ED Oral | Electronic Devices

Tue. Dec 2, 2025 4:45 PM - 5:31 PM JST | Tue. Dec 2, 2025 7:45 AM - 8:31 AM UTC Room D(107)

[ED3] Detector and Readout 2

Chair:Shigetomo Shiki(AIST), Hirotake Yamamori(National Institute of Advanced Industrial Science and Technology (AIST))

4:45 PM - 5:15 PM JST | 7:45 AM - 8:15 AM UTC

[ED3-01-INV]

Emerging Technologies for Superconducting Strip Photon Detectors

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5:15 PM - 5:16 PM JST | 8:15 AM - 8:16 AM UTC

[ED3-02] Cancelled

5:16 PM - 5:31 PM JST | 8:16 AM - 8:31 AM UTC

[ED3-03]

Reveal inhomogeneities in a superconducting nanowire by probing and mapping self-heating hotspots

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Abstract

Superconducting strip photon detector (SSPD) has been recognized as promising detectors for a wide range of applications including quantum information technology, quantum optics, laser ranging, free space optical communications, fluorescence microscopes, and so on. This is attributed to their broad high system detection efficiency, low dark count rates, and low timing jitter. Recently, SSPD technology has undergone advancements in various directions. For example, while superconducting strips narrower than ~100 nm have traditionally been considered essential for achieving high detection efficiency in SSPDs, we have successfully demonstrated high-performance operation using a 20-µm-wide superconducting strip which is 200 times wider than conventional designs [1]. Arraying SSPDs has led to enhanced functionality, such as higher operation speed, photon-number resolution, imaging capabilities, and so on. Cryogenic signal processing technology for SSPD arrays and multi-channel SSPDs has also been progressed. In particular, various processing readout circuits based on superconducting single flux quantum (SFQ) circuits have been designed and demonstrated, including time-multiplexer [2], address encoder [3], coincidence circuit [4], and so on. In this talk, we present our recent research on these emerging technologies for SSPDs.

Acknowledgements

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References

1)M. Yabuno et al. Optica Quantum Vol. 1, pp. 26, 2023
2)S. Miki et al. Optics Letter Vol. 46, pp. 6015, 2021
3)S. Miyajima et al. Optics Express Vol. 26, pp. 2018, 2018
4)S. Miki et al. Applied Physics Letter Vol. 112, pp. 262601, 2018

Keywaords: SSPD, SNSPD, SWSPD, SFQ

Reveal inhomogeneities in a superconducting nanowire by probing and mapping self-heating hotspots

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Abstract

The pursuit of uniform superconducting nanowires is paramount for advancing superconducting devices, particularly in single-photon detection, digital circuits and quantum computing. Although advanced nanofabrication techniques are applied, inhomogeneities, which are on orders of the coherent length in several nanometers, exist universally and affect the macroscopic superconducting phenomena in a long range. Consequently, the lack of the locations, numbers and their dependence on device performance prevents from clarifying superconducting switching mechanisms and optimizing performance further. In this talk, a hotspot scanning microscope (HSM) for locating and identifying inhomogeneities in situ and with nanoscale resolution will be introduced. This method leveraged the multi-photon detection mechanism and self-heating equilibrium in a superconducting nanowire to generate and manipulate a hotspot. The current-voltage (IV) relationship reflected the initialization and growth of the hotspot, from which the geometric variation can be reconstructed. In a 12 μm long nanowire, 50 different types of IV curves were found, revealing the large amount of inhomogeneities. When the hotspot shrunk to a minimum size (~100 nm) at a location considered as a local constriction, 23 constrictions were identified 23 local constrictions were identified, with their positions marked at a spatial resolution of ~100 nm. The resulting constriction map facilitated the localization of dark count sources with enhanced spatial resolution and allowed for the separation of their contributions to the total counts. This work demonstrates the ubiquitous presence of inhomogeneities and clarifies their influence on device performance, providing a foundation for future optimization and engineering efforts.

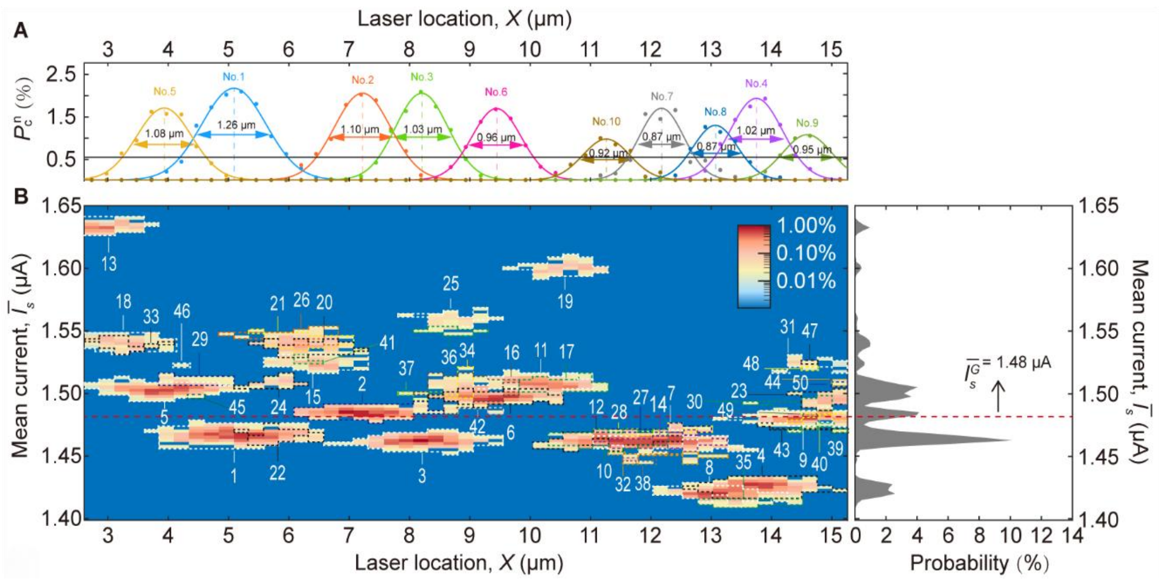

Figure 1 Inhomogeneity analysis based on data extracted from localized hotspot IVs. (A) Spatial distributions of occurrence probability $\boldsymbol{P_c^n}$ for the top ten IV types and their Gaussian fitting profiles. (B) Colormap of the mean self-heating current $\overline{\boldsymbol{I_s}}$ vs. Laser location X, with $\boldsymbol{P_c^n}$ as the weight at the maximum hotspot; right panel shows the histogram of $\overline{\boldsymbol{I_s}}$ from all locations.

Keywaords: Superconducting nanowire, Inhomogeneities, Hotspot