E.2: User activities at Indus beamlines

Indus-1 and Indus-2 are national facilities that have a total of 27 operational beamlines. These beamlines have been in regular use by the scientists, researchers and students from the Indian academia and Indian industry. The total number of user experiments that have been carried out at Indus beamlines during June-Dec 2025 were 482 and 120 peer reviewed publication generated. More than 104 academic institutes and 7 industries utilized Indus for their research work. Work on diverse topics have been carried out at the Indus beamlines. Some of the published works are highlighted below:

The Scanning EXAFS investigations revealed how atomic-level tailoring of Zn-ZIF-8 via RuNi nanoalloy replacement enhances hydrogen evolution reaction (HER) performance. Concurrent studies focus on Zn–air batteries, high-energy-density systems limited by sluggish oxygen reduction and oxygen evolution kinetics and the monofunctional behaviour of conventional metal–organic frameworks (MOFs). Measurements have been pivotal in the development of a bifunctional FeNi-MOF/C_3N_5 catalyst. EXAFS resolved the mixed Fe/Ni coordination environment, revealing metal-supported electronic coupling, charge redistribution, and reaction-specific catalytic switching. Consequently, the material functioned as an efficient bifunctional catalyst, improving battery power output and cycling stability (*Advanced Functional Materials Volume 36, Issue 19, 2025*).

Also, investigation was done on the role of orbital degrees of freedom in $CrVO_4$, focusing on orbital-driven spin-exchange interactions and spin-phonon coupling through both experiments using x-ray absorption fine structure measurements and first-principles calculations. This work was published in *Phys. Rev. Research 7, 043189, 2025*. The field of high-entropy oxides (HEOs) surprises traditional materials science. By exploring material properties via tuning configurational disorder one can imbues HEOs with surprising functional properties, sometimes surpassing those of their more ordered counterparts. Strain-Driven Lattice Distortion in Calcium-Added (Co, Cu, Mg, Ni, Zn)O and its Electrical Properties have been studied using spectroscopy beamlines at Indus *(Advanced Engineering Materials, Volume 27, Issue 23 2025)*.

Influence of high-pressure severe plastic deformation on germanium using rotational diamond anvil cell was examined using in situ scanning micro-XRD measurements. Nearly threefold reduction in the cubic diamond to β-tin phase transition (PT) was observed. PT initiation pressure varied from ~ 10.4 GPa under quasi-hydrostatic conditions to ~ 3.1 GPa under severe plastic deformation at high pressures. These findings provide the first in situ evidence of plastic strain–driven phase transformation in germanium and emphasize the critical role of deviatoric stresses in shaping phase behaviour in covalently bonded materials.

Protein crystallography beamline of Indus-2 has been used by various national labs. Crystal Structure of glucose tolerant beta-glucosidase has been determined which has implications in bioethanol production. Crystal structures of two artificial intelligence (AI) designed protein which bind specifically to cancer and SARS-CoV-2 proteins have been determined, which has importance for diagnosis and therapy. Crystal Structure of HadAB protein complexes with its substrate from TB causing bacteria, *Mycobacterium tuberculosis*, have also been determined. In the calendar year, total of 30 protein structures has been released in Protein Data Bank (PDB) and published in peer-reviewed journals.

Synchrotron-assisted micro X-ray fluorescence based mapping of micro nutrient was carried out using microprobe-XRF beamline. The study was done on for four representative Indian wheat varieties; namely Emmer (Khapli), Bansi (durum), Sonamoti (Indian dwarf wheat), and black wheat. A thin transverse cross-section of the wheat grain was prepared using microtome cutter of thickness ~ 200 µm to investigate the spatial distribution of important micro-nutrients present in different varieties of grains. µ-XRF results clearly demonstrate that elemental distribution within the wheat grains is highly non-uniform and strongly dependent on grain anatomy. In case of all wheat grains, K, Fe, Cu, and Zn were found to be predominantly localized in the bran layer region, particularly in the aleurone region, while the endosperm region was largely devoid of essential micronutrient elements. This observation highlights that there are fair chances of loss of essential minerals during the conventional milling processes that removes mostly bran region. This study showed that Sonamoti wheat, which is considered to be very age-old Indian wheat variety, contains relatively higher amount of micronutrients abundance compared to other wheat varieties *(Analytical Letters, Volume 59, Issue 6, 1096-1108, 2025)*.

Regarding applications for DAE and ISRO, stress analysis of different weld joints and components have been carried out for optimizing the fabrications process. Also, number of soft and hard x-ray detectors were calibrated for ISRO's Aditya mission.

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