【Grant-in-Aid for Scientific Research (S)】

Broad Section B

Title of Project： **Synthesis and Development of Room-Temperature Superconducting Device**

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Research Project Number: 20H05644 Researcher Number：70283736
Keyword：Superconductivity, High-Pressure Synthesis, Hydride

【Purpose and Background of the Research】

In recent years, it has been experimentally clarified that hydrides exhibit superconductivity exceeding 200 K under high-pressure conditions, then we can expect "room temperature superconductivity" comes into reality. Various hydrides are predicted to become high-Tc superconductors with their transition temperatures of room temperature or high. In this research, we are investigating whether room temperature superconductivity can be realized and how high the superconducting transition temperature can be raised, by targeting hydrides. To reach the goal of "a room-temperature superconducting device", we focus (1) to synthesize a room-temperature superconductor under high pressure, and (2) to operate a superconducting device in a high-pressure cell. We are aiming to expand our technology of material synthesis and measurement of physical properties and to provide the guideline that not only to realize room-temperature superconductivity but also to connect to social implementation.

【Research Methods】

The starting materials of the hydrides are elements and hydrogen. The element is sealed together with hydrogen into a high-pressure cell: a diamond anvil cell (DAC), and compressed and heated by laser (Figure 1). Although this method has been widely used, a limited number of successive synthesis has been reported, which indicates the difficulty in handling hydrogen. We focused on the importance of searching for an appropriate synthesis (heating) method. We will challenge several new synthetic routes and methods such as; pressurize at low temperature and a Joule heating. Some ternary hydrides are predicted theoretically to be superconductors with higher temperatures. We will perform theoretical calculations and precise crystal structural analysis to make an optimal synthesis of the superconductive hydrides.

To construct a superconducting device under high pressure, the superconductor is shaped into a device structure in a DAC. Starting the test with using existing superconductors, we will establish know-how for constructing superconducting devices under pressure.

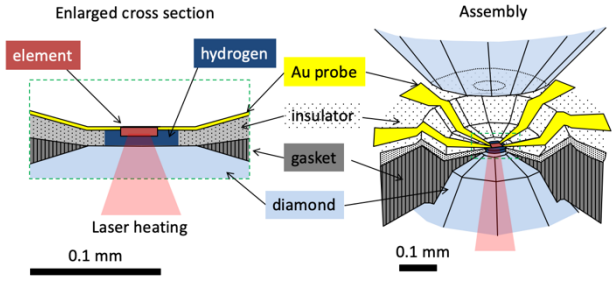

Figure 1 Schematic drawing of synthesis method.

【Expected Research Achievements and Scientific Significance】

The impact on society of "room temperature superconductivity (RTSC)" is immeasurable. The RTSC will be used widely in energy systems and electronics and communication systems. In this research, we aim to realize the RTSC by high-pressure hydride as a candidate and challenge the superconductor device under high-pressure conditions. This will provide a guideline for the social implementation of RTSC, and, in addition, will be an opportunity to develop research toward the practical use of RTSC at low pressure or ambient pressure. A high-sensitive magnetic sensor is an example of the RTSC device.

The academic background of this research is "the quest of the ultimate form of matter". The themes of this research are to answer the questions of "can RTSC be realized?" and "can RTSC be used?"

Based on the belief of the PI "essence of physics locates in extreme", we will challenge the realization of RTSC using high-pressure technology, we will answer the questions.

【Publications Relevant to the Project】

· M. Einaga, K. Shimizu *et al.*, “Crystal structure of the superconducting phase of sulfur hydride”, Nature Phys. 12, 835–838 (2016).
· M. Sakata, K. Shimizu *et al.*, “Superconductivity of lanthanum hydride synthesized using AlH_3 as a hydrogen source”, Supercond. Sci. Technol. 33 (2020) 114004 (6pp).

【Term of Project】 FY2020-2024

【Budget Allocation】 151,200 Thousand Yen

【Homepage Address and Other Contact Information】

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