Optical Properties of Superconducting Nanowire Single-photon Detectors

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High-efficiency single-photon detection requires careful design of the device optics. For superconducting-nanowire single-photon detectors (SNSPDs) [1-3], this challenge is amplified by the complexities of optical propagation in subwavelength structures. We have conducted an initial theoretical study of the optical design issues that must be addressed to achieve efficient absorption of infrared light by SNSPDs. We found that the absorption depends not only on geometrical parameters of the device, but also on the polarization of the incident photon. We are now testing our model by directly measuring the optical absorptance of SNSPDs fabricated at MIT. We will then feed back the testing results to the design process to realize high-efficiency SNSPDs that, by design, are either sensitive or insensitive to incident photon polarization. This work is sponsored by the United States Air Force under Air Force Contract #FA8721-05-C-0002. Opinions, interpretations, recommendations and conclusions are those of the authors and are not necessarily endorsed by the United States Government.

Figure 1: Plot of the predicted ratio of parallel to perpendicular absorptance by the SNSPD as a function of pitch, \( p \), wire width \( w \) (given in nm), and fill factor, \( f = w/p \). A maximum sensitivity to polarization occurs when the fill factor and wire width are both small. We fabricated devices that correspond to points \( d_1-d_5 \) shown on this plot in order to test our model.

Figure 2: Scanning electron micrograph of device \( d_4 \), where the wire width was 50 nm and pitch was 150 nm. This device was fabricated using processes described in [1] and tested using the apparatus described in [2] and [3].

REFERENCES

