active interest in animal biology, plant sciences, biochemistry, biotechnology and the development of drugs, diagnostic tools and therapies for many life-threatening diseases. The School of Medical Sciences faculty is involved in optometry and vision sciences as well as fundamental aspects relating to public health, cognition and neurological issues. In the School of Engineering Sciences and Technology, there is a very major interest in high entropy alloys, piezo and Ferro-ceramics, graphene-based devices, steels, corrosion and micro-electro-mechanical systems. This non-exhaustive list of research areas is an indicator of the rich variety of inter-disciplinary research being carried out. One of the common themes threading through these areas is the need to probe and analyse chemical information, AFM detects topography, structure, and physical properties such as stiffness, adhesion, etc. of the sample’s surface.

5.3.3 Justification

The major lacuna in the facilities of the **UoH is the absence of iCRM-FLIM-TLM.** This multipurpose instrument (iCRM-FLIM) can be used for Raman and PL spectroscopy, PL Lifetime and time-correlated PL spectroscopy studies. Although UoH has Raman micro-spectroscopy we still do not have an integrated tool to investigate the vibration- and electronic- spectra and excited state PL life-time and optical light confinement effect, etc. The proposed instrument not only record the spectral data in a time-correlated manner but also useful to image the sample based on the generated data (Raman, PL, Life-time, etc.). The versatile nature of the instrument can not only be applied to bulk samples but also to nano/micro-scale samples as well. Samples such as routine chemical samples, speciality compounds such as drugs, polymers, biomacromolecules, protein and molecular crystals, heterojunctions, solar-cells, quantum dots, micro-device structures, optical cavities, etc., UoH alone many faculty members, scientists and research students are working on projects related to the above theme. Further, the proposed machine is simple to use and does NOT require additional resources such as cryo-liquid, special sample preparation facility, chillers, etc

5.4. Outcomes and Deliverables

Stated aims and objectives of the scheme

1. Establishment of an integrated Confocal Raman Microscopy coupled with time-correlated single-photon counting Module for FLIM and TLM Applications (**iCRM-FLIM**) facility at the University of Hyderabad.

2. Enable students and faculty of UoH and HEIs' across the country to access this facility which, in turn, will result in higher quality research output in areas spanning Physics, Chemistry, Life Sciences, Medical Sciences and Engineering.
3. Publications in high impact factor journals
4. Better quality PhD theses in advanced materials, nanomaterials and devices, biomaterials and allied areas.

5.4.1 Outcomes of the Scheme in the form of measurable indicators:

1. Publications in high impact factor journals.
2. More international collaborations
3. Project proposals submitted for funding, based on this facility
4. PG and PhD theses based on this facility.
5. Trained human resource in iCRM-FLIM.

5.4.2 Target Beneficiaries:

1. Students and faculty of UoH and HEIs' across the country with special focus on marginalized sections and other vulnerable groups.
2. Scientists from various national labs under DST, DRDO, CSIR etc.
3. Materials, Electronics and Pharma Industries in the Hyderabad area.

6. Title of the Scheme: Establishment of a Dual Focussed Ion Beam (FIB-SEM) facility at the Proposed IOE-Interdisciplinary Cluster Building, University of Hyderabad

6.1. Total Cost of the proposed Scheme: Rs. 6 crore (Six crore only)

6.2. Proposed duration of the scheme: FY 2022-23

6.3. Detailed Proposal

6.3.1 Introduction

Focused ion beam (FIB) technologies are used in many fields of science for site-specific analysis, imaging, milling, deposition, micromachining, and manipulation. Dual-beam platforms, combining a high-resolution scanning electron microscope (HR-SEM) and an FIB column, additionally equipped with precursor-based gas injection systems (GIS), micromanipulators, and chemical analysis tools (such as energy-dispersive spectra (EDS) or wavelength-dispersive spectra (WDS)), serve as multifunctional tools for direct lithography in terms of nano-machining and nano-prototyping, while advanced specimen preparation for transmission electron microscopy (TEM) can practically be carried out with ultrahigh precision. Especially when hard materials and material systems with hard substrates are concerned, FIB is the only technique for site-specific micro- and nanostructuring. Moreover, FIB sectioning and sampling techniques are frequently used for revealing the structural and morphological distribution of material systems with three-dimensional (3D) network at micro-/nanoscale.

6.3.2 Origin of the proposal

The University of Hyderabad has five Schools of study (Physics, Chemistry, Life Sciences, Medical Sciences and Engineering Sciences and Technology) with several faculty members who are actively engaged in research and development related to a variety of materials. For example, in the School of Physics there is active interest in magnetic, optical, electronic, semiconducting, multi-ferroic and superconducting materials in bulk and thin film form, sensors of different kinds, microelectronic and semiconductor devices, materials for energy storage, 2D materials and nanomaterials and devices. The School of Chemistry faculty are involved in R&D on advanced molecular materials, polymers, nanomaterials, catalysis, new generation of photovoltaic cells and advanced inorganic-organic hybrids. In the School of Life Sciences, there is active interest in animal biology, plant sciences, biochemistry, biotechnology and the development of drugs, diagnostic tools and therapies for many life-threatening diseases. The School of Medical Sciences faculty are involved in optometry and vision sciences as well as fundamental aspects relating to public health, cognition and neurological issues. In the School of Engineering Sciences and Technology there is very major interest in high entropy alloys, piezo and ferro-ceramics, graphene based devices, steels, corrosion and micro electro-mechanical systems. This non-exhaustive list of research areas is an indicator of the rich variety of inter-disciplinary research being carried out. One of the common themes threading through these areas is the need to probe and analyze elemental composition, empirical formula, chemical state and electronic state of the elements of the materials and devices.

The University established the Centre for Nanotechnology (CFN) in 2007 through a project funded by the Department of Science and Technology (DST). Subsequent to the completion of the project in 2014, the University is supporting all research activities of the CFN from its own resources. The mandate of the Centre, initially, was to facilitate research in nanoscience and nanotechnology within the University. In the last few years, the Centre has become a hub for advanced materials characterization, which is accessible to users across the country. It facilitates research activities of users from many HEIs including IITs, NITs, Central and State Universities and colleges. Access is open and transparent and based on a nominal user charge.

The Centre is equipped with facilities such as Transmission Electron Microscope with sample preparation facility, Physical Property measurement systems, SQUID, Scanning Near field optical microscope with Raman spectrometer, micro/Nano fabrication facility with class 100 and class 1000 clean room, photolithography facility, electron beam lithography and vacuum deposition systems.

6.3.3 Justification

One of the major lacunas in the facilities of the UOH is the absence of a nano – manipulator that is not just limited to surface. Nano-manipulation below surface is essential for realizing 3D fabrication. Heavy ions (Like Ga) are used in FIB systems to achieve 3D designs. Integration of microscopy, back scattering spectroscopy and other characterization techniques can further strengthen the system. A survey of the HEIs and national labs in Hyderabad shows that such facilities are available only in defence or national labs. These are not easily accessible and even if they are accessible the user charges are too high for users from Central and State Universities. Users requiring access to FIB typically go to IISc. Bangalore, IGCAR Kalpakkam or IIT Kanpur. It is difficult to get access to this facility. Clearly, the absence of the facility affects not only the University of Hyderabad but also users from across the region. There is, therefore, an urgent need to establish such a facility that will be beneficial to several hundred post-graduate and Ph.D. students and enable their institutions to carry out world-class research.

In a recent work 50 nanometer thin lamellae from Nano banite steel sample were prepared using **focused ion beam facility at TU-Delft in the Netherlands** under collaborative work with **University of Hyderabad and Tatasteel Europe**. Ultra-fine austenite grains could only be seen in transmission mode of EBSD which was prepared in Focused Ion Beam. There is, therefore, an urgent need to establish such a facility that will be beneficial to several hundred post-graduate and Ph.D. students and enable their institutions to carry out world-class research.

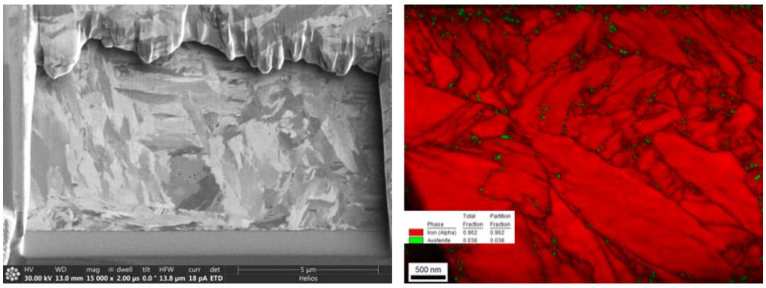

Figure 1: FIB sample of NanoBainite steel (left) and corresponding ultra-fine grain structure (right) of Austenite (green) and Bainite laths (red)

6.3.4. Outcomes and Deliverables

Stated aims and objectives of the scheme

1. Establishment of an Focused Ion Beam facility at the University of Hyderabad.
2. Enable students and faculty of UoH and HEIs' across the country to access this facility which, in turn, will result in higher quality research output in areas spanning Physics, Chemistry, Life Sciences, Medical Sciences and Engineering.
3. Publications in high impact factor journals
4. Better quality PhD theses in advanced materials, nanomaterials and devices, biomaterials and allied areas.

6.4.1 Outcomes of the Scheme in the form of measurable indicators:

1. Publications in high impact factor journals.
2. More international collaborations
3. Project proposals submitted for funding, based on this facility
4. PG and Ph.D. theses based on this facility.
5. Trained human resource in XPS.

6.4.2 Target Beneficiaries:

1. Students and faculty of UoH and HEIs' across the country with special focus on marginalized sections and other vulnerable groups.
2. Scientists from various national labs under DST, DRDO, CSIR etc.
3. Materials, Electronics and Pharma Industries in the Hyderabad area.

7. Title of the Scheme: Establishment of an Analytical Transmission Microscope facility at the the Proposed IOE-Interdisciplinary Cluster Building, University of Hyderabad

7.1. Total Cost of the proposed Scheme: Rs. 14 crore (Fourteen crore only)

7.2. Proposed duration of the scheme: 3-5 years

7.3. Detailed Proposal

7.3.1 Introduction

Analytical transmission electron microscope (ATEM) has become a tool for not only observing nano-scale structures, but also for capturing information on the interaction between the incident electrons and the atoms of the specimen. As a result, the application of the electron microscope has dramatically expanded. They are valuable tools in cutting-edge fields, such as scientific research and material development.

TEM imaging combined with electron diffraction and analytical methods like EDS and EELS becomes increasingly important in cross-sectional on-product characterization and defect analysis in semiconductor industry, mainly driven by the ongoing scaling-down of device structures Thus, Analytical TEM is a tool that is central to all types of materials science and engineering and enables understanding of many fundamental and applied aspects of physics, chemistry, life science and engineering by high resolution imaging.

7.3.2 Origin of the proposal

The University of Hyderabad has five Schools of study among the sciences (Physics, Chemistry, Life Sciences, Medical Sciences and Engineering Sciences and Technology) with several faculty members who are actively engaged in research and development related to a variety of materials. For example, in the School of Physics there is active interest in magnetic, optical, electronic, semiconducting, multi-ferroic and superconducting materials in bulk and thin film form, sensors of different kinds, microelectronic and semiconductor devices, materials for energy storage, 2D materials and nanomaterials and devices. The School of Chemistry faculty are involved in R&D on advanced molecular materials, polymers, nanomaterials, catalysis, new generation of photovoltaic cells and advanced inorganic-organic hybrids. In the School of Life Sciences, there is active interest in animal biology, plant sciences, biochemistry, biotechnology and the development of drugs, diagnostic tools and therapies for many life-threatening diseases. The School of Medical Sciences faculty are involved in optometry and vision sciences as well as fundamental aspects relating to public health, cognition and neurological issues. In the School of Engineering Sciences and Technology there is very major interest in high entropy alloys, piezo and ferro-ceramics, graphene based devices, steels, corrosion and micro electro-mechanical systems. This non-exhaustive list of research areas is an indicator of the rich variety of inter-disciplinary research being carried out. One of the common themes threading through these areas is the need to probe and analyze elemental composition, empirical formula, chemical state and electronic state of the elements of the materials and devices.

The University established the Centre for Nanotechnology (CFN) in 2007 through a project funded by the Department of Science and Technology (DST). Subsequent to the completion of the project in 2014, the University is supporting all research activities of the CFN from its own resources. The mandate of the Centre, initially, was to facilitate research in nanoscience and nanotechnology within the University. In the last few years, the Centre has become a hub for advanced materials characterization, which is accessible to users across the country. It facilitates research activities of users from many HEIs including IITs, NITs, Central and State Universities and colleges. Access is open and transparent and based on a nominal user charge.

The Centre is equipped with facilities such as Transmission Electron Microscope with sample preparation facility, Physical Property measurement systems, SQUID, Scanning Near field optical microscope with Raman spectrometer, micro/Nano fabrication facility with class 100 and class 1000 clean room, photolithography facility, electron beam lithography and vacuum deposition systems.

7.3.3 Justification

The major lacuna in the facilities of the **UoH is the absence of an Analytical TEM.** In the year 2009 Central Facility Nano Technology acquired the TEM with Lab6. The efficiency of the TEM has been reduced. School of Chemistry will acquire new TEM with FEG TIP with standard imaging and EDS facility. The proposed Analytical Transmission Electron Microscope will have additional features of .not only the nano structure but also for capturing information on the interaction between the incident electrons and the atoms of the specimen The large SSD area will ensure the detection of light element in EDS. The research interest of several faculty members of the School of Engineering Sciences and Technology, Physics, Chemistry and Life Sciences cover the following topics:

- Preparation and characterization of advanced structural engineering materials such as steels, Al-alloys, Ni-base superalloys, Ti- alloys, high-entropy alloys etc.
- Preparation and characterization of advanced functional ceramics and Nano materials
- Preparation and characterization of graphene based composites, energy storage materials, thin films, coatings, sensors etc.
- Bio- Materials

To realize the above mentioned objectives of high quality international research the Analytical Transmission Electron Microscope Facility with necessary accessories like in column energy filter with elemental mapping is essential.

References:

1) On the strain rate sensitive Characteristics of Nanocrystalline Aluminium Alloys Sridevi Varam, K Bhanu Sankara Rao and KV Rajulapati, TMS 2017

2) Loading rate dependent mechanical properties of BulkTwo phase Nanocrystalline Al-Pb Alloys studied by Nano Indentation. sreedevi varam, koteswararao v. rajulapati, k. bhanu sankara rao, ronald o. scattergood, korukonda l Murty, and carl c. Koch, Metallurgical and Materials Transections Volume 45 A October 2014, pp 5249

3) Strain controlled isothermal low cycle fatigue life, deformation and fracture characteristics of Superni 263 superalloy J. Jadav, K.V. Rajulapati, K. Bhanu Sankara Rao, N. Eswara Prasad, R. Mythili and Kartik Prasad, Materials science and Engineering A, 760, 2019, pp 296-315

4) Strengthening mechanisms in equiatomic ultrafine grained AlCoCrCuFeNi high-entropy alloy studied by micro- and nanoindentation methods Ramya Sree Ganji, P. Sai Karthik, K. Bhanu Sankara Rao and Koteswararao V. Rajulapati, Acta Materiala, Vol. 125, 2017 pp 58-68

5) A critical assessment of the microstructure and mechanical properties of friction stir welded reduced activation ferritic–martensitic steel Vijaya L. Manugula, Koteswararao V. Rajulapati, G. Madhusudhan Reddy, R. Mythili and K. Bhanu Sankara Rao, Materials and Design, Vol 92, 2016, pp 200-212.

7.3.4. Outcomes and Deliverables

Stated aims and objectives of the scheme

1. Establishment of an Analytical Transmission Electron Microscope facility at the University of Hyderabad.
2. Enable students and faculty of UoH and HEIs' across the country to access this facility which, in turn, will result in higher quality research output in areas spanning Physics, Chemistry, Life Sciences, Medical Sciences and Engineering.
3. Publications in high impact factor journals
4. Better quality PhD theses in advanced materials, nanomaterials and devices, biomaterials and allied areas.

7.4.1 Outcomes of the Scheme in the form of measurable indicators:

1. Publications in high impact factor journals.
2. More international collaborations
3. Project proposals submitted for funding, based on this facility
4. PG and Ph.D. theses based on this facility.
5. Trained human resource in XPS.

7.4.2 Target Beneficiaries:

1. Students and faculty of UoH and HEIs' across the country with special focus on marginalized sections and other vulnerable groups.
2. Scientists from various national labs under DST, DRDO, CSIR etc.
3. Materials, Electronics and Pharma Industries in the Hyderabad area.

8. Title of the Scheme: Establishment of 800 MHz NMR spectrometer at the Proposed IOE-Interdisciplinary Cluster Building, University of Hyderabad

8.1. Total Cost of the proposed Scheme: Rs. 15 Cr (Fifteen crore only)

8.2. Proposed duration of the scheme: 3-5 years

8.3. Detailed Proposal

8.3.1 Introduction

Research in the nuclear magnetic resonance (NMR) phenomenon involves a variety of areas that require a high field magnet. Such studies involve multi-dimensional spectroscopy in conjunction with specially designed radiofrequency pulses to examine structure and dynamics of large molecules, titanic proteins and their complexes up to the size of a little organelle. These studies occupy the interface of physics, chemistry, biology, and computational methods.

8.3.2. Origin of the proposal and Justification:

The major lacuna in the facilities of the **UoH is the absence of High Frequency NMR Spectrometer.** The requirement of a 800 MHz (118.8 Tesla magnetic field) spectrometer in the University was felt for almost two decades. The NMR researchers had to either drop out the idea of doing high field experiments or travel to Mumbai (TIFR) and Bangalore (IISc) to hire hundreds of hours of instrument time there. The lack of high field NMR in the University in fact impeded both development of the field and hiring of new NMR faculty.

The facility being asked will be used for a variety of RF-pulse programming, magnetic field gradient applications, development of NMR techniques and methodologies, and for solution structural studies of large molecular complexes that are not amenable otherwise. The proposed spectrometer will serve not only the University's existing NMR spectroscopists but also researchers from universities and institutions from other parts of the country.

Existing manpower expertise in the University is highly experienced in installation, software and hardware operation, and routine maintenance of high field spectrometers.

A few NMR papers (not limited) to justify the requirement of higher-filed NMR spectrometers

References:

1. Sahu, S. C., Bhuyan, A. K., Udgaonkar, J. B., and Hosur, R. V. (2000) Backbone dynamics of free barnase and its complex with barstar determined by ^{15}N NMR relaxation study, J. Biomol. NMR 18, 107-118.
2. Sahu, S. C., Bhuyan, A. K., Majumdar, A., and Udgaonkar, J. B. (2000) Backbone dynamics of barstar: a ^{15}N NMR relaxation study, Proteins: Struct. Funct. Genet. 41, 46-474.
3. Rao, D. K., and Bhuyan, A. K. (2007) Complexity of aromatic ring-flip motions in proteins: Y97 ring dynamics in cytochrome c observed by cross-relaxation suppressed exchange NMR spectroscopy, J. Biomol. NMR 39, 187-196.
4. Sashi, P., Singarapu, K. K., Bhuyan, A. K. (2018) Solution NMR structure and backbone dynamics of partially disordered Arabidopsis thaliana phloem protein 16-1, a putative mRNA transporter. Biochemistry 57, 912–924.

8.4. Outcomes and Deliverables

Stated aims and objectives of the scheme

1. Establishment of a High-frequency NMR facility at the University of Hyderabad.
2. Enable students and faculty of UoH and HEIs' across the country to access this facility which, in turn, will result in higher quality research output in areas spanning Chemistry, Life Sciences, and Medical Sciences.
3. Publications in high impact factor journals
4. Better quality PhD theses in advanced materials, nanomaterials and devices, biomaterials and allied areas.

8.4.1 Outcomes of the Scheme in the form of measurable indicators:

1. Publications in high impact factor journals.
2. More international collaborations
3. Project proposals submitted for funding, based on this facility
4. PG and Ph.D. theses based on this facility.
5. Trained human resource in high frequency NMR.

8.4.2 Target Beneficiaries:

1. Students and faculty of UoH and HEIs' across the country with special focus on marginalized sections and other vulnerable groups.
2. Scientists from various national labs under CCMB, CSIR etc.
3. Pharma Industries in the Hyderabad area

9.0. Facility management and Revenue generation

All the participating schools will strive to develop appropriate mechanisms to efficiently manage the equipment facilities after the acquisition and develop schemes for charging user fees for internal revenue generation and also possibly generating revenues from external users.

10. Purchase Procedure

The University of Hyderabad has an established purchase procedure which is fully compliant with the latest General Financial Rules of the Govt. of India. The users will strictly follow these purchase procedures along with HEFA guidelines in the purchase and procurement of the above equipment.

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