The 2nd International Conference on

ROOM TEMPERATURE SUPERCONDUCTORS (RTS2018)

Date: December 11th, 2018

Place: National Institute for Materials Science, Sengen the second conference room

Program

1:00 Opening Address

1:05 ***Russel J. Hemley***, School of Engineering and Applied Science, The George Washington University, USA (Presentation 30min)
"*Superconductivity above 280 K in superhydrides at megabar pressures*"

1:50 ***Katsuya Shimizu,*** KYOKUGEN, Osaka University, JAPAN (Presentation 30min)
"*Synthesis of Superconductive Sulfur Hydride from Elemental Sulfur and Hydrogen*"

2:30 ***George W. Crabtree***, Argonne National Laboratory & University of Illinois at Chicago, USA (Presentation 30min)
"Room Temperature Superconductivity: Challenges and Opportunities"

3:10 Coffee Break

3:40 ***Xiao-Jia Chen***, Center for High Pressure Science & Technology Advanced Research CHINA (Presentation 30min)
"*Exploring high-temperature superconductivity in phenyl molecules*"

4:20 ***Ryosuke Akashi***, Department of Physics, The University of Tokyo, JAPAN (Presentation 30min)
"*Diversity of metastable structures in compressed hydrides: A case study on H_xS*"

5:00 ***Takahiro Ishikawa***, ESICMM(Elemental Strategy Initiative Center for Magnetic Materials), NIMS, JAPAN (Presentation 30min)
"*Search for superconducting hydrides from first-principles*"

5:35 ***Kaveh Delfanazari***, University of Cambridge, UK (Presentation 20min)
"*Quantum integrated circuits based on two-dimensional electron gas platform*"

6:00 ***Ryo Matsumoto***, MANA NIMS, University of Tsukuba (Presentation 10min)
"*Discovery of New Pressure-induced Superconductors Explored by Data-driven Approach*"

6:15 Closing Remarks

6:20 Banquet (Canteen in NIMS)

Superconductivity above 280 K in superhydrides at megabar pressures

Russel J. Hemley
School of Engineering and Applied Science, The George Washington University,
Washington DC 20052, USA
(rhemley@email.gwu.edu)

Abstract

Recent predictions and experimental observations of high Tc superconductivity in hydrogen-rich materials at very high pressures are driving the search for superconductivity in the vicinity of room temperature. We confirmed the existence of a new class of such materials – so-called superhydride phases (MHX, x > 6), and have developed preparation techniques for their syntheses and characterization, including measurements of structural and transport properties, at megabar pressures. Four-probe electrical transport measurements of lanthanum superhydride samples display signatures of superconductivity at temperatures ranging from 210 K to above 280 K near 200 GPa. The experiments are supported by pseudo-four probe conductivity measurements, critical current determinations, low-temperature x-ray diffraction, and magnetic susceptibility measurements. These near room temperature measurements of superconductivity are in good agreement with density functional and BCS theory-based calculations.

Synthesis of superconductive sulfur hydride from elemental sulfur and hydrogen

Katsuya Shimizu

KYOKUGEN, Graduate School of Engineering Science, Osaka University, Toyonaka, Osaka 560-8531, JAPAN

(shimizu@stec.es.osaka-u.ac.jp)

Abstract

A superconductive sulfur hydride (H_3S) was synthesized from elemental sulfur and hydrogen and the electrical resistance and the crystal structure were measured under high pressure. A rectangular shaped pure sulfur with electrodes was compressed with hydrogen in a laser-heated diamond anvil cell at room temperature up to 150 GPa. The sulfur was heated by an infrared laser to initiate the chemical reaction ($3H_2 + 2S \rightarrow 2H_3S$). After the heating, we measured the powder x-ray diffraction and observed the same but very sharp diffraction peaks of bcc-structure sulfur as reported in previous low-temperature compressed superconductive H3S. A drop of the electrical resistance which may correspond to the superconductivity at 200 K was observed. This method is applicable to the synthesis of other superconductive hydrides.

Room temperature superconductivity: challenges and opportunities

George Crabtree
Argonne National Laboratory & University of Illinois at Chicago, USA
(crabtree@anl.gov)

Abstract

I would like to talk about some of the scientific opportunities created by the latest results on LaH_{10}, such as the nature of the superconductivity, magnetic and specific heat measurements, critical fields, coherence length and penetration depth, and what other materials might be out there.

Exploring high-temperature superconductivity in phenyl molecules

Xiao-Jia Chen
Center for High Pressure Science & Technology Advanced Research, Shanghai
201203, CHINA
(xjchen@hpstar.ac.jp)

Abstract

Organic compounds are always promising candidates of superconductors with high transition temperatures Tc's. Here we will talk about our recent discovery of superconductivity in polyparaphenylene oligomers. We will show that doping C-C bond connecting molecules – p-terphenyl or p-quaterphenyl by potassium can bring about superconductivity above 120 K at atmosphere pressure, which is comparable to the highest Tc in cuprates. Superconductivity has also been found in other oligomers with short or long chain lengths, together with other phenyl molecules. The easy processability, light weight, durability of plastics, and environmental friendliness of these new superconductors have great potential for the fine-tuning of electrical properties. This discovery opens a window for exploring high temperature superconductivity in phenyl molecules.

Diversity of metastable structures in compressed hydrides: A case study on H_xS

Ryosuke Akashi

Department of Physics, The University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-0033, JAPAN

ryosuke.akashi31@gmail.com

akashi@cms.phys.s.u-tokyo.ac.jp

Abstract

There have been reports on pressure-induced high-Tc superconductivity in La-H systems very recently, and determination of the crystal structure emerging in the experimental situation is regarded of pivotal importance.

We revisit theoretical crystal structure search studies for H_xS systems to suggest it could be a difficult task even from theoretical point of view, not only from experimental one.

Search for superconducting hydrides from first-principles

Takahiro Ishikawa
ESICMM(Elemental Strategy Initiative Center for Magnetic Materials), NIMS, 1-2-1 Sengen, Tsukuba, Ibaraki 305-0047 Japan
(ishikawa@stec.es.osaka-u.ac.jp)

Abstract

Superconductivity at 203 K was discovered in hydrogen sulfide compressed to 155 GPa in 2015, and room-temperature superconductivity was recently found in compressed lanthanum hydride. These amazing results suggest that further high-temperature (Tc) superconducting materials can be found in other hydrides, and first-principles study is a big help for the search. In my talk, I show our calculated results on the superconductivity in sulfur-hydrogen system reviewing previous theoretical works, and introduce an inductive search for novel high-Tc superconducting materials based on a machine learning technique.

Quantum integrated circuits based on two-dimensional electron gas platform

Kaveh Delfanazari
University of Cambridge, UK
(kd398@cam.ac.uk)

Abstract

The principle of quantum transport in hybrid superconductor-semiconductor-superconductor (S-Sm-S) structures is the phase coherent Andreev reflections at the interface of superconducting leads and semiconducting contacts, where the microscopic phase of the quasiparticles wavefunction in semiconductor and the macroscopic phase of the superconductor order parameter are combined. The S-Sm-S structures have been proposed to be the building blocks of the next generation of quantum processors and computers, after the purported detection of exotic Majorana particles with zero electrical charges at the interface of S-Sm junctions.

However, there still is a fundamental technological problem in the (i) fabrication of highly transparent interfaces between superconductors and semiconductors and (ii) scaling the number of junctions up in a single chip to realize a quantum device applicable for quantum technology. To deal with this, we introduced an integrated circuit consisting of arrays of planar Josephson junctions based on two-dimensional electron gas (2DEG) in In0.75Ga0.25As heterostructure. The methods that are used for ballistic 2D Josephson junction and hybrid quantum integrated circuit fabrication will be demonstrated. Furthermore, the temperature and magnetic field dependences of the phase coherent quantum transport in 2D Josephson junctions, the induced superconducting properties into 2DEG, and the subharmonic energy gap structures (SGS) due to Andreev reflections at the S-Sm interfaces will be discussed.

Discovery of New Pressure-induced Superconductors Explored by Data-driven Approach

*Ryo Matsumoto[1,2], Zhufeng Hou[1], Kiyoyuki Terakura[1], Yoshihiko Takano[1,2]
1. National Institute for Materials Science, Tsukuba 305-0047, Japan
2. University of Tsukuba, Tsukuba 305-8577, Japan

Abstract

It has been recently started a use of a data-driven approach by a high-throughput computing for exploring new functional materials such as thermoelectric materials, superconductors, and so on, instead of a traditional carpet-bombing type experiment depending on experiences and inspirations of researcher. In this study, the candidates for new thermoelectric and superconducting materials, which have narrow band gaps and flat bands near band edges, were searched by high-throughput first-principles calculation from an inorganic materials database [1]. The synthesized $SnBi_2Se_4$ among the target compounds showed a narrow band gap of 200 meV and a thermal conductivity of ~1 $W \cdot K^{-1} \cdot m^{-1}$ at ambient pressure. As shown in Fig. 1, the $SnBi_2Se_4$ showed a metal–insulator transition at 11.1 GPa, as predicted by theoretical estimation. Furthermore, two pressure-induced superconducting transitions were discovered under 20.2 and 47.3 GPa. The data-driven search is a promising approach to discovering new functional materials. In the conference, a discovery of superconductivity in the other candidate $PbBi_2Te_4$ [2] will be also reported.

[1] R. Matsumoto et al., *Appl. Phys. Express* **11**, 093101 (2018).
[2] R. Matsumoto et al. arXiv:1808.07973.

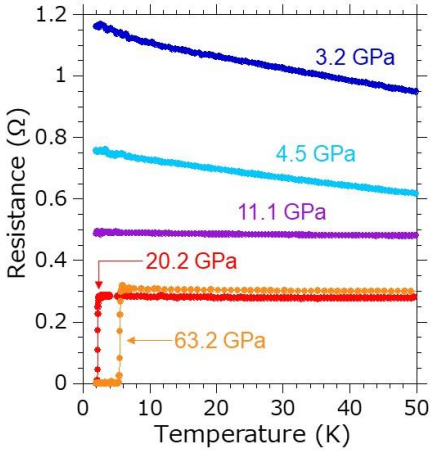

Fig. 1. *R-T* properties under high pressure of $SnBi_2Se_4$.