

## 【Grant-in-Aid for Scientific Research (S)】

### Broad Section C



Title of Project : Development of new imaging technology based on superconducting single-photon camera

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Keyword : Single-photon detector, Image sensor, Superconducting digital signal processing

#### 【Purpose and Background of the Research】

Photon detection technique with high spatial and temporal precision is fundamental in a wide range of fields such as quantum information and processing, quantum communication, photon spectroscopy, astronomical observation, bioimaging and so on. Cooled CCD is the most sensitive image sensor that can detect extremely weak light by a factor of 100 million lower than moonlight, but it still has several tens of thousands of photons per second. In addition, the sensitivity of CCD in near infrared region is not good enough, while the near infrared light is useful because it can penetrate deep inside the biological sample. Furthermore, the frame rate is also slow as several tens kHz even in high-speed electron multiplying CCD.

The superconducting nanowire photon detectors (SSPDs) have sensitivity in a wide spectral range from deep ultraviolet to mid infrared, and have been already used in many advanced experiments in quantum information field. The SSPD has detection efficiency over 90% at 1.55  $\mu\text{m}$ , low dark count rate below 1 cps, excellent timing jitter below 20 ps. Photon imaging technology with a wide spectral range, ultra-low noise, high spatial and temporal resolution will be possible by realizing two-dimensional SSPD array, but the number of pixels demonstrated so far is as large as 64 due to the difficulty in signal readout.

#### 【Research Methods】

We aim to realize a large-scale SSPD image sensor with the configuration shown in Fig. 1, where SSPD array with row-column readout scheme and a single flux quantum (SFQ) signal processing circuit are employed. We also introduce an adiabatic flux quantum parametron (AQFP) circuit in addition to the SFQ circuit to reduce the bias current, where the SFQ/AQFP hybrid signal processor will be fabricated by using the AIST Nb standard process. Our goal is to realize SSPD image sensor with  $100 \times 100$  pixels and it will be applied to photon spectroscopy and bioimaging system.

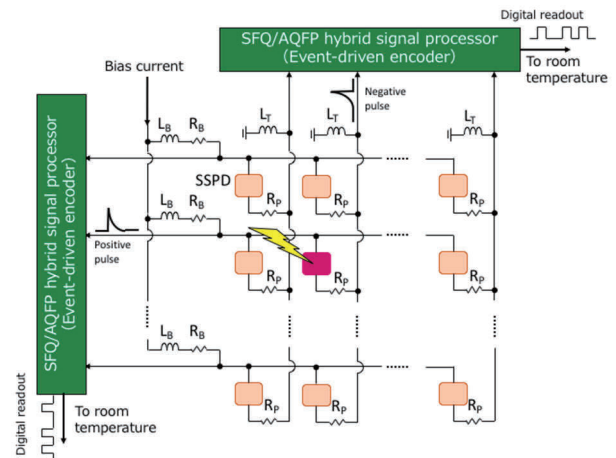


Figure 1 Configuration of superconducting single-photon image sensor

#### 【Expected Research Achievements and Scientific Significance】

By realizing an image sensor with a photon countable sensitivity, extremely low noise, high spatial and temporal resolution with a wide spectral range from deep ultraviolet to mid infrared, it will be an innovative tool in various fields and make a big contribution to create new academics.

#### 【Publications Relevant to the Project】

- N. Takeuchi, T. Yamashita, S. Miyajima, S. Miki, N. Yoshikawa, and H. Terai, *Optics Express* 25, 32650 (2017).
- H. Terai, S. Miki, and Z. Wang, *IEEE Trans. on Supercond.* 19, 350 (2009).

【Term of Project】 FY2018-2022

【Budget Allocation】 149,400 Thousand Yen

#### 【Homepage Address and Other Contact Information】

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