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Launch of Development of High-Efficiency Refrigeration Technology for the Industrialization of Superconducting Quantum Computers

Taiyo Nippon Sanso Corporation (Head Office: Shinagawa-ku, Tokyo; President: Kenji Nagata; hereinafter "TNSC"), a Japanese industrial gas business company in the Nippon Sanso Holdings Group, together with IHI Corporation (hereinafter "IHI") and the National Institute of Advanced Industrial Science and Technology (hereinafter, "AIST"), has jointly applied with IHI and AIST for the "Development of High-Efficiency Refrigeration Technology for the Industrialization of Superconducting Quantum Computers" project under the "Research and Development Project of the Enhanced Infrastructures for Post-5G Information and Communication Systems" of the NEDO (New Energy and Industrial Technology Development Organization). The project period is approximately three years, from FY2025 through FY2027.

It is commonly considered that the realization of practical quantum computers in the future will require large-scale systems equipped with approximately one million physical qubits. However, in order to suppress errors caused by heat and other factors, the greatest challenge is to achieve both large capacity and high energy efficiency in refrigeration systems that can operate stably at ultralow temperatures of several tens of millikelvins (mK[*1]).

In this newly adopted project, TNSC will work together with IHI and AIST to develop and demonstrate an ultralow-temperature refrigeration system with both higher cooling capacity and superior energy efficiency than conventional systems on the scale of 10,000 physical qubits as a step toward realizing one-million-qubit quantum computers. TNSC will leverage its accumulated expertise in the design and manufacture of dilution refrigerators to develop the key technologies required for scaling up dilution refrigeration systems[*2].

By focusing on the development of this dilution refrigeration system, TNSC aims to contribute to the practical implementation of quantum computers.

Note 1: An extremely low temperature, very close to absolute zero (0 K: -273.15°C), unattainable with ordinary cooling technologies. By cooling qubits to several tens of millikelvins, it is possible to minimize errors caused by thermal noise.
Note 2: A refrigerator capable of stably generating temperatures below 50 mK (-273.1℃ or less) using a mixture of helium-4 and helium-3.

Roles of Each Organization

IHI: Overall coordination of the ultralow-temperature refrigeration system and development of the few-kelvin refrigeration system (turbo-type refrigeration system).
TNSC: Development of the tens-of-millikelvin refrigeration system (dilution refrigeration system).
AIST: Performance evaluation of the turbo-type refrigeration system and dilution refrigeration system.

Taiyo Nippon Sanso Corporation
Tnsc.Info@tn-sanso.co.jp