**Diamond-Anvil Cell Infrared Facility at the National Synchrotron Light Source II**

2016 COMPRES Annual Report

November 2015 – October 2016

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Geophysical Laboratory, Carnegie Institution of Washington

**Overview**

**F**rontier Synchrotron **I**nfrared **S**pectroscopy Beamline under Extreme Conditions (FIS), the successor of NSLS-U2A, will be the first synchrotron infrared (IR) beamline on the NSLS-II experimental floor and a new home for high-pressure infrared user community. NSLS-II committed over $2M from its FY16 operation funds for two major FIS/MET beamline developments including procurements of the dipole vacuum chamber for IR beam extraction and acquisition/installation of the FIS/MET beamline cabins. The construction of the FIS/MET beamline cabins is projected to be completed and ready for beneficial occupancy in the spring of 2017. At that time, the integrated optical facility for far-IR to UV absorption and reflectance spectroscopy with conventional sources, together with laser Raman and photoluminescence spectroscopy will open for users for experiments. The installation of the dipole vacuum chamber for IR beam extraction has been scheduled at the end of 2017. FIS/MET will adapt one of the novel design features of NSLS II – the large-gap IR dipole – to provide unparalleled brightness and more than an order of magnitude of flux compared to U2A throughout much of the IR spectrum. It will also have the improved far-IR capabilities that have made the high-pressure synchrotron IR program at NSLS unique. The source will also have exceptional stability for spectroscopic studies under extreme conditions such as static and dynamic compression and variable temperatures. Full synchrotron IR capability is expected in early 2018. FIS as a new and state-of-art integrated synchrotron IR facility will continue to be a COMPRES showcase for the worldwide earth science and high-pressure research communities and a unique resource for COMPRES user community. The new capabilities such as in-situ high *P-T* synchrotron FTIR spectroscopy combined with laser heating technique will greatly promote our users’ research projects to address problems ranging from outer solar system bodies to the Earth’s core, complemented by studies in materials science, condensed-matter physics, and chemistry (many of which are also carried out by the COMPRES user community).

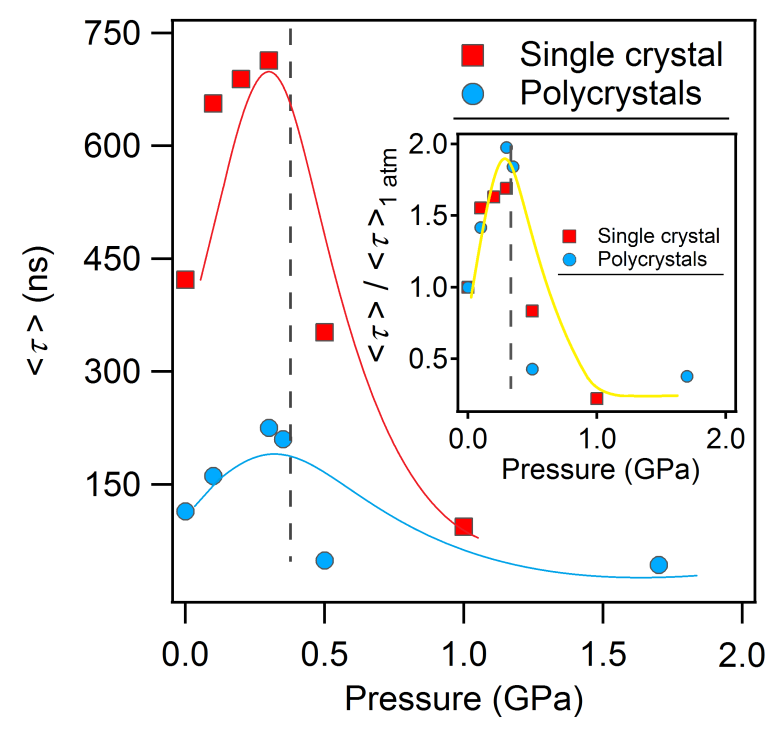
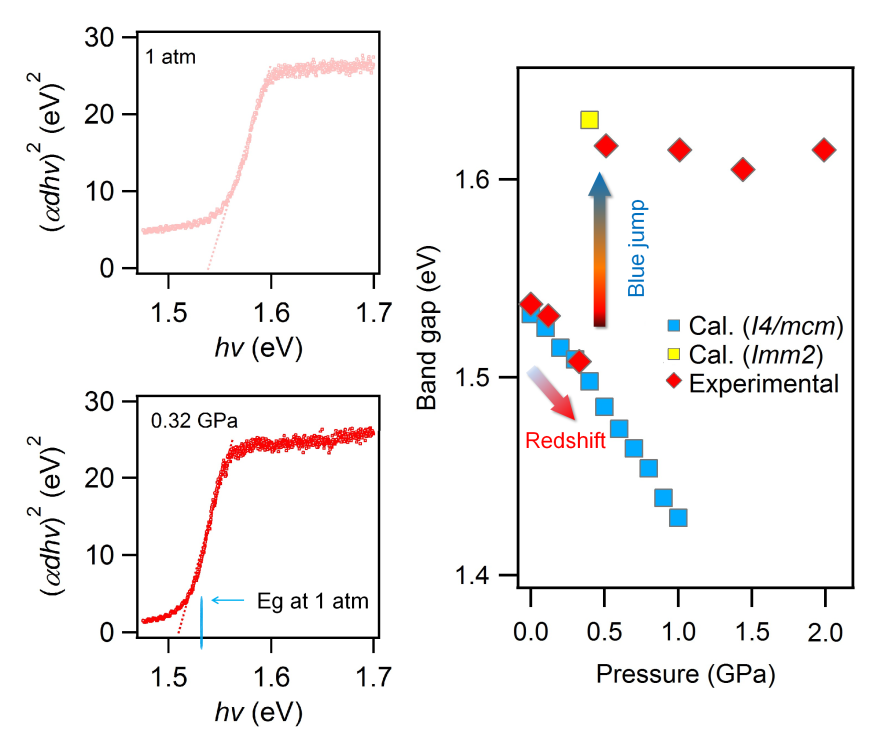
To bridge the gap between NSLS and NSLS-II, we established an offline infrared lab including FTIR and Raman spectroscopic systems and available for users since May 2016 (the first user research lab of NSLS-II open to general users). In addition, an Advanced Program proposal for developing high-pressure IR programs at Advanced Light Source has been approved and a custom IR microscope system has been set up in August 2015. Up to 50% of the AP beamtime could be allocated to COMPRES users as needed. We started to provide on-site or mail-in user support since January 2016.

**Scientific Highlights**

**a. *Pressure-tuned Hybrid Perovskites (first user publication from the IR Lab)***

The organic–inorganic hybrid lead trihalide perovskites have been emerging as the most attractive photovoltaic materials. As regulated by Shockley–Queisser theory, a major materials science challenge for improvement to the next level requires further band-gap

narrowing for broader absorption in solar spectrum, while retaining or even synergistically prolonging the carrier lifetime, a critical factor responsible for attaining the near-band-gap photovoltage. A new study led by **L. Kong** (HPSTAR and Carnegie Institution) reports an unprecedented simultaneous enhancement in both band-gap narrowing and carrier-lifetime prolongation (up to 70% to ∼100% increase) by applying controllable hydrostatic pressure under mild pressures at ∼0.3 GPa. The pressure-induced modulation of pure hybrid perovskites without introducing any adverse chemical or thermal effect clearly demonstrates the importance of band edges on the photon–electron interaction and maps a pioneering route toward a further increase in their photovoltaic performance. The pressure dependence of the band gap, a key finding of this study, was obtained at the IR Lab, the first ‘user research lab’ available for general users at NSLS-II.



**(a)**

**(b)**

**(c)**

**(d)**

***Figure 1.*** *Realization of band edges approaching in MAPbI3 single crystal upon compression. (A and B) Direct band-gap Tauc plots for MAPbI3 single crystals at 1 atm and 0.32 GPa. The magnitude of band gap can be determined by extrapolating the linear portion of the Tauc plot to the baseline. Pressure-driven red-shift of the band gap gradually occurs between 1 atm and 0.3 GPa, followed by a blue jump at 0.51 GPa, corresponding to the low-pressure and high-pressure phase ranges, respectively. (C) Pressure-driven band-gap evolution of MAPbI3. Band edges approaching was realized in a low-pressure phase range. (D) Pressure dependence of the mean carrier lifetime, <τ> = [ατ1/(ατ1+βτ2)]τ1 + [βτ2/(ατ1 + βτ2)]τ2, for both MAPbI3 single-crystal and polycrystal samples. Peak values in carrier lifetimes of MAPbI3 were observed at 0.3 GPa. Inset: a normalized result. Compared*

*with the values of <τ> measured at 1 atm, dramatic increases of ∼70% and ∼100% were observed at 0.3 GPa for single crystals and polycrystals, respectively.*

*Reference:* L. Kong, G. Liu, J. Gong, Q. Hu, R.D. Schaller, P. Dera, D. Zhang,

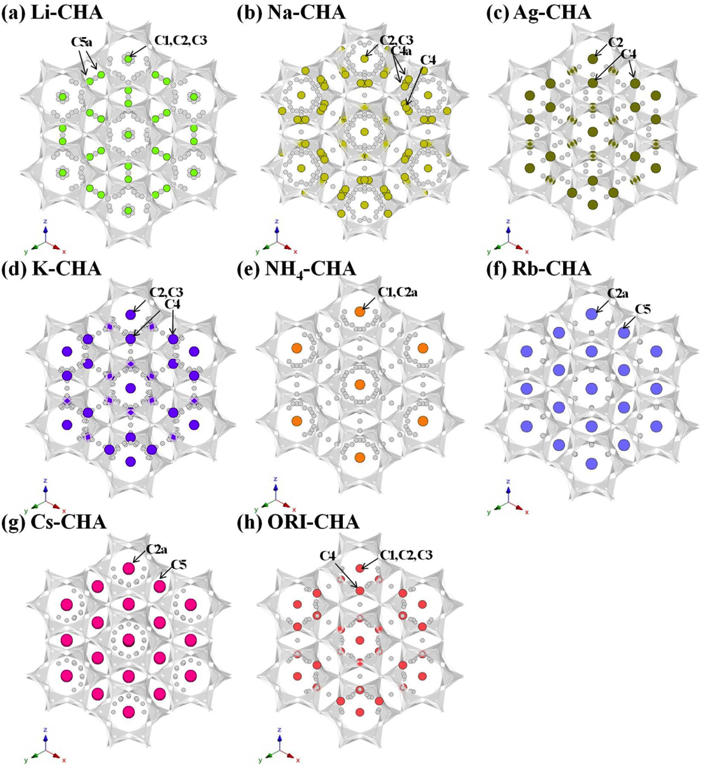
Z. Liu, W. Yang, K. Zhu, Y. Tang, C. Wang, S.Wei, T. Xu, and Ho-kwang Mao, Simultaneous Band-gap Narrowing and Carrier-lifetime Prolongation of Organic–inorganic Trihalide Perovskites, *Proc Natl Acad Sci USA*, **113**(32), 8910-8915 (2016).

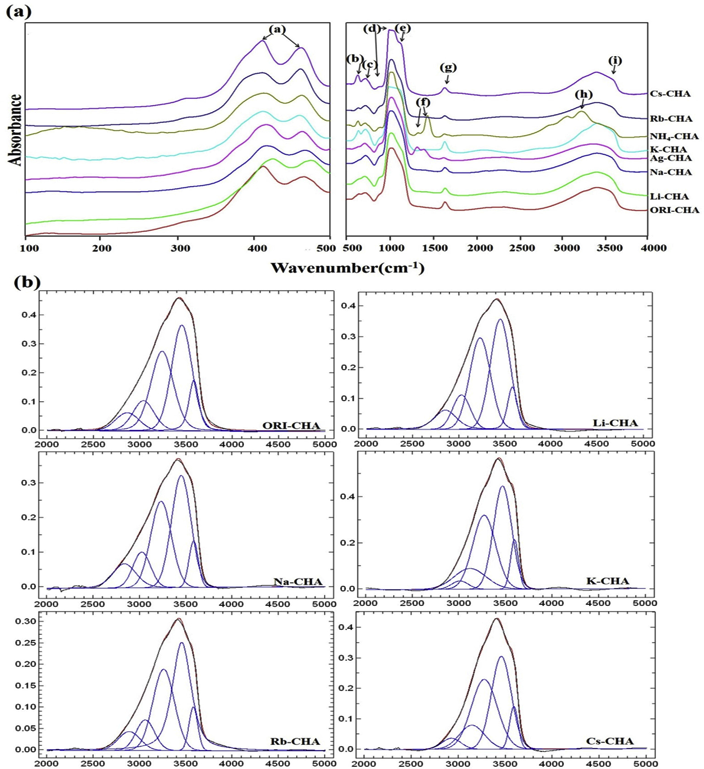
**b. *Chabazite structures with Li+, Na+, Ag+, K+, NH4+, Rb+ and Cs+ as extra-framework cations***

Chabazite is one of the most ubiquitous natural zeolites and has excellent ion-exchange properties and a wide range of industrial and technological applications. Natural chabazite is a mineral with variable composition (i.e. Ca1.6Na0.5Si8.4Al3.6O24•14.3H2O) and occurs predominantly in cavities of basaltic rocks. Its framework is built up of double six-membered rings (D6R) stacked in an ABC sequence and linked by tilted four-membered rings. The six-membered rings form the top and bottom of the D6R secondary building unit, whose geometry is approximately that of a hexagonal prism. The framework contains large ellipsoidal cavities with approximate apertures of 6.7×10 Å which are accessible through eight-membered rings.

In recent work led by **M. Kong** from Yonsei University, chabazites with Li+, Na+, Ag+, K+, NH4+, Rb+, Cs+ as monovalent extra-framework cations have been prepared from natural chabazite (ORI-CHA, Ca1.6Na0.5Si8.4Al3.6O24•14.3H2O) and characterized using a combination of Rietveld analyses of high-resolution synchrotron X-ray powder diffraction data and synchrotron infrared (IR) spectroscopy. All monovalent cation-exchanged chabazites crystallize in the rhombohedral space group R3m. The studies not only establish correlations between the unit-cell volume, extra-framework cation distribution, and cation selectivity in chabazites but also reveal that the unit cell volume of monovalent-cation exchanged chabazites decreases in the order of decreasing ion selectivity, based on the standard free hydration energies of exchange i.e., Cs+> K+> Ag+> Rb+> Na+> Li+ and not the cation size.

This work has demonstrated that the crystal chemistry of chabazite can be extended to larger monovalent cations and the occupancy of extra-framework cation sites varies depending on the cation. The extent of the volume expansion or reduction observed as the cation varies reveals lower values than those reported for natrolites. The chabazite framework is a rigid aluminosilicate structure with 3-dimensional channels and its medium Si/Al ratio favors cation exchange by monovalent cations or divalent ones with low hydration energies. The variation of the unit cell volume in monovalent-cation exchanged chabazites and the cation selectivity sequence allows for tailored molecular absorption and sieving as well as the immobilization of toxic and environmentally undesirable metals and complexes (i.e. NH4+) or radionuclides (i.e. 137Cs+).





***Figure 2.*** *Left: Structural models of the hydrates phases at ambient conditions of (a) Li-CHA, (b) Na-CHA, (c) Ag-CHA, (d) K-CHA, (e) NH4-CHA, (f) Rb-CHA, and (g) Cs-CHA, (h) Ca, Na-CHA, depicted along the ternary axis [111]. Opened circles represent known extra-framework cation sites; filled ones indicate newly established ones. Gray small ones are oxygen atoms of H2O molecules. Gray stick bond, tetrahedron, illustrate a disordered distribution of Si (Al) atoms in the framework.*

*Right:(a) Far- and mid-IR absorption spectra from 100 to 500 cm-1 and 500 to 4000 cm-1 for Li-, Na-, K-, NH4-, Rb-, Cs-exchanged chabazites. Bending O–Si(Al)–O (a), Libration of H2O. (b) Symmetric stretching Si(Al)–O (c), Antisymmetric stretching Si(Al)–O (d), Stretching TO4 (e), Vibration NH4 (f), Bending H–O–H (g), Vibration NH4 (h), Antisymmetric and symmetric stretching vibration O–H (i). (b) IR spectra (2500-4000 cm-1) peak fitting of Li-, Na-, K-, NH4-, Rb-, Cs-exchanged chabazites.*

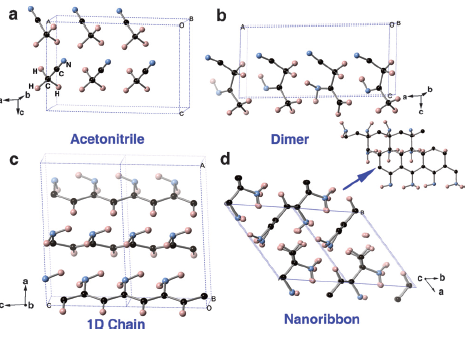
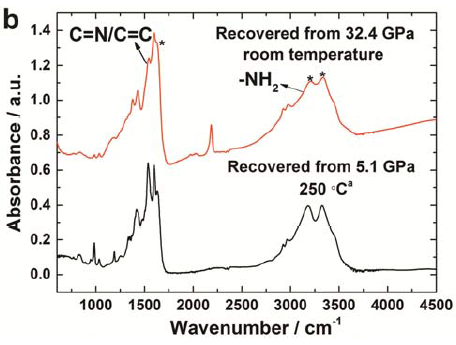
*Reference:* M. Kong, Z. Liu, T. Vogt, Y. Lee, Chabazite Structures with Li+, Na+, Ag+, K+, NH4+, Rb+ and Cs+ as Extra-framework Cations, *Microporous Mesoporous Mater.*, **221**, 253-263 (2016).

**c. *Pressure-Initiated Polymerization***

Chemical reactions involving acetonitrile (CH3CN) most often occur as the result of activating the C-N triple bond, while the C-H bonds are generally considered inert. Weak intermolecular hydrogen bonds of the N - - H - C type, however are susceptible to modification by applied pressure. Now a group led by**H. Zheng** (HPSTAR and Carnegie Institution) has shown that at modest pressures in the diamond anvil cell, the C-H bond in acetonitrile is activated and results in the formation of an amino group, initiating polymerization of the molecule. Infrared Spectroscopy Beamline U2A at NSLS has played a key role in the characterization of a new polymeric material synthesized at high pressure from acetonitrile, (CH3CN).

Acetonitrile undergoes a phase transition at about 5 GPa, and then becomes amorphous at about 20 GPa. In this new work, infrared spectroscopy shows the presence of C=N, C=C and -NH2group vibrations above 23 GPa, indicating that a polymerization reaction has taken place involving transfer of a hydrogen atom from the H3C- group to either the the other carbon atom or the nitrogen atom. The polymerization reaction results in the formation of dimers, one-dimensional chain and two-dimensional ribbon-type structures with both sp2- and sp3-bonded carbon atoms (Fig. 3). The sensitivity of infrared spectroscopy to the presence of the C=C, C=N and -NH2 groups permits the observation of the onset of polymerization within narrow pressure intervals. At room temperature, the onset of polymerization takes place at about 32 GPa, but at 251 oC, the reaction takes place at only 7 GPa. Upon decompression, ammonia is released and a carbon-enriched material is formed.

Acetonitrile is one of a number of organic compounds that have been discovered in outer space and is thought to be involved in the origins of simple amino acids, one of the basic molecules of life. In a cosmic event such as an asteroid collision, the pressures and temperatures generated can be very large, well exceeding the conditions of the current experiments. With the addition of oxygen to acetonitrile, possibly through reaction with carbon dioxide or water, complex carbon structures similar to the kind proposed for early formation of amino acids on Earth may be realized.

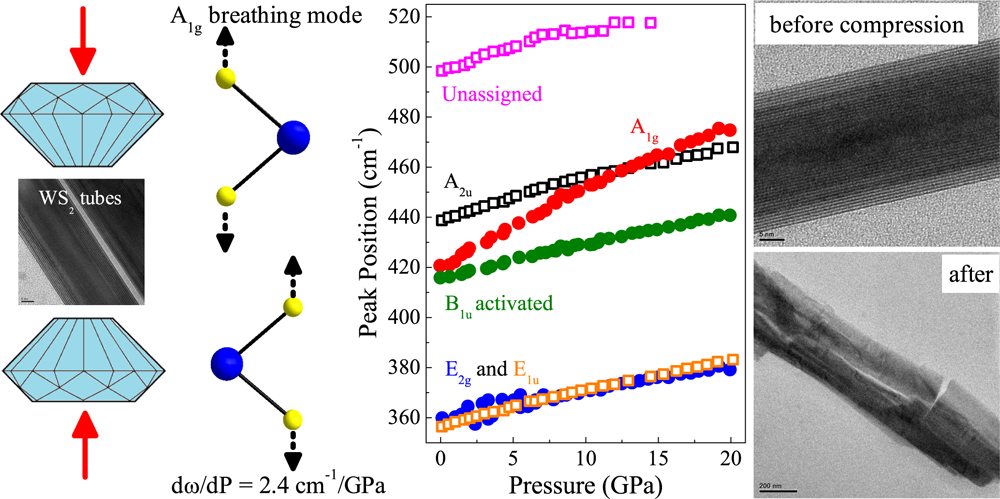
***Figure 3.*** *Left: The possible reaction process of acetonitrile under high pressure indicated by metadynamic calculations at 35 GPa. Right: The IR spectra of the product recovered from 32.4 GPa, room temperature and 5.1 GPa, 250 °C. aThe pressure is dropped from 7.2 GPa to 5.1 GPa after getting reaction.*

*Reference:* H. Zheng, K. Li, G. Cody, C. Tulk, X. Dong, G. Gao, J. Molaison, Z. Liu, M. Feygenson, W. Yang, I.N. Ivanov, L. Basile, J. Idrobo, M. Guthrie, and Ho-kwang Mao, Polymerization of Acetonitrile via a Hydrogen Transfer Reaction from CH3 to CN under Extreme Conditions, *Angew. Chem. Int. Ed.*, **55**(39), 12040 –12044 (2016).

**d. *High Pressure Vibrational Properties of WS2 Nanotubes***

Transition metal dichalcogenides are attracting tremendous interest due to their exotic properties and demonstrated applications. These van der Waals solids form multiwall nanotubes and nanoparticles, and just like graphite, they can be cleaved into single- and few-layer sheets. The tubes and particles are well-known to display superior mechanical stability and solid-state lubrication properties that have led to their commercial availability and wide use in power generation, heavy industry, mining, and potential application in jet engines and medical devices. Nanotube-reinforced polymer composites also benefit from the small tube size, modulus, and high aspect ratio, as well as excellent dispersion and adhesion to the polymer matrix. Under high shearing rates, however, the tubes and particles begin to deform and exfoliate. The recent availability of macroscopic quantities of multiwall WS2 nanotubes provides an opportunity to reveal the behavior of different local lattice distortions under pressure and by doing so test various breakdown pathways.

A new study led by **K. O’Neal** (University of Tennessee) brings together synchrotron-based infrared and Raman spectroscopies, diamond anvil cell techniques, and an analysis of frequency shifts and lattice dynamics to unveil the vibrational properties of multiwall WS2 nanotubes under compression. While most of the vibrational modes display similar hardening trends, the Raman-active A1g breathing mode is almost twice as responsive, suggesting that the nanotube breakdown pathway under strain proceeds through this displacement. At the same time, the previously unexplored high-pressure infrared response provides unexpected insight into the electronic properties of the multiwall WS2 tubes. The development of the localized absorption is fit to a percolation model, indicating that the nanotubes display a modest macroscopic conductivity due to hopping from tube to tube. Transmission electron microscope images taken after compression support the possible involvement of this mode in the tube breakdown mechanism.

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***Figure 4.*** *Right: Schematics of the anvils/sample configuration, A1g breathing mode, and its pressure coefficient. Middle: Frequency versus pressure for the IR- (open squares) and Raman-active (closed circles) modes, displaying the stronger pressure sensitivity of the A1g mode. The unassigned feature is likely a combination mode rather than a fundamental. Left:* high-resolution transmission electron microscopy images of the WS2 nanotubes before and after compressions.

*Reference:* K. O’Neal, J. Cherian, A. Zak, R. Tenne, Z. Liu, and J. Musfeldt, Revealing the pressure-induced breakdown pathway in WS2 nanotubes, *Nano. Lett.*, **16**(2), 993-999 (2016).

**Beamline Personnel**

The management team is headed by PIs Russell J. Hemley (Professor, George Washington University; Visiting Investigator, Geophysical Laboratory) and Zhenxian Liu (Research Scientist, Geophysical Laboratory). Carnegie serves as the funding host for the current phase of the project.

***Beamline Scientist***

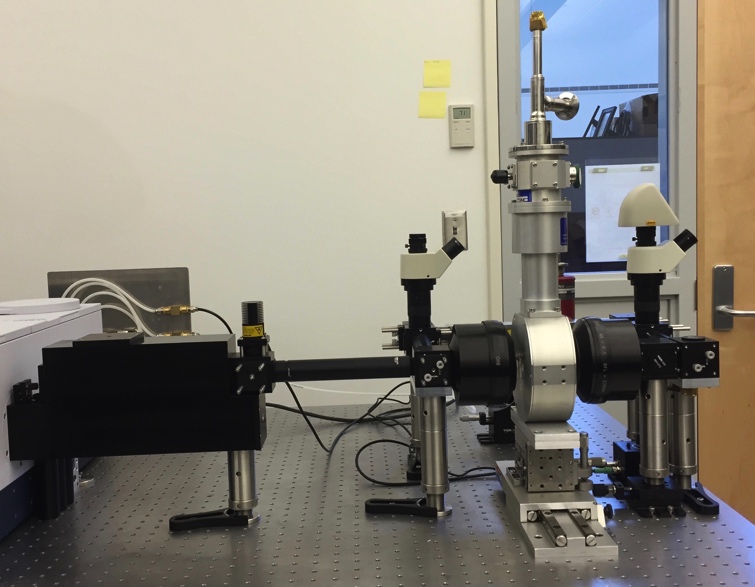
Zhenxian Liu was appointed as Research Scientist/Beamline Scientist at Carnegie in 2000. He provided scientific and technical support to the high-pressure programs at the U2A beamline. As the lead beamline scientist of FIS at NSLS-II, the successor of NSLS-U2A, he is in charge the transition of the NSLS-U2A facility to FIS, setting up the Infrared Lab, and the FIS development at NSLS-II. He has a strong background in spectroscopy, solid-state physics, and multiple synchrotron techniques. He actively develops novel experimental techniques (e.g., vacuum far-IR spectroscopy down to 30 cm-1 at high pressure and cryogenic techniques with DACs down to 5 K and 360 GPa, far-IR reflectivity spectroscopy over megabar pressure, and off-line CO2 laser heating for DACs) and assists users in carrying out research projects in geoscience, planetary science, materials science, condensed matter physics, and chemistry. In addition, he uses synchrotron infrared spectroscopy, Raman scattering, photoluminescence as well as synchrotron x-ray diffraction techniques to explore physical and chemical properties and phase transitions of hydrous minerals, simple molecular systems, and nanoscale materials at high pressures and variable temperatures.

**Beamline Operations**

Significant progress has been made in terms of operation of the IR Lab at NSLS-II and the high pressure IR user program at ALS. The IR Lab was officially open for general users in May 2016. It is first and still the only research laboratory available for general users through peer review process at NSLS-II. Almost 30 user proposals have been received, reviewed, and allocated laboratory time since May 2016. One of the custom IR microscopes has been moved from NSLS and installed at ALS IR beamline 1.4.3 made the high-pressure IR measurements more feasible. There is a significant increase of user beam time for high-pressure studies at 1.4.3 since we started our high-pressure IR program there including coordinated user beam time and on-site user support. All these activities are summarized in Appendix 2 and 3. Our effort will continue to minimize the impact of the “dark period” due the NSLS shutdown and before the first IR light at FIS, NSLS-II.

**Beamline Development: *expand the capability from high-P and room T to high-P variable T at the Infrared Lab, Bldg. 741, NSLS-II***

In situ FTIR measurements under high pressure and variable temperature require larger space to accommodate various devices such as cryostat and furnace combined with DACs. However, the reflective objectives, key components in IR microscope, normally have shorter working distance or smaller numerical aperture. We developed a specially designed objective with long working distance (WD=40 mm) and large numerical aperture (NA=0.5) in collaboration with INO. A new custom IR microscope (see Figure 5) was developed and installed together with Bruker Vertex 80v FTIR spectrometer at the IR Lab, NSLS-II. This new system will be able to accommodate existing cryostat and heating devices combined with different types of DACs and significantly enhance the performance at high pressure and broad temperature range. An existing micro-Raman system with a 647nm solid-state laser will be added soon. As a result, the capabilities at the IR Lab will be expanded from high pressure and room temperature to high pressure and variable temperatures.



*Figure 5. New custom IR microscope system installed in the IR Lab at Bldg. 741, NSLS-II. This new system will be able to accommodate cryostat or external heating DAC devices due to its long working distance (>80 mm). Combined with Bruker FTIR spectrometer Vertex 80v, it will significantly improve the performance for IR measurements under extreme P-T conditions due to its large numerical aperture (NA=0.5). The existing micro-Raman system with red laser (λ=647nm) will be coupled with this IR system upon safety approval by NSLS-II.*

**Planned Activities**

As the ~$2M committed funding took place by NSLS-II through its 2016 operation funds for two major procurements including the dipole vacuum chamber for IR beam extraction and acquisition/installation of the FIS/MET beamline cabins, we will start to focus the transition from offline IR Lab to the activities on the NSLS-II experimental floor. The planned activities for will include:

***a) Relocating and installing all equipment in FIS cabins on the NSLS-II experimental floor***

The construction of the FIS/MET beamline cabins is going to begin in December 2016 and expected to be ready for beneficial occupancy in March-May, 2017. We will install a new FTIR spectrometer (Bruker Vertex 80 currently in process of procurement). This will allow us to simultaneously keep the IR Lab open for general users while relocating and installing rest equipment including the new spectrometer and those in the storage area. We expect to have two end stations ready for users in October 2017.

***b) Planned installation of dipole vacuum chamber for IR beam extraction***

The dipole vacuum chamber for IR beam extraction is currently under fabrication. The projected installation will take place at the NSLS-II storage ring during the December 2017 winter shutdown period. We are going to actively engaged in the process and ensure the feasibility for coupling the synchrotron IR beam with the two end stations inside the FIS cabin. If all goes as planned, we could start to set up the beam delivery pipe system in early 2018 following user’s science commissioning.

**Budget**

Actual and anticipated spending for beamline operations (June 2016– May 2017):

**1. Budget for Beamline Operations: June 2016-May 2017**

|  |  |  |  |
| --- | --- | --- | --- |
| Personal:  Beamline scientist | Salary plus fringe benefits | $149,910 | These include a normal raise and cost of living adjustment for the beamline scientist. |
| Materials/supplies  a.  b. | Operation    Equipment | $16,072  $8,000  $9084 | Miscellaneous expenses for the offline Infrared Lab operation at NSLS-II;  Miscellaneous expenses for high-pressure IR beamline activities/user experiments at ALS (4×$2000/trip);  Optical components for a custom IR microscope with long working distance (WD=40mm) and large numerical aperture (NA=0.5) installed in the IR Lab and future end station of FIS. |
| Travel | Travel for beamline scientists | $3,000 | Travel between BNL and Washington as well as for the beamline scientist to attend COMPRES and other scientific meetings. |
|  | Total direct cost | **$183,065** |  |
| **Total cost for operation** |  | **$237,000** | This total includes indirect costs at a rate of 31%. ($173,982×1.31\*) plus the equipment ($9084) |

\* Indirect Costs  
Carnegie has a rate agreement with its cognizant agency, NSF, which has issued a maximum provisional indirect cost rate of 75.0% for FY2015; however, for administrative purposes the Carnegie Institution is voluntary limiting its indirect cost recovery to 31.0% of Total Modified Direct Costs (TMDC). Total Modified Direct Costs are calculated as Total Direct Costs minus Equipment, Participant Support Costs, and Subcontract costs in excess of $25,000 for each subcontract.

**2. Budget Request for Beamline Operation: June 2017-May 2018**

|  |  |  |  |
| --- | --- | --- | --- |
| Personal:  Beamline Scientist\* | Salary plus fringe benefits | $169,695 | This includes a normal raise and cost of living adjustment for the beamline scientist |
| Materials/Supplies  a.  b. | NSLS-II fees & stockroom  Diamond anvils and heating cell accessories | $12,043  $6,000 | Routine beamline expenses including office spaces, phone charges, and materials such as liquid helium  Type IIa anvils and parts for external heating DACs required for dedicated use for high P-T experiments at the facility |
| Travel | Travel for senior personnel | $6,000 | Travel between BNL and Washington and to attend annual COMPRES and other scientific meetings |
|  | Total direct cost | **$193,738** |  |
| **Total** |  | **$244,110** | This total includes indirect costs\*\* at a rate of 26% ($193,738×1.26). |

\* Fringe benefits: The GWU’s fringe benefit rate is 25.7%. Fringe benefits include normal costs associated with employment such as retirement, Social Security, Medicare, disability insurance, health insurance and other required taxes. Salaries are based on a full calendar year and include all leave taken.

\*\* Indirect costs: The off-campus indirect cost rate is 26.0% of total modified direct costs (TMDC). Total modified direct costs are calculated as total direct costs minus equipment, and participant support Costs.

**Appendices**

**1. A publication list for 2015 and 2016:**

Brinzari, T., K. O'Neal, J. Manson, J. Schlueter, A. Litvinchuk, Z. Liu, and J. L. Musfeldt, Local lattice distortions in Mn[N(CN)2]2 under pressure, *Inorganic Chem*., **55**, 1956-1961 (2016).

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Kong M., Z. Liu, T. Vogt, Y. Lee, Chabazite Structures with Li+, Na+, Ag+, K+, NH4+, Rb+ and Cs+ as Extra-framework Cations, *Microporous Mesoporous Mater.*, **221**, 253-263 (2016).

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**2. List of users & affiliations**

**a. Users who performed experiments at the IR Lab, NSLS-II since May 2016:**

Yale University: Kanani Lee, Jie Deng, Kierstin Daviau, and Sarah M. Arveson;

Stanford University: Yu Lin, Bridget Connor, and Adam Jaffe;

University of Chicago: Elizabeth Thompson and Anne Davis;

University of Tennessee: Janice Musfeldt, Amanda Clune, and Ken O’Neal;

NJIT: Andrei Sirenko and Taras;

HPSTAR: Lingping Kong, Gang Liu, Bin Chen, Hengzhong Zhang, Zhiqiang Chen, Lulu Geng, and Yunqi Gong.

**b. Mail-in users at the IR Lab, NSLS-II and on-site users supported at 1.4.3 beamline, ALS**

Stanford University: Yu Lin;

Yale University: Kanani Lee and Sarah M. Arveson;

Yonsei University: Yongjae Lee, Huijeong Hwang and Donghoon Seoung;

University of Chicago: Elizabeth Thompson;

Arizona State University: Dan Shim and Huawei Chen;

University of California at Santa Crus: Earl O'Bannon;

HPSTAR: Hong Fang and Bingbing Yue;

Geophysical Laboratory: Haidong Zhang, Tim Strobel, Ajay Mishra, and Muhetaer Aihaiti;

Pennsylvania State University: Xiang Li;

University of Hawaii: Murli Manghnani;

University of Saskatchewan: John Tse;

National Research Council of Canada: Dennis Klug.

**3. General user proposals for the high-pressure research lab (IR Lab) received since May 1, 2016:**

| [**Proposal ID**](http://passadmin.bnl.gov/FeasibilityReview/GetResourceRequests?ResourceRequests-sort=Proposal_ID-asc) | [**Title**](http://passadmin.bnl.gov/FeasibilityReview/GetResourceRequests?ResourceRequests-sort=Proposal_Title-asc) | [**PI**](http://passadmin.bnl.gov/FeasibilityReview/GetResourceRequests?ResourceRequests-sort=PI_Last_Name-asc) | [**Cycle**](http://passadmin.bnl.gov/FeasibilityReview/GetResourceRequests?ResourceRequests-sort=Cycle-asc) | [**Status**](http://passadmin.bnl.gov/FeasibilityReview/GetResourceRequests?ResourceRequests-sort=Status-asc) |
| --- | --- | --- | --- | --- |
| 300984 | [Verwey transition in Greigite](http://passadmin.bnl.gov/FeasibilityReview) | John Tse | 2016-2 | Expired |
| 300986 | [Do local lattice distortions trigger magnetic crossovers in molecule-based magnets?](http://passadmin.bnl.gov/FeasibilityReview) | Janice Musfeldt | 2016-2 | Expired |
| 300990 | [In-situ High-Pressure Infrared Spectroscopy Studies of NaN3, CsN3, Ca(N3)2, and Sr(N3)2](http://passadmin.bnl.gov/FeasibilityReview) | Hongyang Zhu | 2016-2 | Expired |
| 300991 | [Wavelength-dependent absorption of silicon carbide and its influence on temperature determination in high-pressure experiments with laser-heated diamond-anvil cells](http://passadmin.bnl.gov/FeasibilityReview) | Kierstin Daviau | 2016-2 | Expired |
| 300992 | [High-pressure infrared study on multilayer and monolayer transition metal dichalcogenides](http://passadmin.bnl.gov/FeasibilityReview) | Yu Lin | 2016-2 | Expired |
| 300987 | [Wavelength-dependent absorption of pressure media and its influence on temperature determination in high-pressure experiments with laser-heated diamond-anvil cells](http://passadmin.bnl.gov/FeasibilityReview) | Jie Deng | 2016-2 | Expired |
| 300993 | [In-situ infrared spectroscopic studies of hydroxyl in mantle phases at high pressure](http://passadmin.bnl.gov/FeasibilityReview) | Lily Thompson | 2016-2 | Expired |
| 300995 | [Phase diagram of Nano-confined water under pressure](http://passadmin.bnl.gov/FeasibilityReview) | Bin Chen | 2016-2 | Expired |
| 300994 | [Combined IR and XRD probing of interaction forces between structural layers in clay minerals](http://passadmin.bnl.gov/FeasibilityReview) | Bin Chen | 2016-2 | Expired |
| 300996 | [Investigate the band gap and IR vibration behavior of novel solar cell materials under high pressure condition](http://passadmin.bnl.gov/FeasibilityReview) | Lingping Kong | 2016-2 | Expired |
| 300993 | [In-situ infrared spectroscopic studies of hydroxyl in mantle phases at high pressure](http://passadmin.bnl.gov/FeasibilityReview) | Lily Thompson | 2016-3 | Allocated Time |
| 301045 | [Infrared and Raman spectroscopic studies of GeO2 and SiO2 glasses under Extreme Conditions](http://passadmin.bnl.gov/FeasibilityReview) | Xinguo Hong | 2016-3 | Allocated Time |
| 300991 | [Wavelength-dependent absorption of silicon carbide and its influence on temperature determination in high-pressure experiments with laser-heated diamond-anvil cells](http://passadmin.bnl.gov/FeasibilityReview) | Kierstin Daviau | 2016-3 | Allocated Time |
| 300992 | [High-pressure infrared study on multilayer and monolayer transition metal dichalcogenides](http://passadmin.bnl.gov/FeasibilityReview) | Yu Lin | 2016-3 | Allocated Time |
| 301069 | [Exploring the growth mechanism of nanothread via in-situ high pressure IR](http://passadmin.bnl.gov/FeasibilityReview) | Li Xiang | 2016-3 | Allocated Time |
| 300986 | [Do local lattice distortions trigger magnetic crossovers in molecule-based magnets?](http://passadmin.bnl.gov/FeasibilityReview) | Janice Musfeldt | 2016-3 | Allocated Time |
| 301139 | [Low temperature Raman scattering in multiferroics](http://passadmin.bnl.gov/FeasibilityReview) | Andrei Sirenko | 2016-3 | Allocated Time |
| 300996 | [Investigate the band gap and IR vibration behavior of novel solar cell materials under high pressure condition](http://passadmin.bnl.gov/FeasibilityReview) | Lingping Kong | 2016-3 | Allocated Time |
| 301155 | [The Infrared spectroscopy experiments for the pressure- and heat- induced phase transitions in hydrous layered minerals](http://passadmin.bnl.gov/FeasibilityReview) | Huijeong Hwang | 2016-3 | Allocated Time |
| 301241 | [Ferroelectricity in SrTiO3 nanoparticles: Pressure and Temperature Dependent IR and Raman Measurements](http://passadmin.bnl.gov/FeasibilityReview) | Trevor Tyson | 2017-1 | Allocation |
| 301246 | [Wavelength-dependent absorption of pressure media and its influence on temperature determination in high-pressure experiments with laser-heated diamond-anvil cells](http://passadmin.bnl.gov/FeasibilityReview) | Jie Deng | 2017-1 | Allocation |
| 300991 | [Wavelength-dependent absorption of silicon carbide and its influence on temperature determination in high-pressure experiments with laser-heated diamond-anvil cells](http://passadmin.bnl.gov/FeasibilityReview) | Kierstin Daviau | 2017-1 | Allocation |
| 301045 | [Infrared and Raman spectroscopic studies of GeO2 and SiO2 glasses under Extreme Conditions](http://passadmin.bnl.gov/FeasibilityReview) | Xinguo Hong | 2017-1 | Allocation |
| 301440 | [Investigate the band gap and IR vibration behavior of novel lead-free solar cell materials under high pressure condition](http://passadmin.bnl.gov/FeasibilityReview) | Gang Liu | 2017-1 | PRP Review |
| 300994 | [Combined IR and XRD probing of interaction forces between structural layers in clay minerals](http://passadmin.bnl.gov/FeasibilityReview) | Bin Chen | 2017-1 | Allocation |
| 300995 | [Phase diagram of Nano-confined water under pressure](http://passadmin.bnl.gov/FeasibilityReview) | Bin Chen | 2017-1 | Allocation |
| 301483 | [Infrared spectroscopy study of high‒temperature superconductivity at high‒pressure](http://passadmin.bnl.gov/FeasibilityReview) | Yang Ding | 2017-1 | PRP Review |
| 300986 | [Do local lattice distortions trigger magnetic crossovers in molecule-based magnets?](http://passadmin.bnl.gov/FeasibilityReview) | Janice Musfeldt | 2017-1 | Allocation |
| 301139 | [Low temperature Raman scattering in multiferroics](http://passadmin.bnl.gov/FeasibilityReview) | Andrei Sirenko | 2017-1 | Allocation |