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Feature Articles: Superconducting Microwave/Terahertz Wave Device Technology
- High Speed Quantum Distribution System using SSPD

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The reassurance of a safe communication network is an important attribute in a society where networks are developing rapidly. This is where the distribution of a quantum key has gained attention, which theoretically enables the sharing of random numbers between two parties, whatever the technology, without an eavesdropping threat. The technology allows secure information exchange between two parties by performing an exclusive OR operation on every bit of information. Up until now, with installed optical fibre, quantum key distribution systems developed by the US Department of Defence and the European Union have limited voice encryption capabilities and restricted transmission distances of up to 10km. In Japan, since 2001, under a cooperative project involving academia, industry and the Government, the National Institute of Information and Communications Technology (NICT) has undertook a research and development programme for the world's fastest quantum key distribution technology that would possibly allow for entire encryption of a TV conference in a metropolitan area. A single photon detector is the key device behind influencing quantum key distribution performance. An InGaAs-based avalanche photodiode (APD) used conventionally in gated Geiger-mode, was previously employed as a single photon detector at fibre communication wavelengths. However, employing a superconducting single photon detector (SSPD) for quantum key distribution tests reveals superior performance characteristics such as low jitter, low noise and greater high-speed operation compared to a conventional InGaAs APDs. This article introduces the Tokyo Quantum Key Distribution (QKD) network, which started test operations in October 2010, and a SSPD system utilized for this developed quantum key distribution.

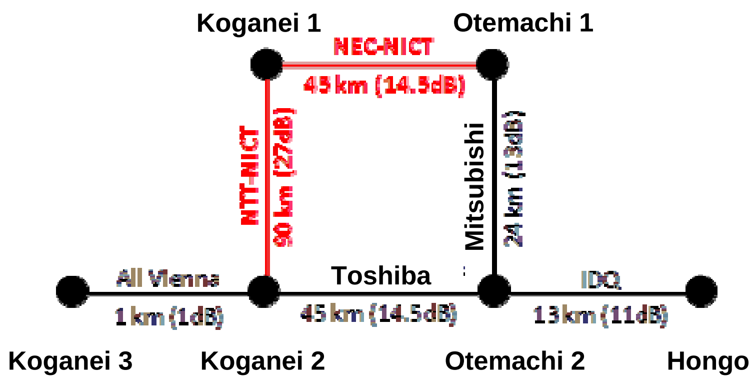

Fig. 1 The Tokyo QKD network layout

Tokyo QKD network makes use of JGN2plus, which represents an open test bed network that provides a platform for NICT R&D activities. It connects four operation centres of the JGN2plus based in Otemachi, Koganei, Hakusan, and Hongo. The network layout of the Tokyo QKD Network is shown in Figure 1[1]. The systems for each research group involved (NEC, Mitsubishi, NTT, Toshiba, IDQ, All Vienna) are located opposite each other and grouped together with six nodes. Amongst those, the NTT-NICT and NEC-NICT nodes housed the SSPD system for evaluation studies. The NTT-NICT node employed a differential phase shift quantum key distribution (DPS-QKD) system developed by NTT, with 15 kbps of shift-keying data rate successfully transmitted between the links (transmission loss 27-28 dB) over a total distance of 90 km[2]. The DPS-QKD required two SSPDs. At the NEC-NICT node, a QKD system utilizing a multiplexed decoy pulse method, BB84 protocol, has been employed, successfully creating cryptograph keys that exceed 200 kbps over a 45 km distance[3]. Here, three wavelengths are multiplexed using an avalanche photodiode for λ_1 and SSPDs (8 in total) for λ_2 and λ_3 during testing. A live demonstration of the Tokyo QKD network was presented at the "Updating Quantum Cryptography and Communications 2010" conference held on 18th-20th October 2010, where a quantum key distribution videoconference between Koganei and Otemachi, in Tokyo, took place (Figure 2). Full details of the performance and images can be found on the website[4].

Fig. 2 Video-conferencing at the "Updating Quantum Cryptography and Communications 2010" conference.

An outline view of the SSPD system used at the Tokyo QKD network is shown in Figure 3. A mechanical driven-type GM cryocooler operating at AC100V enables continuous system operation without requiring additional liquid refrigerant or an additional high voltage supply. Furthermore, it is possible to install a maximum of six superconducting single photon detectors (SSPD) into a single refrigeration unit, allowing quantum key distribution using multiple SSPDs. Each SSPD element is equipped with an optical cavity structure that effectively absorbs incident photons in the 1550nm wavelength band. A packaging technology to realize effective coupling between the SSPD elements and incident photons was developed. With this technology, the results were successful and showed maximum enhanced detection efficiencies of around 30%, leading to the rapid progress in the detection efficiency of the SSPD system[5]. Even though the SSPD system is in the middle of development, future systems performance improvements will benefit not only quantum key distribution systems, but also the development of various other research fields including quantum optics and bio-medical imaging.

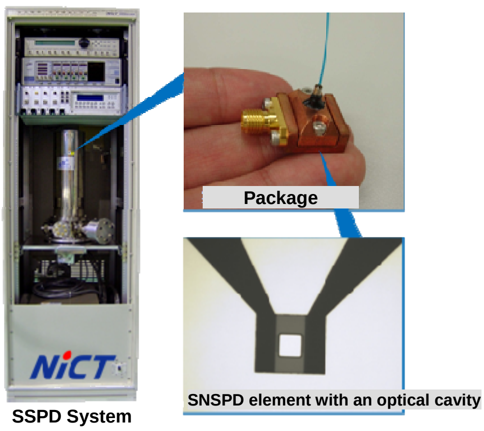

Fig. 3 Photo of the SSPD System

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Reference:

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