**NSLS-II Partner User Proposal**

**A. Basic Information (1-2 pages):**

**Title of the Proposal: High-Pressure Infrared User Program at NSLS-II**

**NSLS-II Laboratory(s):** *Infrared Lab*

**Principal Investigator (single spokesperson for the proposal):**

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**Beamline Staff Consulted:** *Lawrence (Larry) Carr*, Beamline: *FIS/MET*

The study of the effects of pressure on materials is fundamental to understanding a broad range of problems in Earth and planetary sciences, physics, biology, chemistry, materials science, and high-technology. Increasing pressure on materials can radically alter the physical and chemical properties of materials. Tremendous progress and breakthroughs in the development of ultrahigh-pressure diamond-anvil cell techniques have been made in the past several decades. For example, the behavior of materials at pressures comparable to those found near the Earth’s inner core (*i.e*., roughly to >300 GPa) can be studied under sustained conditions with unprecedented accuracy, precision, and sensitivity. Such experiments are crucial for developing a comprehensive understanding of the structure, dynamics, and evolution of planetary interiors. High-pressure spectroscopy provides essential and often unique information about the properties of materials under these conditions. For instance, vibrational infrared (IR) spectroscopy provides detailed information on bonding properties of crystals, glass, and melts, thereby yielding a microscopic description of thermochemical properties. Infrared measurements also provide information on electronic excitations including crystal-field, charge-transfer, excitonic spectra of insulating and semiconducting materials, interband and intraband transitions in metals, and pressure-induced metallization of insulators.

Using synchrotron radiation for infrared studies substantially improves our ability to probe microscopic samples including *in situ* measurements under extreme conditions due to its high brightness, broad-spectrum distribution, and diffraction-limited performance. The development of synchrotron infrared spectroscopy as a whole is fast becoming a leading technique in synchrotron radiation research. The National Synchrotron Light Source (NSLS) has the unique capability to provide synchrotron radiation over a broad range from hard x-ray down to the very far-infrared. The infrared radiation at the VUV ring of the NSLS has world-class performance with up to ~104 times the brightness of a conventional thermal (lamp) source. The high-pressure infrared program was initiated by Geophysical Laboratory, Carnegie Institution of Washington back to 1990. Later on, as one of the six infrared beamlines at the NSLS, U2A became the first dedicated high-*P* synchrotron infrared facility in the world, with many unique capabilities compared to high-pressurex-ray beamlines. The beamline was built and managed by Geophysical Laboratory, Carnegie Institution of Washington since 1998 and became available for general users in 2000. The beamline operation has been supported by National Science Foundation (NSF) through the Consortium for Materials Properties Research in Earth Sciences (COMPRES) since 2002.The high-pressure infrared program at the NSLS has been very successful in terms of beamline development, outreach of user community, and scientific productivity. A number of important scientific and technical challenges are being addressed at the facility, making it a highly attractive complement to x-ray sources for high-pressure studies.

In order to continue to accommodate the growing user demand and further expand the high-pressure infrared research at the NSLS-II, we proposed the establishment of high pressure infrared program at the **F**rontier Synchrotron **I**nfrared **S**pectroscopy Beamline under Extreme Conditions (FIS) of NSLS-II, an integrated infrared facility dedicated to the study of materials under extreme pressure and temperature (*P-T*) conditions. The design capabilities of NSLS-II with its small source size, high brilliance, and broad spectral range ideally match the materials research under extreme *P-T* conditions. The proposal has been approved in October 2010 and FIS is currently under development at NSLS-II. Due to the funding constrains, the first synchrotron light is expected available for general users in the summer of 2018 based on current schedule.

To bridge the gap between NSLS and NSLS-II, we propose to establish a general user program using the facilities installed at the infrared lab 1LL10. The core facilities include a FTIR spectrometer with conventional sources combined with an IR microscope, a micro-Raman system, and a user-working bench for sample preparations. Such general user program will allow users to carry out their experiments in moderate pressure with reasonable sample size and significantly minimize the impact for the high pressure IR user community during the “dark period” between NSLS and NSLS-II.

**B. GENERAL MANAGEMENT OF THE PARNTER USER PROGRAM**

The management plan is as follows:

Hemley’s research team, with the funding support of COMPRES, will provide support for general users to carry out high pressure infrared and Raman experiments at the Infrared Laboratory of NSLS-II during the IR “dark period” as soon as the approval of the user access by the NSLS-II management. The research team continues to develop and maintain the high-pressure equipment on FIS and support GU usage of this equipment for research experiments. A full-time beamline scientist [Dr. Zhenxian Liu, Carnegie Institution of Washington] is available to train and assist general users in the preparation for, and execution of, their experiments.

**PU CONTRIBUTIONS**

The partners propose to make the following contributions available to the infrared lab:

|  |  |
| --- | --- |
| Contribution(s) | Estimated Value |
| Bruker Vertex 80v spectrometer, Hyperion-2000 IR microscope | $210,000 |
| Custom built far-IR microscope system | $20,000 |
| Bolometer (dial detector system, Infrared Laboratories) | $33,000 |
| Custom micro-Raman microscope system | $100,000 |
| Sample preparation working bench (Leica microscope and EDM machine) | $300,000 |
| Compact cryostat (Cryo Industries of America) | $35,000 |

**PU MEMBERS**

Principal Investigators from the PU institutions and PU beamline staff members are listed below:

|  |  |
| --- | --- |
| **Name of Partner Members** | Institutions |
| Russell J. Hemley | Carnegie Institution of Washington |
| Zhenxian Liu | Carnegie Institution of Washington |
| Karl Agee | Consortium for Materials Properties Research in Earth Sciences |
| Larry Carr | National Synchrotron Light Source II |

The PU program will be devoted to the following research techniques:

Infrared microspectroscopy  
High Pressure Research  
Infrared vibrational spectroscopy

Diamond anvil cell combined cryogenic techniques

**FINANCIAL COMMITMENT**

The anticipated sources of funding and the associated funding level per year for the requested term of your program are as follows:

|  |  |  |
| --- | --- | --- |
| **Name of Funding Source** | Yearly Funding Level(in dollars) | **Year** |
| NSF-COMPRES | $195,379 | 2015 |

**D. Signatures (1 page):**

The PUP should be signed by the Principal Investigator and all Co-Investigators.