Hybridizing Quantum Systems for Quantum Technologies

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Transduction of quantum information in different frequency domains, and precision measurement of various physical quantities rely on the interactions of quantum states in different nature. Realizing such interactions require the hybridization of various quantum device platforms such as superconducting microwave quantum circuits, nanomechanical resonators and photonic devices. My talk will focus on recent research activities on hybrid quantum devices at KRISS. I will first present our work on cavity optomechanics using a niobium-based superconducting nanoelectromechanical device. This device realizes various optomechanical phenomena such as phonon cooling and amplification, optomechanically induced transparency [1], and microwave frequency combs [2] thanks to strong electromechanical coupling of microwave fields and nanomechanical vibrations. I will also share our current progress on the development of integrated quantum devices. This includes, for example, the realization of gate-tunable superconducting microwave resonators [3], efficient microwave-phonon transduction via microwave impedance engineering, and cavity optomechanics in silicon photonic crystal devices. I will then discuss how the results of our work can be used in various applications such as quantum transduction for remote optical quantum entanglement of superconducting quantum devices, nanomechanical quantum sensing and phonon-based quantum information processing.

[1] *Nano Letters* **21,** 1800-1806 (2021)
[2] *Nano Letters* **22,** 5459-5465 (2022)
[3] *Nano Letters* **24,** 1223-1230 (2024)