Gate-tunable Josephson parametric amplifiers based on semiconductor nanowires

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Josephson parametric amplifiers (JPA) working in the microwave range allow the addition of the minimum amount of noise permitted by quantum mechanics for an amplifier [1]. They have allowed fast and accurate single-shot measurement of superconducting qubits and nano-mechanical resonators [2].
A JPA rely on a non-linear, dissipation less element, the Josephson junction, that is typically fabricated by putting an Aluminum oxide (AlOx) tunnel barrier between two superconducting Aluminum electrodes.
For the first time, we have fabricated a JPA where the oxide barrier of the Josephson junction is replaced by several semiconducting InAs nanowires in parallel grown by Molecular Beam Epitaxy [3] (Figure 1, left). The parallel nanowires geometry features a large critical current, needed for a JPA (Figure 1, right).
Contrary to a JPA made with AlOx, the presence of the semiconducting weak link allows to tune the resonance frequency of the amplifier via a gate-voltage.
We report close to 30 dB of gain (Figure 2) and a noise approaching the quantum-limit. This type of device has been made before using Graphene [4] or planar InAs [5] but never using semiconducting nanowires.

References

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Figures

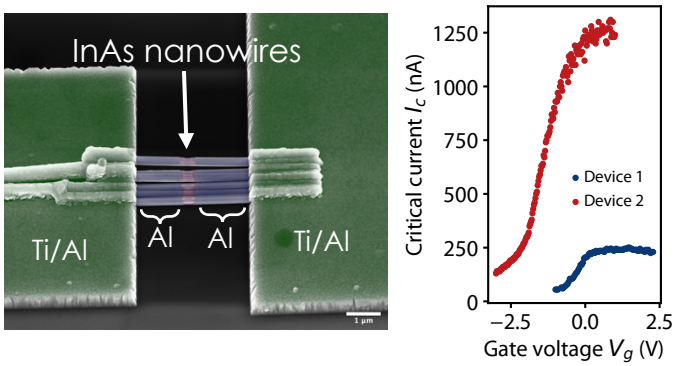

Figure 1: (Left) False-colored SEM micrograph of parallel InAs nanowires Josephson junction contacted by Ti/Al electrodes. Scale bar is 1 *μm*. (Right) Critical current of InAs nanowires Josephson junction as a function of the gate voltage.

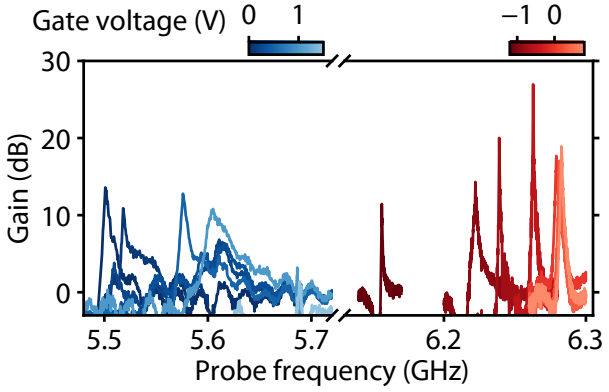

Figure 2: Effect of the gate-voltage on the frequency tuning of the JPA for Device 1 (blue) and Device 2 (red).