

Design of a superconducting nanowires single photon detector with dual broadband and high detection efficiency

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Abstract: In this paper, we propose a structure of a superconducting nanowire single photon detector (SNSPD) with a composite cavity. Compared with the SNSPD in previous studies, our device exhibits a property of high efficiency and dual broadband. Based on the transmission line theory, the structure is abstracted as an equivalent circuit model and a design method is presented. Taking $\lambda=1310$ nm and $\lambda=1550$ nm as an example, the structural parameters are calculated and verified by commercial software FDTD Solutions. The simulation results show that peaks of the absorption curve appear at both wavelengths and peak values are all larger than 97.5%. The influence of the upper half cavity on the full width at half maximum (FWHM) of the absorption peak is discussed. Our work provide a reference for designing a SNSPD with different FWHM.

Index Terms: superconducting nanowire single photon detector, high efficiency, dual broadband.

1. Introduction

In recent years, superconducting nanowire single photon detectors (SNSPDs) have attracted more attention because of those high detection efficiency in the near-infrared regime, low dark count, low time jitter and fast response speed[1-9]. In view of these advantages, SNSPDs have been widely used in quantum key distribution (QKD)[10-12], time-of-flight ranging[13], space laser communication[14], and so on. Especially in the application of QKD, photons are encoded and transmitted with different phase or polarization to achieve confidential communications. For this application, the efficiency of the detector has an effect on the bit error rate of the system directly. Therefore, the detection efficiency has been an important performance indicator for a SNSPD and also become an important research topic. In recent reports, F. Marsili et al[15] fabricate a high efficiency SNSPD with an optical cavity and the detection efficiency is larger than 90%. For this results, the optical cavities can be satisfactory for high-efficiency devices and have been widely used[16, 17]. However, this kind of the simple optical cavity can only improve the detection efficiency at the target wavelength and has an inhibitory effect at the other wavelength[18], which can lead to restrictions in certain applications. In fiber-based optical communications, both 1310 nm and 1550 nm are both technologically interested wavelength. Therefore, simultaneously optimizing the absorption of an SNSPD at these two wavelengths would expand SNSPDs' application space.

In this paper, we propose a device structure of the SNSPD with a composite cavity, which enables a high detection efficiency at two wavelengths, simultaneously. Based on the transmission line theory, a design method is proposed and verified by taking $\lambda=1310$ nm and $\lambda=1550$ nm as an example. Numerical simulations show that the peaks of absorption curve appear at the both wavelengths and the peak values are all larger than 97.5%.

2. Design of SNSPD

We first briefly describe the method of establishing the equivalent circuit model before our designing. Fig. 1 shows the schematic and the corresponding equivalent circuit diagram of the SNSPD with a composite cavity. From an optics standpoint, the superconducting nanowires can be approximately considered as sub-wavelength periodic structures. In each unit cell, the light transmits in the form of single-mode (TEM) and the higher order mode is cut off by the period boundary condition in our device. For this reason, we can express the SNSPD structure as an equivalent circuit model and complete our design by the transmission line theory. In the circuit model, each layer of the SNSPD is equivalent to a transmission line. The intrinsic impedance and the length of the transmission line are equal to the reciprocal of the medium refractive index and the thickness of the medium layer, respectively. The metal mirror (Au) is equivalent to a load impedance (Z_L). It should be noted that the refractive index of gold is about 10 and does not tend to infinity in infrared band. Therefore, the load impedance is not

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Design of Broadband High-efficiency Superconducting-nanowire Single Photon Detectors ,2016

Nanophotonics and Plasmonics Dr. Ching Eng (Jason) Png, Dr. Yuriy Akimov, 2017-08-21 This book provides a first integrated view of nanophotonics and plasmonics covering the use of dielectric semiconductor and metal nanostructures to manipulate light at the nanometer scale The presentation highlights similarities and advantages and shows the common underlying physics targets and methodologies used for different materials optically transparent materials for nanophotonics vs opaque materials for plasmonics Ultimately the goal is to provide a basis for developing a unified platform for both fields In addition to the fundamentals and detailed theoretical background the book showcases the main device applications Ching Eng Jason Png is Director of the Electronics and Photonics Department at the Institute of High Performance Computing Agency for Science Technology and Research Singapore Yuriy A Akimov is a scientist in the Electronics and Photonics Department at the Institute of High Performance Computing Agency for Science Technology and Research Singapore

Photon Counting Nikolay Britun, Anton Nikiforov, 2018-03-21 Photon counting is a unified name for the techniques using single photon detection for accumulative measurements of the light flux normally occurring under extremely low light conditions Nowadays this approach can be applied to the wide variety of the radiation wavelengths starting from X ray and deep ultraviolet transitions and ending with far infrared part of the spectrum As a special tribute to the photon counting the studies of cosmic microwave background radiation in astronomy the experiments with muon detection and the large scale fundamental experiments on the nature of matter should be noted The book provides readers with an overview on the fundamentals and state of the art applications of photon counting technique in the applied science and everyday life

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dissertations engineering drawings and journal articles from worldwide sources are also included Abstracts and full text are provided if available **Electrical & Electronics Abstracts**, 1997 **High-field EPR Spectroscopy on Proteins and Their Model Systems** Klaus Möbius, Anton Savitsky, 2009 Understanding the major factors determining the specificity of transmembrane transfer processes in proteins is now a hot topic in molecular bio science Advanced electron paramagnetic resonance EPR at high magnetic fields is a powerful technique for characterizing the transient states of proteins in action High Field EPR Spectroscopy on Proteins and their Model Systems characterization of Transient Paramagnetic States offers a comprehensive overview of experimental techniques in and paradigmatic examples of the application of high field EPR spectroscopy in biology and chemistry The book's focus is on the use of the technique in conjunction with site specific mutation strategies and advanced quantum chemical computation methods to reveal protein structure and dynamics This yields new insights into biological processes at the atomic and molecular level The theoretical and instrumental background of high field EPR is described and examples of paradigmatic protein systems such as photosynthetic reaction centres are discussed in the light of recent investigations Aspects of structure dynamics function relations that are revealed by studying site specific mutants are highlighted thereby combining high field EPR with genetic engineering techniques The information obtained complements that obtained from protein crystallography solid state NMR infrared and optical spectroscopy The book documents both background knowledge and results of the latest research in the field Unique features include comparisons of information content of EPR ENDOR Triple resonance ESEEM and PELDOR taken at different microwave frequencies and magnetic fields Coherent treatment of the subject by the leading Berlin high field EPR laboratory covers the theoretical background as well as state of art research both in terms of instrumentation and application to biological systems The book provides an outlook to future developments and references for further reading and is essential reading for postdoctoral scientists professionals academics and graduate students working in this field [Handbook of Superconductivity](#) David A. Cardwell, David C. Larbalestier, Aleksander Braginski, 2022-07-05 This is the last of three volumes of the extensively revised and updated second edition of the Handbook of Superconductivity The past twenty years have seen rapid progress in superconducting materials which exhibit one of the most remarkable physical states of matter ever to be discovered Superconductivity brings quantum mechanics to the scale of the everyday world Viable applications of superconductors rely fundamentally on an understanding of these intriguing phenomena and the availability of a range of materials with bespoke properties to meet practical needs While the first volume covers fundamentals and various classes of materials the second addresses processing of these into various shapes and configurations needed for applications and ends with chapters on refrigeration methods necessary to attain the superconducting state and the desired performance This third volume starts with a wide range of methods permitting one to characterize both the materials and various end products of processing Subsequently diverse classes of both large scale and electronic applications are described Volume 3 ends with a

glossary relevant to all three volumes Key Features Covers the depth and breadth of the field Includes contributions from leading academics and industry professionals across the world Provides hands on familiarity with the characterization methods and offers descriptions of representative examples of practical applications A comprehensive reference the handbook is suitable for both graduate students and practitioners in experimental physics materials science and multiple engineering disciplines including electronic and electrical chemical mechanical metallurgy and others Technological Innovation for the Internet of Things Luis M. Camarinha-Matos, Slavisa Tomic, Paula Graca, 2013-04-15 This book constitutes the refereed proceedings of the 4th IFIP WG 5.5 SOCOLNET Doctoral Conference on Computing Electrical and Industrial Systems DoCEIS 2013 held in Costa de Caparica Portugal in April 2013 The 69 revised full papers were carefully reviewed and selected from numerous submissions They cover a wide spectrum of topics ranging from collaborative enterprise networks to microelectronics The papers are organized in the following topical sections collaborative enterprise networks service orientation intelligent computational systems computational systems computational systems applications perceptual systems robotics and manufacturing embedded systems and Petri nets control and decision integration of power electronics systems with ICT energy generation energy distribution energy transformation optimization techniques in energy telecommunications electronics devices design electronics amplifiers electronics RF applications and electronics applications

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Department of Defense Appropriations United States. Congress. House. Committee on Appropriations. Subcommittee on Department of Defense, 1970 Proceedings of Third International Conference on Computational Electronics for Wireless Communications Sanyog Rawat, Arvind Kumar, Ashish Raman, Sandeep Kumar, Parul Pathak, 2024-12-01 This book includes high quality papers presented at the Third International Conference on Computational Electronics for Wireless Communications ICCWC 2023 held at Dr B R Ambedkar National Institute of Technology Jalandhar India during December 22-23, 2023 The book presents original research work of academics and industry professionals to exchange their knowledge of the state of the art research and development in computational electronics with an emphasis on wireless communications The topics covered in the book are radio frequency and microwave signal processing microelectronics and wireless networks

Department of Defense Appropriations for 1970 United States. Congress. House. Committee on Appropriations. Subcommittee on Department of Defense, 1969 *Technical Abstract Bulletin*, **Millimeter and Submillimeter Detectors for Astronomy**, 2002

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