Study low temperature magnetron sputtering NbN films for fabrication ultra-high sensitive detector

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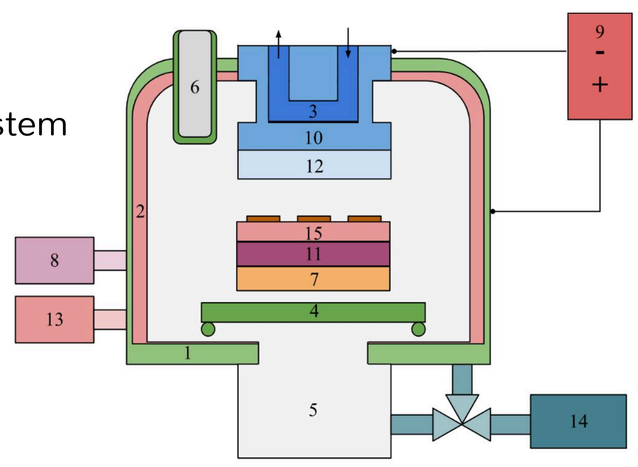
The goal of the study:

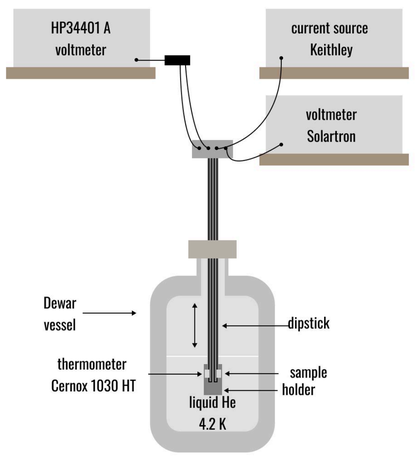
This work is devoted to the study of magnetron sputtering technology of ultrathin NbN films in order to increase the sensitivity of electron-heated bolometers for application in the Millimetron space observatory. Such bolometers are structures based on ultrathin superconductor films on silicon substrates.

Magnetron Sputtering Diagram

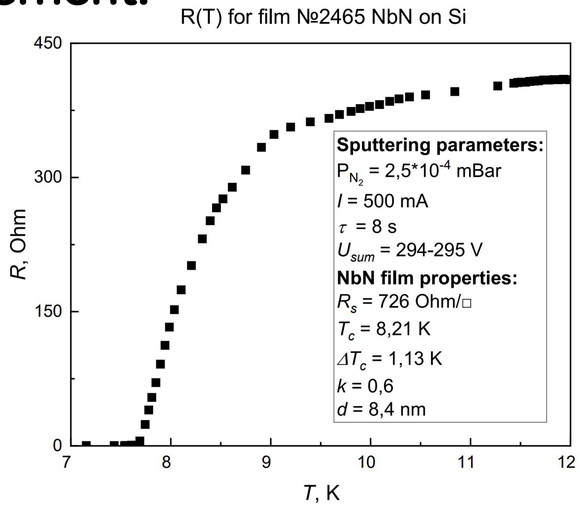
1. Vacuum chamber
2. Dome heating
3. Water cooling
4. High-vacuum valve
5. Two-stage vacuum system
6. Nitrogen trap
7. Substrate heater
8. Ar gas intruder
9. Power supply
10. Cathode
11. Substrate holder
12. Magnetron target
13. N_2 gas intruder
14. Vacuum pump
15. Sapphire substrate



Liquid helium measurement:



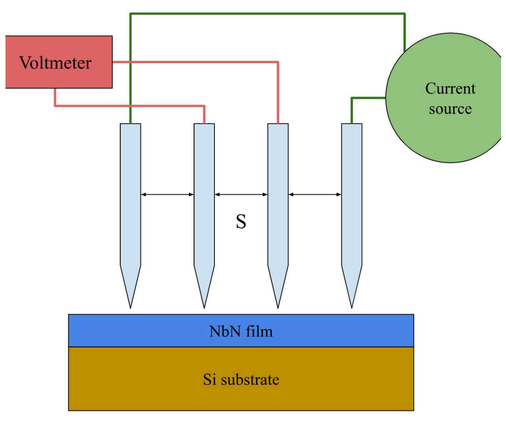
R(T) for film №2465 NbN on Si



$$T_c = T\left(\frac{R_{max}}{2}\right) \qquad \Delta T_c = \frac{T_1 - T_2}{2} \qquad k = \frac{R_{300}}{R_{20}}$$

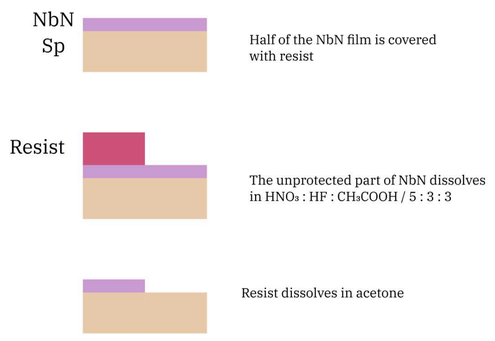
Van der Pauw method:

$$R_s = \frac{\rho}{d}$$

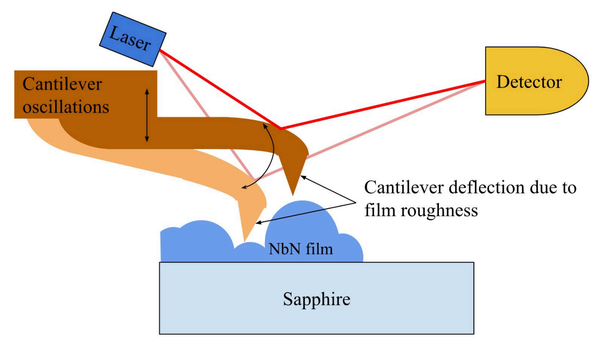


Atomic force microscopy:

Substrate preparation:

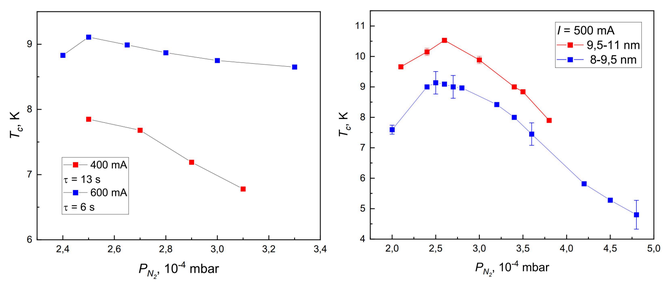


Measurement:

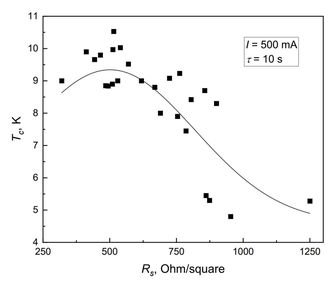


Superconductive film dependencies from technological parameters:

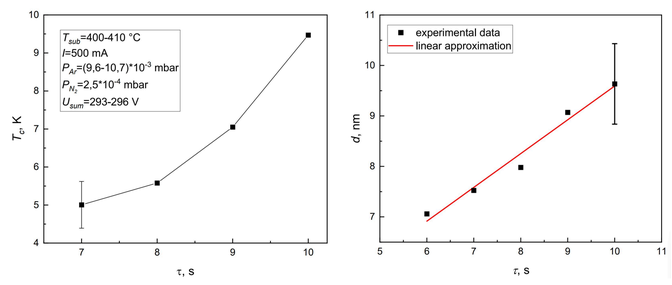
Superconductive temperature T_c from nitrogen pressure:



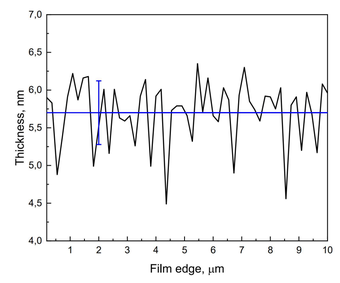
T_c from surface resistance:



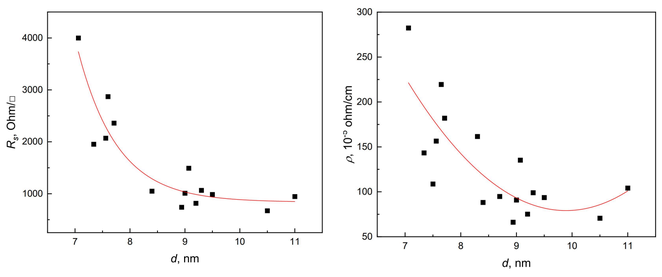
T_c from time sputtering and film thickness:



Thickness during the film:



Island growth (Volmer–Weber mode):



Resultant film properties:

T_c=7-8 K
ΔT_c=1 K
k=0,6
Thickness=7-8 nm
R_s=700 Ohm/square

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