



## Yuimaru Kubo

Principal Research Scientist

Okinawa Institute of Science and Technology Graduate University

### Title: A near-quantum-limited microwave amplifier using spins in diamond

#### Abstract:

Microwave quantum technologies require amplification of weak signals with minimal added noise at millikelvin temperatures. This stringent demand has traditionally been met by superconducting parametric amplifiers. We demonstrate the first-ever non-superconducting microwave amplifier with near-quantum-limited noise performance, based on a maser operating at millikelvin temperatures. The active medium comprises substitutional nitrogen defects (P1 centers) in a diamond crystal, placed within a microwave resonator. Our device delivers over 30 dB of gain at 6.595 GHz, and the minimum noise temperature of 0.86 K corresponds to 2.2 added noise photons—comparable to state-of-the-art superconducting parametric amplifiers. The amplifier features 20 to 30 dB higher compression points than the state-of-the-art superconducting devices. These results establish solid-state masers as a promising non-superconducting platform for quantum-limited microwave amplification, suitable for applications in quantum computing, ultra-sensitive magnetic resonance spectroscopy, and fundamental physics.

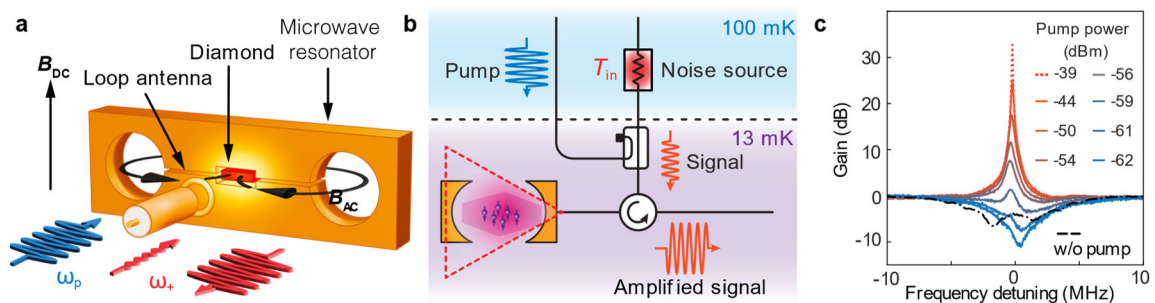


Figure 1: **a**, Device schematic. A diamond crystal is positioned within a loop-gap microwave resonator. Both pump and probe microwave tones are introduced via a coupling loop antenna. **b**, Experimental setup inside a dilution refrigerator. **c**, Maser gain spectra under various pump powers. The horizontal axis represents the detuning from the central resonator frequency  $\omega r/2\pi = 6.595\text{GHz}$ .

#### Biography:

Yuimaru (Yui) Kubo is the head of the Hybrid Quantum Device Team, where he leads research on hardware physics and device engineering for microwave quantum technologies using gem crystals. He received his Ph.D. from the University of Tsukuba in 2009, based on his work at NIMS (National Institute for Materials Science) on quantum effects in high-temperature superconductor devices.

After completing his Ph.D. and a brief stay at TIMS, University of Tsukuba, Yui joined the Quantronics Group at CEA-Saclay in France as a postdoctoral researcher. There, he worked on hybrid quantum devices combining superconducting circuits with impurity spins in diamond and silicon. In late 2015, he joined the Quantum Dynamics Unit at OIST. Since 2021, he has led the Hybrid Quantum Device Team, focusing on spin-based solid-state quantum technologies.