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ASET Colloquium

Amplifiers and bolometers using superconducting 2D devices

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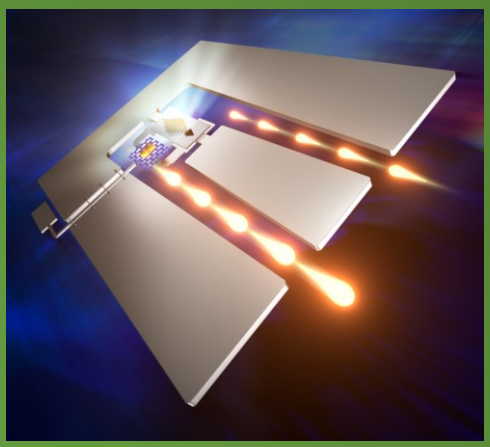

2D materials offer the ability to combine contrasting functionalities, and this provides an opportunity to make unique devices. Mandar will talk about two recent examples of experiments from his lab: One uses a proximitized and tunable Josephson junction to make a parametric amplifier, and the other uses a high Tc superconductor to realize one unit cell thick bolometric sensor.

The core of quantum information processing involves preparing, manipulating, and efficiently detecting quantum states. In cQED architecture, probing quantum systems in a single-photon regime is challenging as the output signals that carry information about the quantum state of these systems are very feeble. Hence, amplification with the least added noise is crucial before signal processing at room temperature. The Josephson parametric amplifiers (JPA) are the routinely used devices for low-noise amplification of quantum signals, which improves the signal-to-noise ratio significantly. The existing JPAs are based on Al-AlOx-Al tunnel junctions where magnetic flux is the control knob for biasing the devices. The lab's recent work demonstrates the implementation of a gate tunable JPA using a graphene Josephson junction (gr-JJ), where the scientists change the device bias using electrostatic gating [1]. Electrostatic control is advantageous over magnetic flux control in cQED devices as it uses a very localized electric field which causes less interference. In addition and in contrast with the Al-based tunnel junctions, the attractive material properties of graphene: low heat capacity, and low electron-phonon coupling, imply a single-photon detector integrated with the quantum noise limited amplifier is realizable using our device.

Superconducting nanowires are very important due to their wide-ranging applications. The research group implements a non-invasive process to fabricate nanowires of high-Tc superconductor $Bi_2Sr_2CaCu_2O_{8+\delta}$ (BSCCO), and demonstrate that the nanowires can be used as bolometers in the visible range with a very high responsivity of 9.7×10^3 V/W [2]. The study presents a scalable method for realizing sensitive bolometers working near the liquid-nitrogen temperature.

[1] J. Sarkar et al., Quantum noise limited microwave amplification using a graphene Josephson junction, arXiv:2204.02103. (Nature Nanotechnology, in press)
[2] S. Ghosh et al. Nanowire bolometer using a 2D high-temperature superconductor, Nanotechnology https://doi.org/10.1088/1361-6528/ac9684

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YouTube Live Link: https://youtu.be/1efYbrJ23DI