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Multi-mode-fiber coupled superconducting nanowire single-photon detector with large active-area and high detection efficiency

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Superconducting nanowire single-photon detector (SNSPD) has been regarded as a promising technology for single-photon counting and detection. Its merits include high system detection efficiency (SDE, >90%), low dark count Rate (DCR, < 100 Hz), small timing jitter (< 20 ps), fast operating speed (> 100 MHz), free running mode, and no afterpulsing. However, its active area often has a lateral size of 8-25 μm, thus turns to be a major limitation in many applications which need large sensitive area, like free space photon detection and biological florescence spectroscopy. The main challenge is to fabricate an extremely long and uniform nanowire with the same thickness and line-width, without adding additional defects, generally called constrictions.

In this paper, we report the fabrication and performance of the SNSPDs with active-area of 35 μm in diameter, which is the largest size for single element nanowire so far. The SNSPDs were fabricated with 10.5-nm-thick NbN film deposited on the silicon substrate with 100-nm-thick SiO_2 in between. Aiming to the application of the fluorescence correlation spectroscopy at the wavelength of 600 nm, we designed the width of the nanowire to be 150 nm and the filling ratio to be 50%. We coupled the light to the device using the GRIN-lensed multi-mode-fiber and the beam waist of the light spot was 28 μm, allowing the optical coupling efficiency close to 100%. Our detector achieved high SDE, which was 48% at wavelength of 635 nm, in combination with ultra-low DCR, which was 600 Hz in maximum and decreased to less than 1 Hz rapidly.

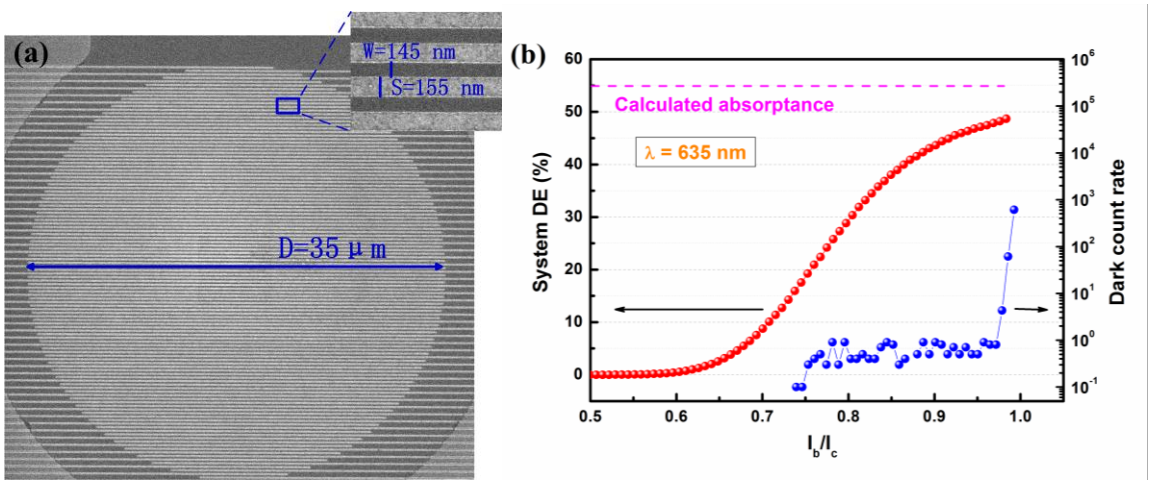

Fig. 1. (a) Scanning electron micrograph of the SNSPD's active-area (b) SDE and DCR vs. normalized bias current.