

$\text{Nb}_x\text{Ti}_{1-x}\text{N}$ Superconducting-Nanowire Single-Photon Detectors

Potential applications include optical communications and quantum cryptography.

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Superconducting-nanowire single-photon detectors (SNSPDs) in which $\text{Nb}_x\text{Ti}_{1-x}\text{N}$ (where $x < 1$) films serve as the superconducting materials have shown promise as superior alternatives to previously developed SNSPDs in which NbN films serve as the superconducting materials. SNSPDs have potential utility in optical communications and quantum cryptography.

NbN-based SNSPDs have exhibited, variously, high detection efficiency, low signal jitter, large dynamic range, and low dark counts, but it has been difficult to fabricate detectors that exhibit all of these desirable properties simultaneously. It has been even more difficult to produce NbN-based SNSPDs in high yield, especially in cases in

which the detectors occupy areas larger than 5 by 5 μm .

$\text{Nb}_x\text{Ti}_{1-x}\text{N}$ is a solid solution of NbN and TiN, and has many properties similar to those of NbN. It has been found to be generally easier to stabilize $\text{Nb}_x\text{Ti}_{1-x}\text{N}$ in the high-superconducting-transition-temperature phase than it is to stabilize NbN. In addition, the resistivity and penetration depth of polycrystalline films of $\text{Nb}_x\text{Ti}_{1-x}\text{N}$ have been found to be much smaller than those of films of NbN. These differences have been hypothesized to be attributable to better coupling at grain boundaries within $\text{Nb}_x\text{Ti}_{1-x}\text{N}$ films.

Four batches of prototype $\text{Nb}_x\text{Ti}_{1-x}\text{N}$ SNSPDs fabricated thus far have shown a

yield >60 percent — much higher than the yields of NbN SNSPDs. In two of the batches, the SNSPDs were fabricated in high-resonance-quality-factor (high- Q) cavities by use of commercial dielectric mirrors. The SNSPDs in the high- Q cavities simultaneously exhibited high detection efficiencies, low dark counts, small jitter, and high yield for a resonance wavelength of 1,064 nm. In the most recent two lots fabricated, the yield was high even for large-area (10 by 10 μm) SNSPDs.

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