COMPRES

COnsortium for **M**aterials **P**roperties **R**esearch in **E**arth **S**ciences

Newsletter
April 2020

COVID-19 Information

Due to the evolving situation of COVID-19 worldwide, all COMPRES beamlines are essentially closed for normal research activities until further notice. In order to cooperate with state mandated stay-at-home orders, the DOE synchrotron facilities are limiting operations to COVID-19 research only.

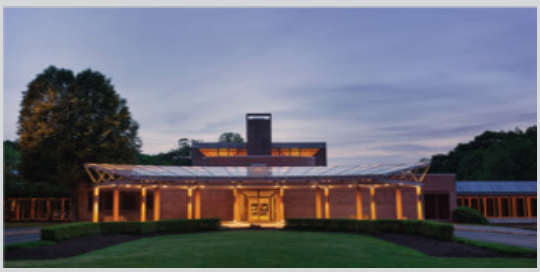
For announcements and COVID-19 status updates for each of our synchrotron facilities see the following:

https://www.bnl.gov/ps/ - National Synchrotron Light Source II
https://www.aps.anl.gov/ - Advanced Photon Source
https://als.lbl.gov/ - Advanced Light Source

COMPRES 2020 Annual Meeting Update

Because of the current COVID-19 stay-at-home and travel restrictions, and the uncertain duration of the pandemic, and the lack of widespread testing or a vaccine, there is a significant possibility that the 2020 COMPRES annual meeting scheduled for July 7-10 in Palisades, NY will be postponed. Options that are being considered include: rescheduling the meeting to fall 2020, rescheduling the meeting to summer 2021, or offering a teleconference version of the annual meeting summer 2020. At the minimum we plan on holding the annual business meeting and elections this summer, possibly through a Zoom conference. We are waiting to discuss our options with the conference center however they currently closed for business until May 1. We will keep you updated through the COMPRES listserv and website. http://compres.unm.edu/events/annual-meeting/2020/2020-compres-annual-meeting-general-information

In accord with the possible meeting postponement, the original deadline for abstract submission and student/post-doc travel support applications has been postponed until further notice. Please contact Beth Ha (beth3ha@unm.edu) or Gloria Statom (gstatom@unm.edu) for any questions.



COMPRES-GSECARS Report

The Consortium for Materials Properties Research in the Earth Sciences (COMPRES) and GeoSoilEnviro Center for Advanced Radiation Sources (GSECARS) are supported by the National Science Foundation (NSF) Earth Sciences Instrumentation and Facilities (EAR/IF) to operate national multi-user facilities, primarily at Department of Energy (DOE) synchrotron light sources, and to provide Earth scientists with access to world leading synchrotron-based techniques to answer major questions in Earth and planetary science research. Currently there is a synergistic relationship between COMPRES and GSECARS that benefits their combined and often overlapping communities of users, but the two organizations have distinctly different missions and management structures.

COMPRES
Consortium for Materials Properties Research in Earth Sciences

GeoSoilEnviroCARS

As we look to the future and map our course for the coming decade, NSF EAR IF has requested that COMPRES and GSECARS explore the possibility of merging. The earliest time frame for such a change would be 2022 when both organizations would be up for their respective 5-year renewals. In response to this request we submitted to NSF EAR the “COMPRES-GSECARS report” (click link below) where we describe the current management structures of COMPRES and GSECARS, and explore three models for a possible future merger of the two organizations, with a discussion of pros and cons of each, and contrasts with the current management models.

http://compres.unm.edu/sites/default/files/publications/COMPRES-GSECARS%20report.pdf

COMPRES Town Hall at 2020 Fall AGU

We have submitted a Town Hall meeting proposal for the 2020 Fall AGU Meeting:

“COMPRES: Future Directions for Materials Properties Research in Earth Sciences”
The Consortium for Materials Properties Research in Earth Sciences (COMPRES) is in the process of planning a renewal proposal to be submitted to the National Science Foundation in September 2021. The purpose of the Town Hall meeting is to provide information about the current status of COMPRES and to serve as an open forum for discussion of the renewal proposal. This Town Hall meeting is an opportunity for the COMPRES community to provide input on the form and substance of the renewal proposal, and the direction of COMPRES for the next five years. We plan on soliciting community input for this meeting in form of brief invited talks presenting science themes or goals to help shape our vision for COMPRES activities in the 2022-2027 time frame.

We will keep you posted on the status of the meeting proposal and schedule information if it is approved.

Education, Outreach, and Infrastructure Development (EOID) Project

"**E**xternally-**H**eated **D**iamond **AN**vil **C**ell **E**xperimentation (EH-DANCE)"

Project Lead: Bin Chen (University of Hawaii at Manoa)

Externally-heated Diamond Anvil Cell Experimentation (EH-DANCE) is a 2-year project funded from the COMPRES Education, Outreach, and Infrastructure Development (EOID) Program to support the development of an externally-heated diamond anvil cell (EHDAC) for high-pressure and high-temperature research of deep interiors of planets and moons. The primary goal is to design, standardize and fabricate these assemblies and accessories for EHDAC experiments. The EHDAC assemblies and accessories will include ring heaters, thermal and electrical insulating layers, and an enclosure for cooling and protective atmosphere. The goal of the project is to deliver stable and reusable heater assemblies and accessories available to the community for scientific and educational purposes. The cooling and protective atmosphere enclosure is designed for routine experiments on beamlines and off-line laboratories. The designs of the heaters and enclosure will be available openly to the community. Tutorials and in person trainings will be offered to the community.

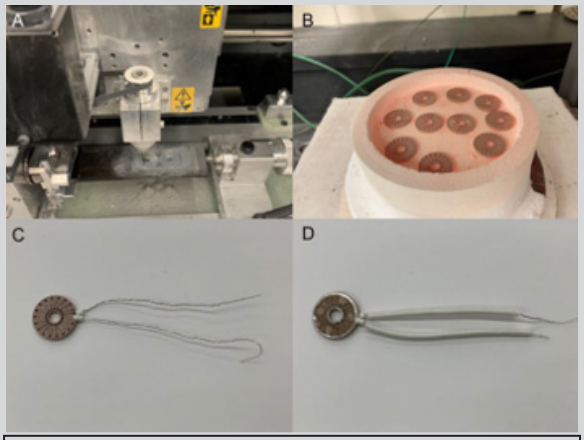


Figure 1, Fabrication of ceramic ring heater base and a micro-heater with Pt/Rh wires. (**A**) Milling the pyrophyllite heater base by the CNC machine. (**B**) Heater bases sintered in the furnace at 1523 K. (**C**) Heater wired using Pt/Rh wires. (**D**) Heater with insulators (mica, insulating tube and high-temp braid sleeving).

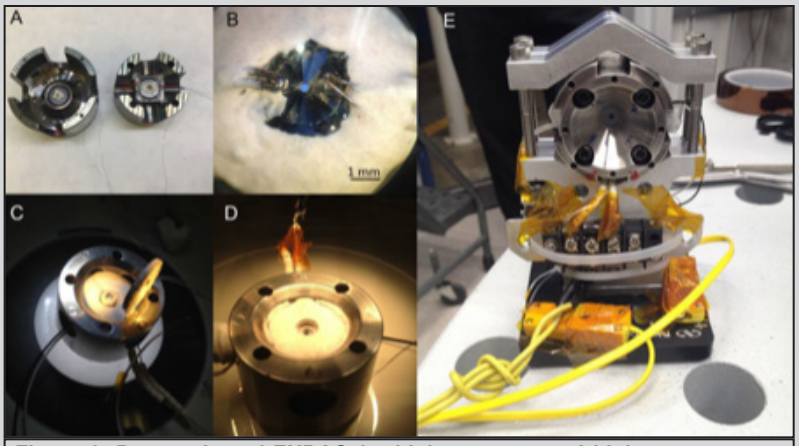
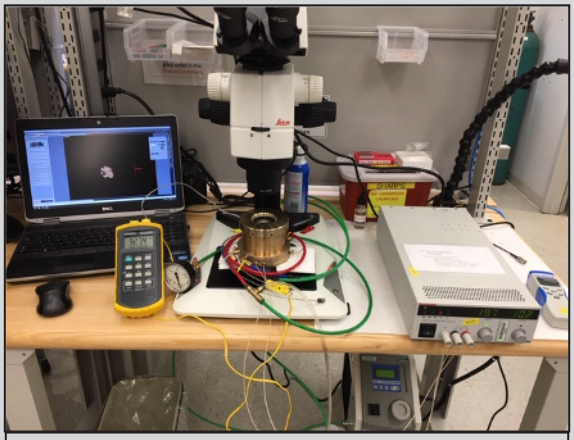


Figure 2, Preparation of EHDAC for high-pressure and high-temperature experiments. (**A**) BX-90 DAC with thermocouple installed. (**B**) Zoom-in view of the placement of thermocouples near the diamond cutlet. (**C, D**) The placement of micro-heater in the EHDAC. (**E**) EHDAC on the cell holder with the heater connected to a DC power supply and thermocouples connected to a thermometer.



Recent bench top testing of the EHDAC up to 1200 K, under vacuum.

The EHDAC can be routinely used to generate megabar pressures and up to 900 K temperature in open air, and potentially higher temperatures up to ~1200 K with protective atmosphere (i.e. Ar mixed with 1% H_2). Compared with laser-heating method for reaching temperatures typically >1100 K, external heating can be easily implemented and provide more stable temperature at ≤900 K and smaller temperature gradient to the sample. We showcased the application of EHDAC for synthesis of single crystal ice-VII and studied its single-crystal elastic properties using synchrotron-based X-ray diffraction and Brillouin scattering at simultaneously high-pressure high-temperature conditions.

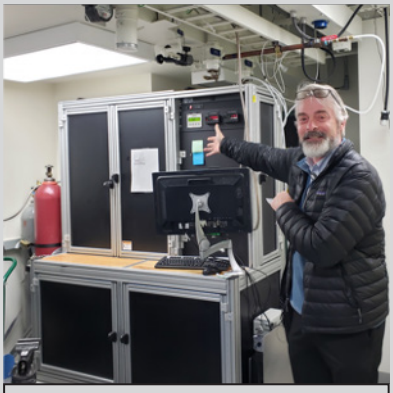
Please contact Dr. Bin Chen for further information: binchen@hawaii.edu

COMPRES Site Visit of Beamline 12.2.2 at the ALS

On Friday December 13, 2019, the COMPRES Facilities Committee participated in a site visit of the Advanced Light Source at Lawrence Berkeley National Lab, and in particular the Diamond Anvil (DAC) beamline 12.2.2, which is led by PI Quentin Williams (UCSC). Tour also included visits to beamlines 12.2.1 (Crystallography), 12.3.2 (Micro-diffraction), 8.3.2 (Tomography), 2.4 (Infrared Spectrometry). Presentations and agenda are shown in the table below.

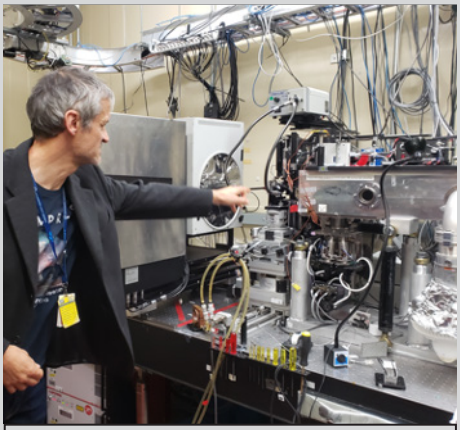
Chris Seagle and Alisha Clark (Facilities), Andy Campbell (Chair, Executive Committee)

Period	Presentations	Comments
09:15		Meet at ALS Lobby.
09:20 – 10:40	Facility tour (including high pressure laboratory and some selected beamlines): High pressure laboratory (Andrew) 12.3.2 Microdiffraction (Nobumichi) 12.2.2 High pressure (Bora/Martin) 12.2.1 Small-Molecule Crystallography(S. Teat) 8.3.2 Tomography (Dula/Haroid) 2.4 IR Imaging and Tomography (Hans)	A short beamline tour will be provided by beamline scientists. 09:20 - 09:30: High pressure lab. 09:35 - 09:45: Micro-diffraction (12.3.2) 09:50 - 10:00: High pressure (12.2.2) 10:05 - 10:15: Crystallography(12.2.1) 10:20 - 10:30: Tomography (8.3.2) 10:35 - 10:45: IR Imaging (2.4)
10:45 – 11:00	Introduction: COMPRES / ALS BL12.2.2 Partnership	Quentin Williams, UCSC
11:00 – 11:20	ALS, ALS-U and what comes in between	Steve Kevan, ALS Director, LBNL
11:20 – 11:40	ALS-U: How does it affect Beamline 12.2.2?	Alastair MacDowell, Staff Scientist, Deputy for Development Photon Science, LBNL
11:40 – 12:00	Discussion: Plans for 12.2.2 with ALS-U	All participants
12:00 – 12:20	Earth Science program at 12.2.2 and beyond	Martin Kunz, Beamline Scientist, LBNL
12:20 – 13:30	Lunch at LBNL Cafeteria	No need reservation. Just walk-in.
13:40 – 14:00	12.2.2 Associated Science Talk	Arianna Gleason, Stanford University
14:00 – 14:20	Resistive heating at 12.2.2.	Jinyuan Yan, COMPRES Beamline Scientist, UCSC
14:20 – 14:40	12.2.2 Associated Science Talk	Earl O'Bannon, LLNL
14:40 – 15:00	12.2.2 Associated Science Talk	Abby Kavner, UCLA.
15:00 – 15:20	12.2.2 Associated Science Talk	Brian Chandler, UC Berkeley
15:20 - 15:40	Single crystal diffraction at 12.2.2	Bora Kalkan, COMPRES Beamline Scientist, UCSC
15:40 - 16:00	Closing remarks	Quentin Williams, UCSC

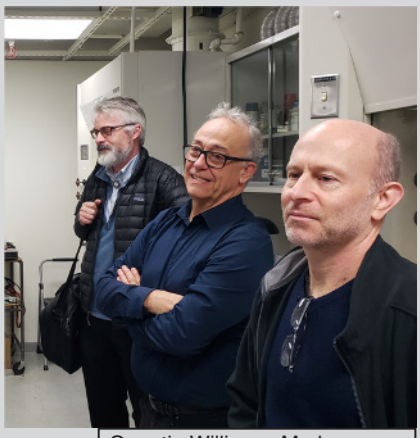


Quentin Williams showing the COMPRES gas loading device.

Alisha Clark and June Wicks (Facilities)



Martin Kunz (LBL) showing the 12.2.2 DAC beamline.



Quentin Williams, Mark Rivers (Facilities Chair), Andy Campbell

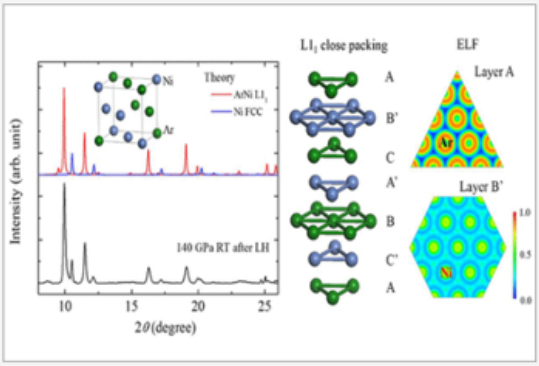
Recent COMPRES Supported Research

A High-Pressure Compound of Argon and Nickel: Noble Gas in the Earth's Core?

Adebayo A. Adeleke, Martin Kunz, Eran Greenberg, Vitali B. Prakapenka, Yansun Yao* and Elissaios Stavrou*

Abstract

Various geophysical models have shown that Ar, a natural decay product of ^{40}K, is depleted in Earth's main reservoirs (i.e., continental crust, atmosphere, and silicate mantle). This indicates that a large amount of Ar may be present in the Earth's core, but such consideration is hindered by the lack of knowledge on the reactability of Ar with the core's main constituents (Ni and Fe). Here we demonstrate the synthesis of a thermodynamically stable compound of Ar and Ni under thermodynamic conditions representative of the Earth's core. Using in situ synchrotron X-ray diffraction and density functional calculations, we identified the compound as ArNi with a $L1_1$ Laves structure. The ArNi compound is stabilized by notable electron transfer from Ni to Ar, changing their electron configurations toward $3d^7$ and $4s^1$. The present results suggest that the abundance of Ar in the Earth's core is controlled, beyond a simple solubility of Ar in molten Ni–Fe, by chemical bonding, which is truly extraordinary considering the inert nature of Ar under ambient conditions. Moreover, establishing the Earth's core as a viable reservoir for Ar helps to postulate the natural decay of ^{40}K in the core as a heating source for Earth's inner dynamics.



Lawrence Livermore National Laboratory (LLNL) scientists, in collaboration with researchers at the University of Saskatchewan (UoS), the Lawrence Berkeley National laboratory (LBNL) and the University of Chicago have discovered that at thermodynamic conditions mimicking that of Earth's core, argon can react with nickel forming a stable ArNi compound. The LLNL-led research was published and highlighted as a cover article in ACS Earth Space Chemistry.

Earlier studies have shown that xenon may also partition into iron metal at core conditions thus offering an explanation for the Xe-deficit enigma for the Earth. This new study may shed light on the apparent ^{40}Ar deficit in the Earth (for example seen in $^{40}Ar/^{36}Ar$). The lion's share of the Earth's Ar is in the form of ^{40}Ar which comes the decay of ^{40}K, primarily in silicate rocks of the mantle and crust. It has been proposed that potassium may show enhanced partitioning into metallic iron at core conditions, and if so this new study suggests that daughter isotope ^{40}Ar could also be sequestered in the Earth's core. To confirm this possibility, future studies should extend the present experiments on metallic Ni to an FeNi alloy. Also, the hypothesis that K becomes siderophile at high pressure needs further testing. Nonetheless, the possibility of noble gases behaving as siderophile elements under extreme conditions could have a significant impact on our understanding of planetary core geochemistry.

This study acknowledges experiments done at the COMPRES beamline at the Advanced Light Source (ALS) 12.2.2, the GSECARS beamline at sector 13 at the Advanced Photon Source (APS), and the COMPRES/GSECARS gas loading facility at the APS. https://doi.org/10.1021/acsearthspacechem.9b00212

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