Graduate Program in Spintronics Seminar

Towards semiconductor-superconductor hybrid qubits based on InAs/Al core/shell nanowires

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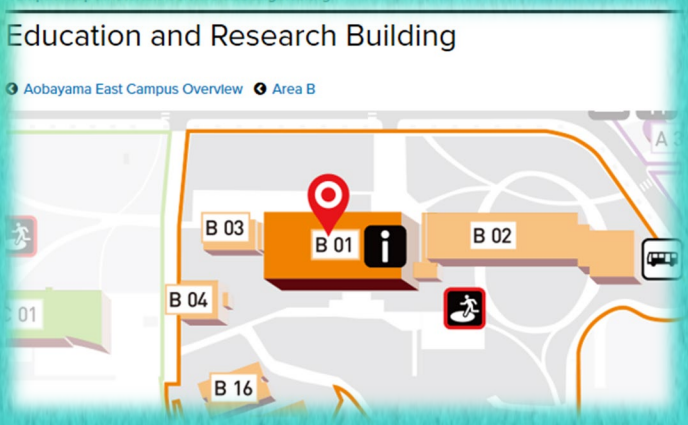
Venue: **1:00** pm – **3:00** pm

Monday, **June 17**, 2019

Seminar Room 407
Education and Research Building B01
School of Engineering, Aobayama East Campus,
Tohoku University



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Towards semiconductor-superconductor hybrid qubits based on InAs/Al core/shell nanowires

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State-of-the-art qubits, like the Transmon, are typically tuned in frequency by a magnetic field. Our goal is to fabricate and characterize electrically tunable qubits, i.e. Gatemon and Andreev qubits, using a semiconductor nanowire Josephson junction as nonlinear element.

The main limitation for the qubit performance is the semiconductor-superconductor interface. This issue can be addressed with an in-situ coverage of the as-grown nanowire with a superconducting shell, which ensures a clean interface without contamination. Here, we give a brief overview about the selective-area molecular beam epitaxy growth of InAs/Al nanowire with both full and half shells as well as of in-situ junctions based on InAs and Nb.

Additionally, we present a detailed analysis of the DC- and AC-properties of InAs/Al core/shell nanowire Josephson junctions based on Shapiro, emission and gate-dependent VI measurements. For the Shapiro and emission measurements, we observe signatures of fractional values for the frequency-dependent characteristic voltage, which indicates the contribution of higher harmonics in the current-phase relationship.

The last part of my talk is focused on flux- and gate-dependent measurements of Andreev qubits as well as the spectroscopy of individual Andreev bound states by means of a pump-probe technique. The latter one reveals an unconventional state structure and a Rashba-induced lifting of the spin degeneracy, which is one of the prerequisites for the realization of topological states and Majorana fermions.

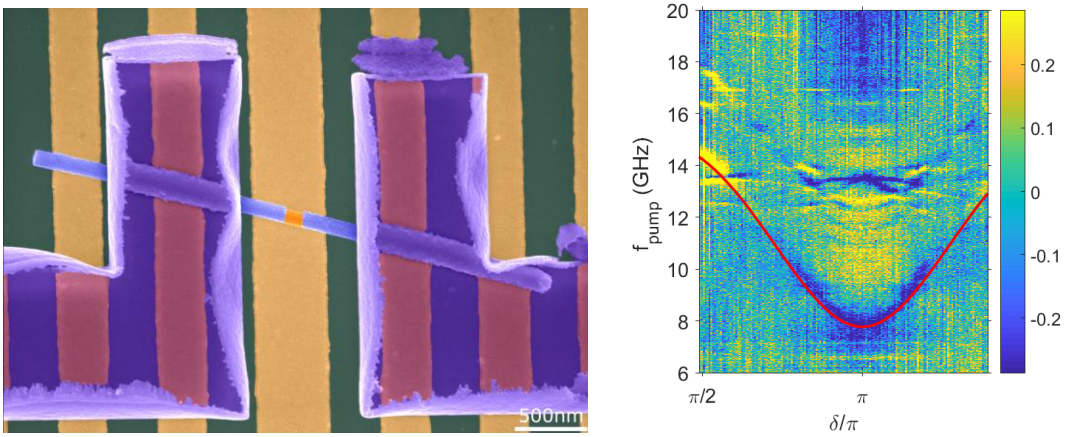

Fig. 1. (left) False-colored SEM-micrograph of a mesoscopic InAs/Al nanowire Josephson junction.
(right) Pump-probe spectroscopy measurements of individual Andreev bound states inside of an InAs/Al Josephson junction.