Nanostructured Superconducting Single-Photon Detectors as Photon Energy, Number, and Polarization Resolving Devices

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题　目：Nanostructured Superconducting Single-Photon Detectors as Photon Energy, Number, and Polarization Resolving Devices

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Abstract:

We present an overview of the physics of operation of superconducting single-photon detectors (SSPDs) and their implementation as the photon-energy, photon-number, and polarization resolving devices. The detection mechanism of SSPDs is based on photon-induced hotspot formation and, subsequent, generation of a voltage transient across a nanostructured superconducting NbN meander (~4-nm-thick and ~100-nm-wide stripe). The NbN SSPD operates in the 4.2-2 K temperature range. The best devices exhibit quantum efficiency of up to near 100% (when encapsulated in a cavity) in the near-infrared (1550 nm) wavelength range, dark count rates <1 Hz, and the noise-equivalent power (NEP) of ~5×10^{-21} W/Hz.$^{1/2}$ For our photon-energy resolution studies, we have adopted a statistical method based on a well-documented fact that quantum efficiency (QE) of SSPDs very strongly (quasi-exponentially) depends on the photon wavelength and the normalized current bias. Thus, by measuring the SSPD QE at different bias levels, we were able to resolve the wavelength of the incident photons with a 50-nm resolution. In another approach, we have implemented a low-noise, cryogenic high-electron-mobility transistor (HEMT) as a very high impedance element to separate the 50-Ω output transmission line from the SSPD. This arrangement allowed us to achieve some amplitude resolution of the recorded output transients and, subsequently, photons with different energies could be distinguished by comparing the output transient amplitude distributions. Next, by designing SSPDs with different physical geometries, we could unambiguously demonstrate their sensitivity to photon polarization. At the end of the presentation, we will discuss selected photon-counting applications and new directions of the SSPD research.

Biography:

Roman Sobolewski is a Professor of Electrical and Computer Engineering, Physics, and Materials Science, as well as a Senior Scientist of Laser Energetics at the University of Rochester, Rochester, NY, USA. He received his Ph. D. and D. Sc. (Habilitation) degrees in Physics from the Polish Academy of Sciences, Warszawa, Poland, in 1983 and 1992, respectively. In 2006, he was granted the State Professorship of the Republic of Poland. In 2011, he received the Spanish Government Research Scholarship and spent a semester at University of Salamanca, Spain. In 2015, he was named a Distinguished Fellow of the Kosciuszko Foundation Collegium of Eminent Scientists of Polish Origin and Ancestry. In 2016, he was a Lecturer at the European Society of Applied Superconductivity Winter School on “Novel frontiers in superconducting electronics: from fundamental concepts and advanced materials towards future applications” in Pozzuoli, Italy. From 2009 till present he has been the Co-Chair and Co-Organizer of the Photon Counting Applications Conferences during the biennial SPIE Europe Optics+Optoelectronics Meeting in Prague, Czechia. Dr. Sobolewski’s current interests are concentrated on the physics of ultrafast phenomena in condensed matter, novel nanostructured electronic and optoelectronic semiconducting and superconducting materials and devices, single-photon quantum detection, and on generation and detection of THz radiation transients, including time-resolved, femtosecond spectroscopy. He has published almost 400 peer-reviewed publications and presented well over 200 invited conference talks, lectures, seminars, and colloquia worldwide.