Superconducting MoSi Thin Films for Single-Photon Detection

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Superconducting Nanowire Single-Photon Detectors (SNSPDs) are a leading technology for the detection of faint light. They combine high system detection efficiency and high maximum count rates, while maintaining low dark counts and low timing jitter. Thin MoSi superconducting films are of very strong interest for single-photon sensing in the near to mid-infrared regime [1, 2, 3] due to their amorphous character that allows reproducible lithography.

In this contribution, we show our recent progress on the deposition of MoSi thin films on Si/SiO_2 substrates, determine their microscopic properties optimize them for SNSPDs operating in the IR regime. By systematically varying the deposition parameters we vary the stoichiometry and map the superconducting metrics, aiming at high critical temperatures (T_c). The stoichiometry and crystalline phase of the thin films was shown to be controllable via the deposition conditions. Grazing incidence X-ray diffraction measurements show the presence of a polycrystalline phase above a critical concentration of 80% molybdenum. Fully optimized films exhibited a maximum T_c=8.4K for 20nm thick $Mo_{0.71}Si_{0.29}$ and T_c=6.2K for 4.5nm films, respectively.

Finally, we defined SNSPDs to link the detector performance to the obtained superconducting metrics. Figure 1 shows normalized detector count rates for different operating temperatures, where the switching current of the detector increases with lower temperature. This facilitates higher bias currents leading to a saturating count rate (indicating unitary internal quantum efficiency) and low dark count rate. Figure 2 shows the wavelength dependent sensitivity with the expected shift of the count rate curve towards higher bias levels for longer wavelengths. Our results provide design rules for optimizing the performance of MoSi SNSPDs.

References

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[2] Varun B Verma et al, Optics Express 23, 033792 (2015).
[3] Dileep V Reddy et al, Optica 7, 1649-1653 (2020).

Figures

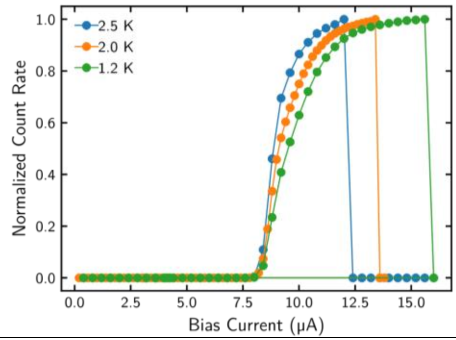

Figure 1: Normalized count rates at different operating temperatures of the SNSPD

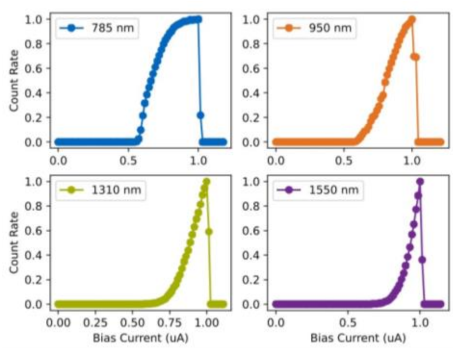

Figure 2: Normalized count rates for different excitation wavelengths at 0.5 K