PRECISE TUNING OF SUPERCONDUCTING AND PHYSICAL PROPERTIES OF Mo_xSi_{1-x} THIN FILMS FOR PHOTON DETECTOR APPLICATIONS

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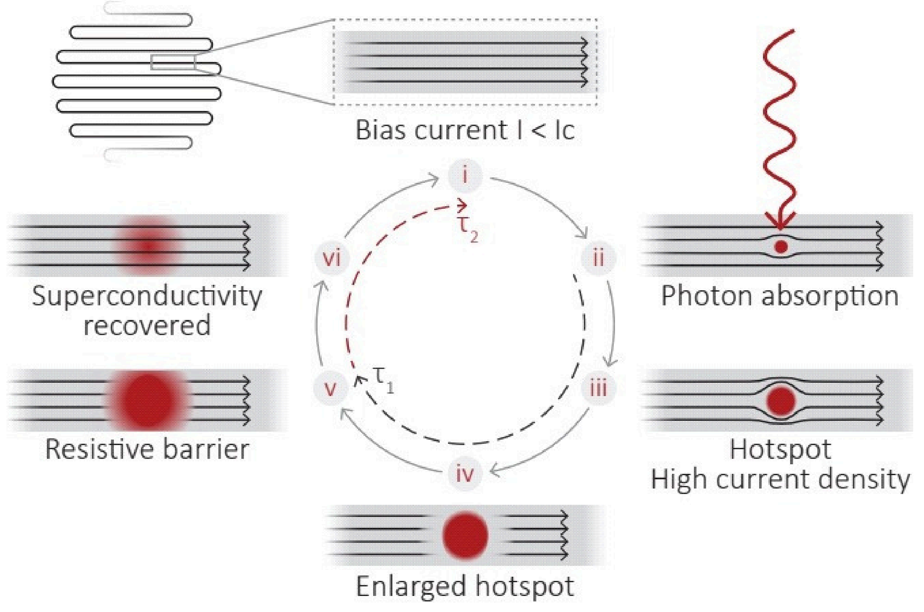
Introduction

MoSi-based structures are promising for single-photon detection at microwave and millimeter-wave frequencies, where conventional photon counters lose efficiency [1]. Their integration into superconducting circuits enables the development of frequency-tunable photon detectors and low-noise parametric amplifiers.

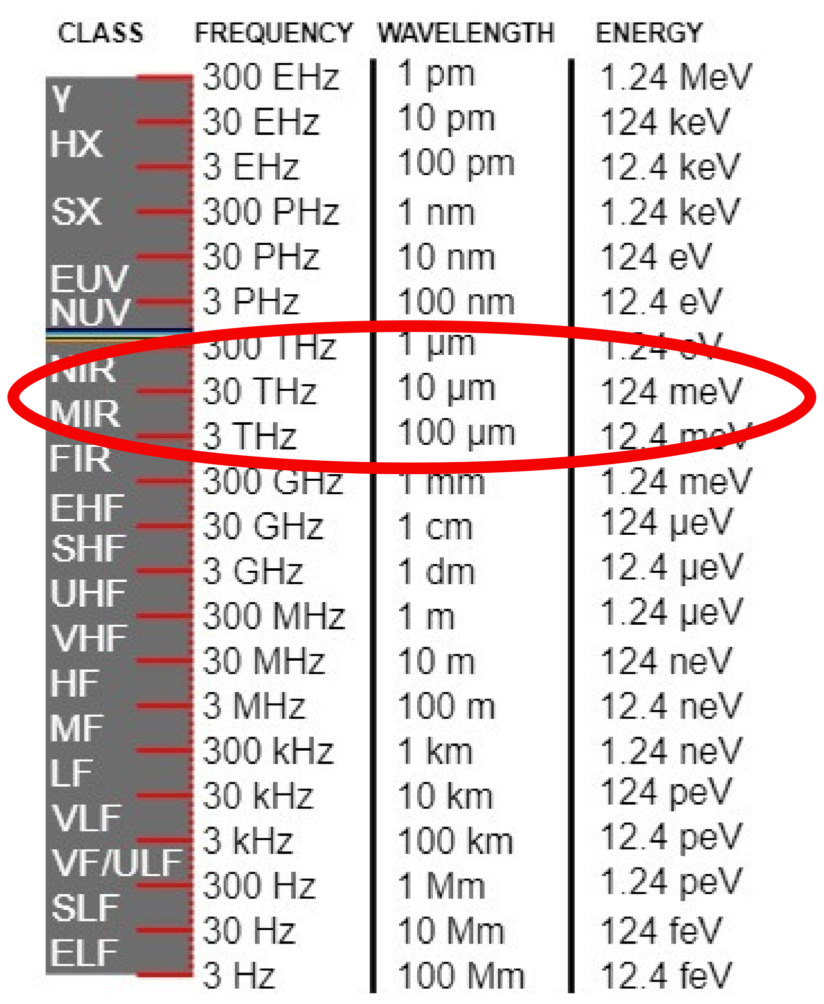
Actual problems and research idea

SNSPD consists of a thin (several nanometers) and amorphous superconducting film. The detector made of such a film is patterned in a compact meander geometry to create a square or round pixel with high detection efficiency.



Large gap amplitude for traditional SNSPD (like NbN [2]) materials is efficient in the single-photon detection regime only in a limited frequency range of the InfraRed domain. Such amorphous superconductors as MoSi, were suggested as alternatives to NbN. The deposition technology we use makes it possible to produce ultrathin films with finely tunable sample composition and high Tc.

Most single photon detectors (SPDs) operate in the near-infrared (NIR) range. Extending detection to longer wavelengths, which are useful for applications such as long-distance quantum communications, remains a challenge.

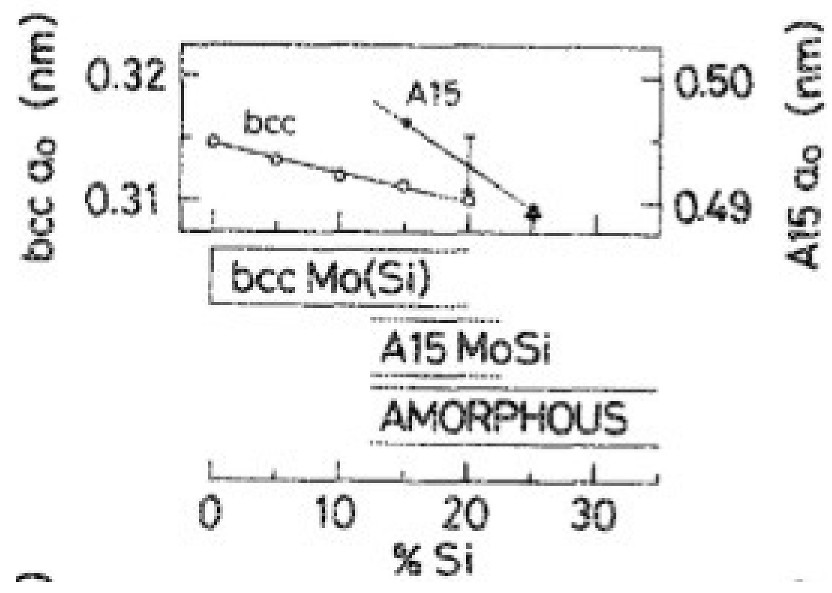


Fabrication method

The magnetron sputtering system is applied. Our technological capabilities enable precise tuning of the normal resistance value of the MoSi superconducting film by controlling its thickness and composition. Advantages of MoSi films

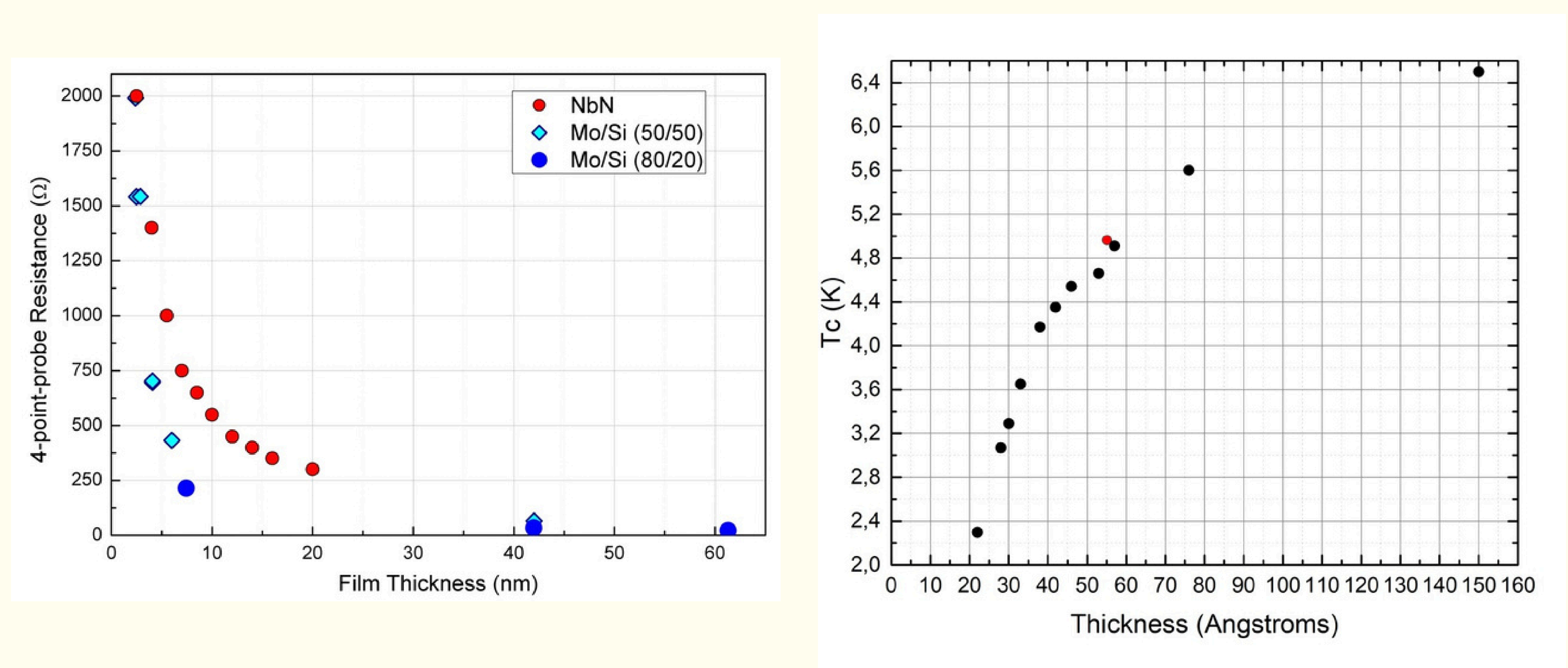
- High critical temperature of superconductivity (T_c)
- High critical current density (J_c)
- Technological compatibility with lithography
- Resistance to “aging” and diffusion-isotropy

By research [2], films with more than 80% Mo tend to have bcc structure and lower T_c.

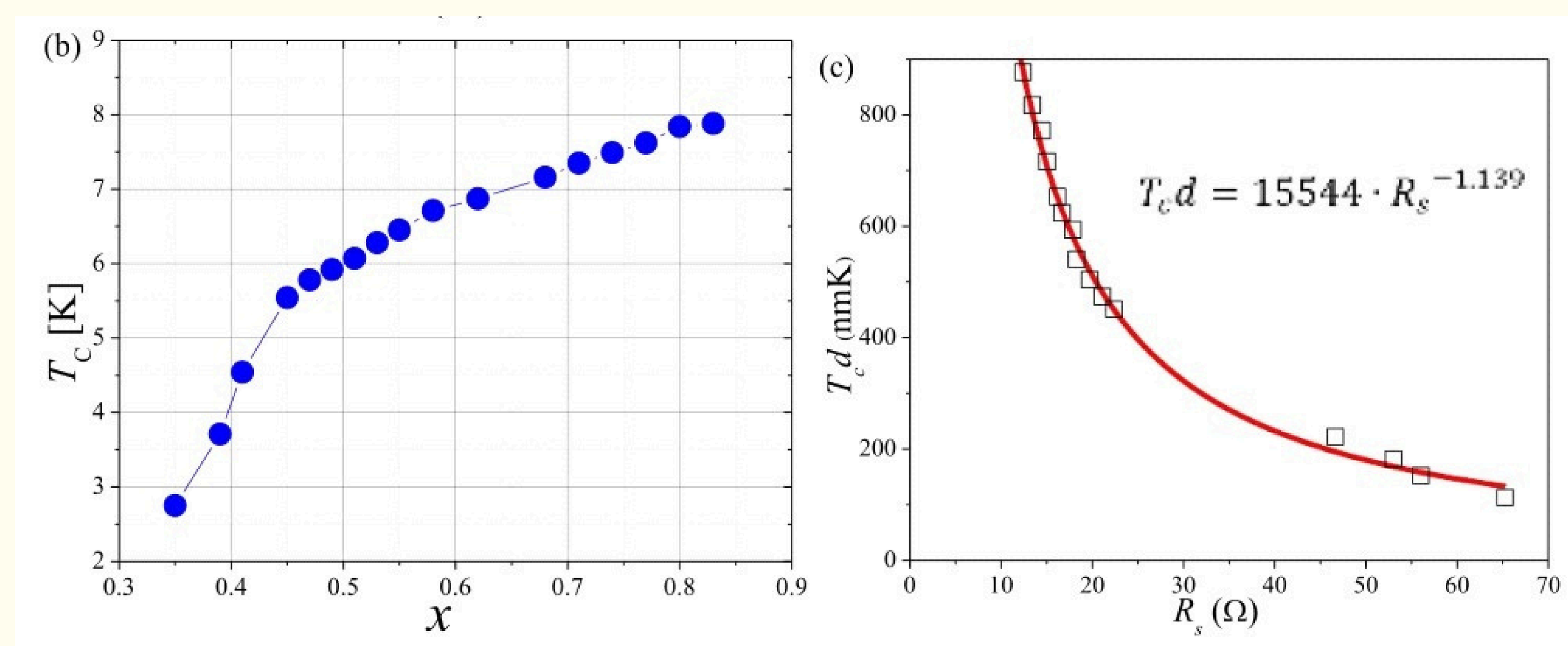


Results

Thin films with different composition, T_c and sheet resistance are fabricated.



Comparison to the published data [3]



Conclusion & references

Our goal was the preparation of thin amorphous films with high Tc and high sheet resistance.
- We fabricated and tested amorphous Mo_xSi_{1-x} films for SNSPD;
- The resistance of the samples was measured using the 4-probe method taking into account the geometry of the samples;
- The obtained results show that MoSi films are not inferior in their characteristics to NbN films;
- The vacuum DC magnetron sputtering technique employed enables the fabrication of ultrathin films with precise compositional control.

[1] Yu. P. Korneeva, M. Yu. Mikhailov, Yu. P. Pershin, et al. Supercond. Sci. Technol. 27 (2014).
[2] Kubo S. Superconducting properties of amorphous MoX (X=Si, Ge) alloy films for Abrikosov vortex memory. Journal of Applied Physics. 1988. Vol. 63, no. 6. P. 2033–2045.
[3] X. Zhang, A. Engel, Q. Wang, et al. Phys. Rev. B 94, 174509 (2016)

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