Spécialité de Master « Optique, Matière, Paris »

Stage de recherche (4 mois minimum, à partir de début mars)

Date de la proposition : octobre 2015

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Lieu du stage / *internship place*: ESPCI

Titre du stage / *internship title*: **Ultra-fast superconducting single photon detectors**

Résumé / *summary :* Superconducting single photon detector (SSPD) technology has emerged as a building block for numerous applications, including quantum communication, optical quantum computing or space to ground communication[1]. Such devices are made of a long superconducting nanowire (typically 100nm wide and several µm long) biased just below its critical current. When an incident photon is absorbed by the nanowire, it generates a hot spot, which locally destroys the superconductivity and creates a resistive region [2] (Figure 1). This phenomenon induces a measurable pulse voltage (typical duration 5 ns) that is used to detect the arrival of a single photon, before the nanowire returns to its initial state. Based on that principle, single photon detection started a decade ago using mainly Nb and NbN nanowires that operate in liquid He (4K). However, the speed of these devices is limited by the reset time, which is intrinsically set by the electron-phonon scattering time of the superconductor. In addition, the constraint of the low temperature slows down the development of most of practical applications. In this context the use of High-Tc Superconducting nanowires presents two main advantages: the critical temperature of the superconducting state is higher and the electron-phonon scattering time is much shorter than the actual SSPD ones, therefore enabling a faster operation.

Our team at ESPCI-ParisTech has developed a powerful technique to structures High-Temperature Superconducting films at the nanoscale combining advanced electron-beam lithography with ion irradiation technique [4]. We have been able to produce reliable meander (30nm thick, 100 nm wide and 450 µm long), which are the main ingredient to build SSPD.

This goal of the project is to develop a new kind of ultra-fast superconducting nanowire single-photon detectors using $YBa_2Cu_3O_7$ and to study the physical mechanism occurring during the detection event. Indeed, knowing the physics of this fast normal transition will allow optimizing the geometry of such a detector.

Nanofabrication will be carried out using an electron beam lithography facility at ESPCI. The first step will be to show photo-response of the device up to the single-photon. The device will be operated as a SSPD using photons delivered by a laser connected to an optical fiber. The detection event will be studied through temperature, magnetic field and photon energy dependence of YBCO SSPD device response.

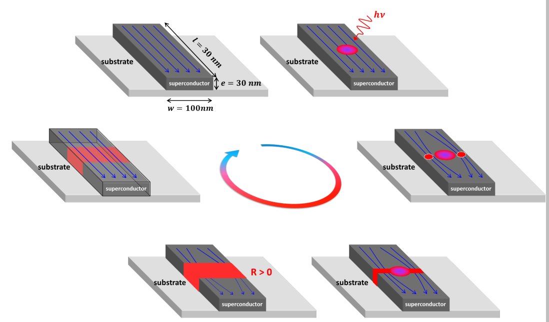

Figure 1: Principle of operation of a SSPD (adapted from [2]). (i) The nanowire is biased just below its critical current (ii) A hot spot is generated by the absorption of a photon (iii and iv) Formation of a resistive area. (v) Expansion of the resistive area (vi) The nanowire returns to its original superconducting state.

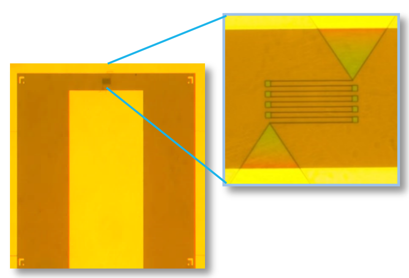

Figure 2 : optical microscope of a Typical YBCO SSDP sample

[1] Nature Photon. 3 696–705 (2009) [2] Supercond. Sci. Technol. (2012) [3] Appl. Phys. Lett. 79, 705–707 (2001). [4] Appl. Phys. Lett. 87, 1025 102, 083903 (2007), Appl. Phys. Lett. 89, 112515 (2006). Appl. phys. Lett. 101, 233505 (2012)

Ce stage pourra-t-il se prolonger en thèse ? *Possibility of a PhD* **? : OUI**

Si oui, financement de thèse envisagé/ *financial support for the PhD*: **Ecole Doctorale**

Lumière, Matière, Interactions	**oui**	Lasers, Optique, Matière	**oui**