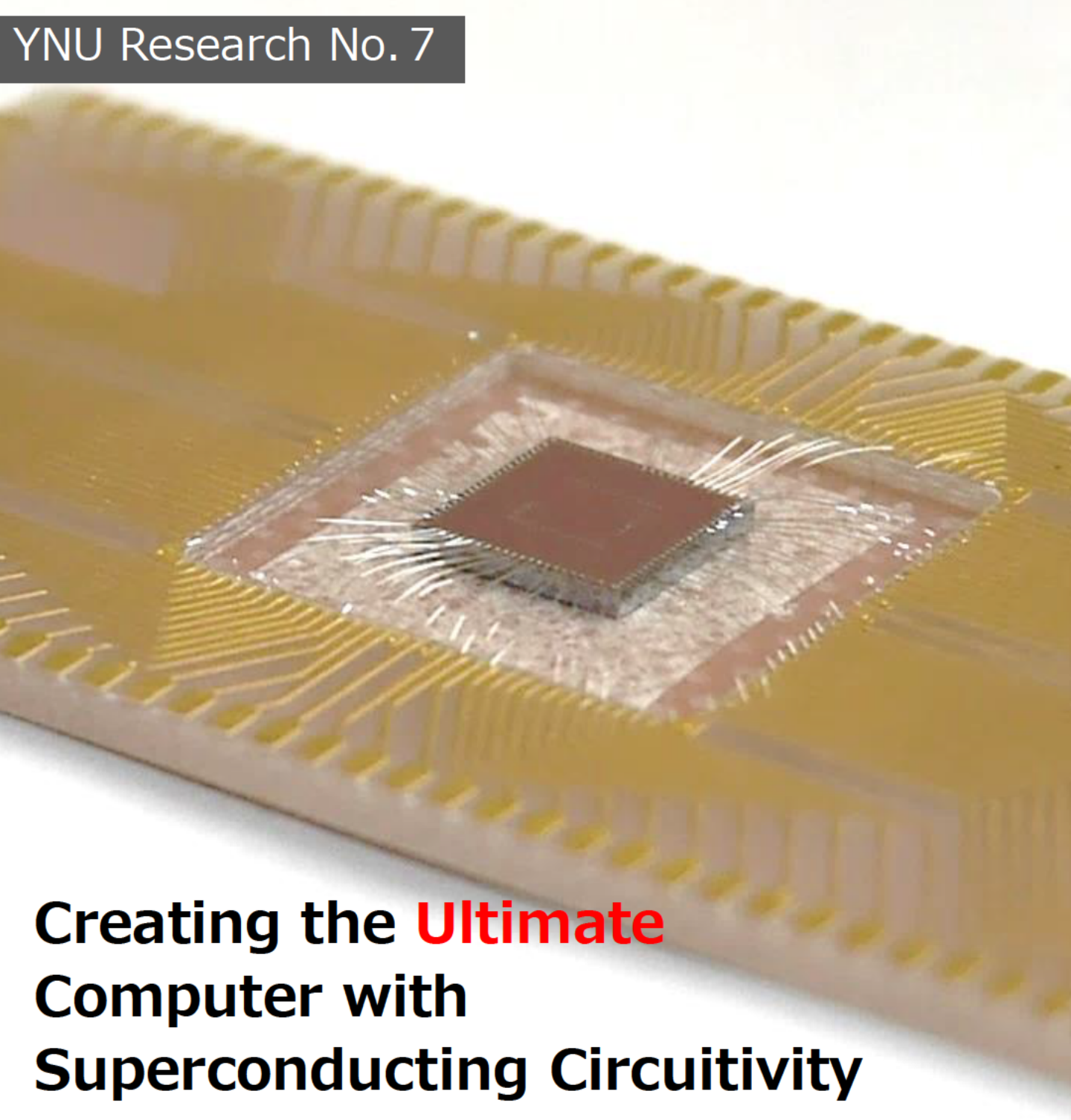
YNU Research No. 7



Creating the Ultimate Computer with Superconducting Circuitity

— From Ultrahigh-speed Calculations to Quantum Calculations —

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What Makes Superconductivity Important?

In the development of the information-oriented society, information has to be processed faster with less energy consumption. Our research aims to realize a computer with overwhelmingly high-speed processing by advancing the technology of superconductivity, a phenomenon of zero electric resistance.
Electrons in superconductors have a unique property, which causes an impossible phenomenon with ordinary materials (right photo). Since the processing speed of computers can be generally defined by the speed of the electron flow in their circuits, we believe that the performance limit of current computers can be overcome by using the peculiarities of superconducting electrons.

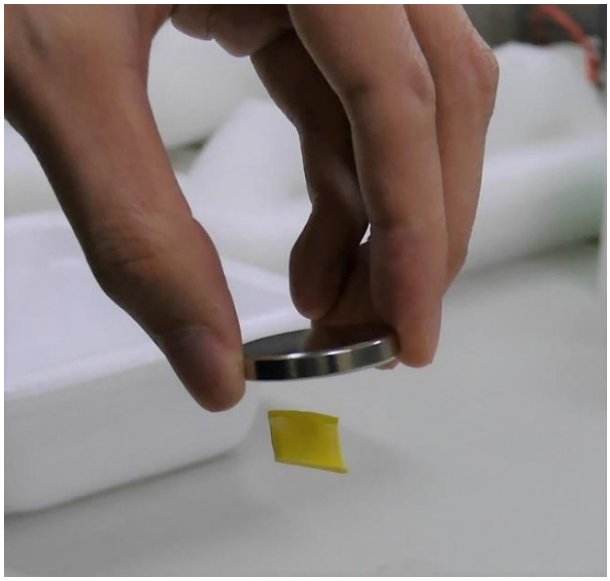

Photo : The item covered with yellow tape is a superconductor. A magnet can suspend the superconductor in the air.

Super-low Power and Fast Computing Using Flux Quanta

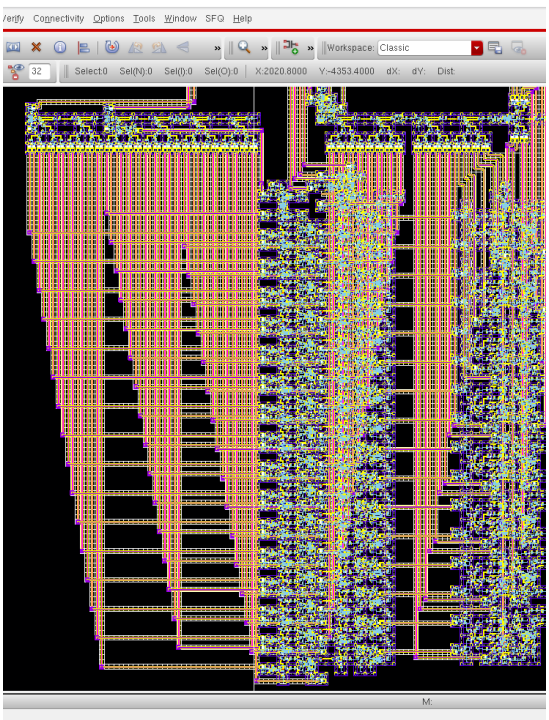

Figure: Layout of a superconducting division circuit

Imagine that magnetic force is visualized as strings of force. The minimum unit of the strings is called a flux quantum. Utilizing a peculiar property of superconducting electrons, a state with or without a flux quantum can be emerged within a superconductor ring. The "0" and "1" states of the digital circuit of computers can be represented by the presence and absence of a flux quantum. Exploiting the peculiarities of superconductivity reduces power consumption of a circuit, and using flux quanta moving at nearly the speed of light allows us to realize super-fast operational circuits.
The left figure shows the layout of the prototype division circuit that we designed and created. We adopted a proper circuit configuration for making use of superconductivity and the circuit is capable of operating at clock speeds of over 50 GHz. We believe that extremely highly-efficient numerical calculations can be achieved with this circuit.

Photo: Facility for evaluating the superconducting circuit. The circuit is submerged in liquid helium at -269℃ from a storage vessel (lower right of the photograph) to maintain the superconducting state, to measure its electric characteristics and circuit response.

A Superconducting Quantum Computer to Solve Optimization Problems

At present, our laboratory is engaged particularly in research on building an annealing-type quantum computer, which is capable of solving specific types of optimization problems very efficiently by using a superconducting circuit. While solutions to optimization problems are expected to be applied in a very wide range of areas, we are involved in developing a superconducting quantum computer dedicated to solving specific optimization problems, such as in machine learning.

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Completed the doctoral program of the Graduate School of Engineering, Yokohama National University.

Was appointed to his current post after working as a research fellow in the Japan Society for the Promotion of Science and a specially appointed assistant professor of Interdisciplinary Research Center of Yokohama National University.

Be forging ahead with research on matters that integrate the computer, a subject of his interest from his high-school days, with physics. Loves playing the guitar, and has participated in ensemble activities for 20 years.

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