Title: Deposition and electrical characterization of NbRe and NbReN thin films for application as superconducting nanowire single photon detectors.

The performances of Superconducting Nanowire Single Photon Detectors (SNSPDs) are strongly linked to the material's parameters on which they are based. There is a constant research for novel superconducting materials which could help in breaking the limits of the SNSPDs currently available. This issue is crucial for instance in the growing field of quantum communications. SNSPDs are devices exploiting the phenomenon of superconductivity to achieve high-speed single photon detection from optical to mid-infrared wavelengths. The devices typically consist of ultrathin (4-10 nm) nanowire (50-100 nm wide) arranged in meander geometry patterned with electron beam lithography out of a superconducting film having a critical temperature around 4-15 K, resulting in a working temperature of the device in the range 1-4 K. The first NbRe-based SNSPDs recently realized revealed the good potential of the material for the realization of fast detectors at an easily accessible cryogenic temperature. The key parameters which make this material promising are the value of the superconducting gap intermediate between crystalline nitrides and amorphous superconductors, the reduced quasiparticle relaxation rates, and its crystalline structure made of small grains which do not set strict requirements on the substrate or on the patterning procedures. Indeed, the superconducting properties are quite robust with respect to deposition and lithographic process, as well as to structural defects.

Therefore NbRe and its nitride NbReN represent a valuable alternative to NbN or NbTiN, but they may require additional optimization efforts. The thesis will be devoted to the fine tuning of the material properties to improve the performance of NbRe- and NbReN-based detectors. The deposition conditions will be systematically varied to match the optimal value of resistivity or critical temperature, as well as to further improve sample homogeneity. In principle, a change in the film stoichiometry can also be explored, since the Nb_xRe_{1-x} compounds are all superconducting in the composition range $0.13 \leq x \leq 0.38$, with a critical temperature varying from above 9 K to below 4 K, respectively. NbRe ultrathin films of different thickness will be deposited by UHV sputtering. Samples will be patterned in form of bridges of variable width of micrometric size. Their transport properties (critical temperature, critical current) will be measured. In particular, study of the vortex instability at high driving currents (voltage-current characteristics in presence of perpendicular magnetic field at different temperatures) will be performed.

In the framework of the thesis, the student will gain expertise in the following main activities: thin films fabrication by sputtering technique, low-temperature magnetotransport, optical lithographic processing; vacuum and cryogenic techniques.

The thesis will be carried out in the research group of Prof. Attanasio at the Physics Department of the University of Salerno. For further information about the group activity in this field of research please visit SNSPD | laboratorioattanasio (wixsite.com)

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