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LiFiAd HocNetworkSecurity using aMicroring Transceiver

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Abstract: This paper proposes a new wireless ad-hoc network security system by quantum cryptography using a graphene ring resonator system as a quantum-processor. To increase the channel capacity and security, the multiplexer is operated incorporating a quantum processing unit via an optical multiplexer. The system consists of two parts, where firstly, the transmission part, generates the quantum codes within the graphene resonators, which is formed by a modified optical add/drop filter, secondly, the receiver part can be communicated by using the quantum key (quantum bit, qubit) via a quantum processors, in which the quantum transceiver is formed. In operation, the reference states can be recognized by using the cloning unit, which is operated by the add/drop filter, where the communication between Sender (Alice) and Receiver (Bob) can be performed. Such a proposed system is formed by using the laser source, which is known as a light fidelity(LiFi) technique. Results obtained have shown that the correlated photons can be generated and formed the entangled photon pair, which is allowed to form the secret key between Alice and Bob. In application, the embedded system within the computer processing unit is available for the quantum computer. Furthermore, such a concept is also available for hybrid communications, which can be used to form the wireless ad-hoc network security system, which is discussed in details.

Keywords: Quantum transceiver; Ad Hoc network; Quantum key distribution; Quantum cryptography

1 Introduction

Ad-hoc such as mobile ad hoc networks (MANETs) are the paradigm of wireless communication for movement the mobile nodes. MANETs are generally dynamic in terms of topology thus making it challenging to a device of a routing mechanism [1]. Each the node connect to other by directly via wireless links while these which far apart rely on other nodes to relay messages and mobility frequent changes in topology. MANETs are especially mobile nodes susceptible to physical attacks than wired nodes in traditional networks. Ad hoc wireless network does not have any predefined infrastructure and all network services are configured and created on the fly. Thus it is obvious that with the lack of infrastructural support and susceptible wireless link attacks, security in ad hoc network becomes the inherent weakness. Achieving security within MANETs are challenging due to following reasons [2]. However, the significance of the physical security in the overall protection of the network is highly dependent on the ad hoc networking approach and the environment in which the nodes operate. A quantum technique is recommended to security technique known as quantum cryptography has been widely used and investigated in many applications [3-5]. Currently, quantum key distribution (QKD) [4] is the only form of information that can provide the perfect communication security. The use of QKD has been proposed in many research works, whereas the applications in different forms such as point to point [5], optical wireless [8], satellite [9], long distance [10] and network [11] have been reported. However, a more reliable system for network security is needed, which is both high capacity and secure. The concept of continuous variable quantum key distribution could be formed chaotic signals generated in a nonlinear micro-ring resonator system [11-13]; the form of dense wavelength multiplexing is introduced to overcome such a problem. By using the continuous variable concept, the continuous QKD can be formed and available for a large demand. There are some works proposed the use of continuous variable QKD with the quantum router and network [14, 15]. However, the requirement of large bandwidth signal and dense wavelength multiplexing become the practical problems, which can be useful for light fidelity (LiFi) technique, wherein either high capacity and security requirements can be realized.

Currently, graphene is being an interesting material in the electronics business. The researchers from the University of California at Riverside, the University of Texas at Dallas and Austin [17], and Xiamen University in China [18] have discovered how to make graphene with thermal properties better, e.g.

isotopes, the new development of graphene that can be used in cooling the laptop, wireless devices and other devices. The material has been developed, and the demand for these materials is increasing due to It is an electronic device with more efficiency, but at a smaller scale. The conditions that are required to control the price of materials, such as specially designed for graphene, which is the first time that graphene can be used as packaging chips [19]. As well as to implement the solar panel according to evidence at the University of California at Riverside have identified. It was also used as silicon for cooling computer chips. This paper, we have used a graphene ring resonator to form the correlated photons and quantum codes, where the secret key codes can be generated by using the entangled photon pair, which can be formed the secret key for two parties known as Alice and Bob by using the Gaussian light pulse propagating with the graphene ring resonator. In application, the device can be embedded within the computer processing unit with using to increase the capacity and the speed of the internet, where the internet security can be provided. Furthermore, such a concept is also available for hybrid communications, for instance, wire/wireless, satellite. However, the theoretical background of correlated photon source generation is reviewed.

2. Theoretical Background

Generally, there are two pairs of possible polarization entangled photons forming within the ring device, which is represented by the four polarization orientation angles as [0°, 90°], [135° and 180°]. These can be formed by using the optical component called the polarization rotatable device and a polarizing beam splitter (PBS). In this concept, we assume that the polarized photon can be performed by using the proposed arrangement. Where each pair of the transmitted qubits can be randomly formed the entangled photon pairs. To begin this concept, we introduce the technique that can be used to create the entangled photon pair (qubits) a polarization coupler that separates the basic vertical and horizontal polarization states corresponds to an optical switch between the short and the long pulses. We assume those horizontally polarized pulses with a temporal separation of Dt. The coherence time of the consecutive pulses is larger than Dt. Then the following state is created by Eq. (1) [20].

$$|\Phi\rangle_p = |1,H\rangle_s|1,H\rangle_i + |2,H\rangle_s|2,H\rangle_i \qquad (1)$$

In the expression $|k,H\rangle, k$ is the number of time slots (1 or 2), where denotes the state of polarization [horizontal $|H\rangle$ or vertical $|V\rangle$], and the subscript identifies whether the state is the signal (s) or the idler (i) state. In Eq. (1), for simplicity, we have omitted an amplitude term that is common to all product states. We employ the same simplification in subsequent equations in this paper. This two-photon state with $|H\rangle$ polarization shown by Eq. (1) is input into the orthogonal polarization-delay circuit shown schematically. The delay circuit consists of a coupler and the difference between the round-trip times of the micro ring resonator, which is equal to Δt. The micro ring is tilted by changing the round trip of the ring is converted into $|V\rangle$ at the delay circuit output. That is the delay circuits convert $|k,H\rangle$ to be

$$r|k,H\rangle + t_2\exp(i\phi)|k+1,V\rangle + rt_2\exp(i_2\phi)|k+2,H\rangle + r_2t_2\exp(i_3\phi)|k+3,V\rangle$$

Where t and r are the amplitude transmittances to cross and bar ports within a coupler. Then Eq. (1) is converted into the polarized state by the delay circuit as

$$\begin{aligned}|\Phi\rangle &= [|1,H\rangle_s + \exp(i\phi_s)|2,V\rangle_s] \times [|1,H\rangle_i + \exp(i\phi_i)|2,V\rangle_i] + [|2,H\rangle_s + \exp(i\phi_s)|3,V\rangle_s] \\ &\quad \times [|2,H\rangle_i + \exp(i\phi_i)|2,V\rangle_i] \\ &= [|1,H\rangle_s|1,H\rangle_i + \exp(i\phi_i)|1,H\rangle_s|2,V\rangle_i] + \exp(i\phi_s)|2,V\rangle_s|1,H\rangle_i + \exp[i(\phi_s+\phi_i)]|2,V\rangle_s|2,V\rangle_i + |2,H\rangle_s|2,H\rangle_i \\ &\quad + \exp(i\phi_i)|2,H\rangle_s|3,V\rangle_i + \exp(i\phi_s)|3,V\rangle_s|2,H\rangle_i + \exp[i(\phi_s+\phi_i)]|3,V\rangle_s|3,V\rangle_i \qquad (2)\end{aligned}$$

By the coincidence counts in the second time slot, we can extract the fourth and fifth terms. As a result, we can obtain the following polarization entangled state as

$$|\Phi\rangle = |2,H\rangle_s|2,H\rangle_i + \exp[i(\phi_s+\phi_i)]|2,V\rangle_s|2,V\rangle_i \qquad (3)$$

We assume that the response time of the Kerr effect is much less than the cavity round-trip time. Because of the Kerr nonlinearity of the optical device, the strong pulses acquire an intensity dependent phase shift during propagation. The interference of light pulses at a coupler introduces the output beam, which is entangled. Due to the polarization states of light pulses are changed and converted while circulating in the delay circuit, where the polarization entangled photon pairs can be generated. The entangled photons of the nonlinear ring resonator are separated to be the signal and idler photon probability. The polarization angle adjustment device is applied to investigate the orientation and optical output intensity, this concept is well described by the published work [21].

3.GraphenePANDA Ring Resonator

In the experiment, the FDTD Method was used to solve the electromagnetic field [22], whereas the architecture of graphene PANDA ring resonator resembles as the ring resonator from [8]. The graphene ring architecture is shown in Figure1, where R_1 is a center ring radius, R_2 and R_3 are the left and right nano-ring radii, respectively. The suitable ring parameters are used, for instance, ring radii R_1= 1.55 μm, R_2= 0.6 μm, R_3= 0.6 μm, the substrate (SiO_2) is 6 mm, gap = 0.1 mm. The other parameters are shown in Table 1. The input source for this simulation is the embedded laser source, i.e. the Gaussian pulse with wavelength is ranged from 1.3 μm to 1.4 μm with the normalized amplitude of 1. After light is input into the system, the Gaussian pulse is chopped (sliced) into a smaller signal spreading over the spectrum due to the nonlinear effects, which is shown in Figures 2 to 5, respectfully.

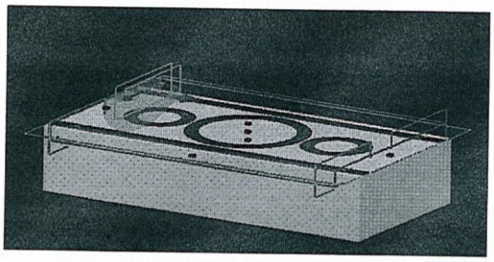
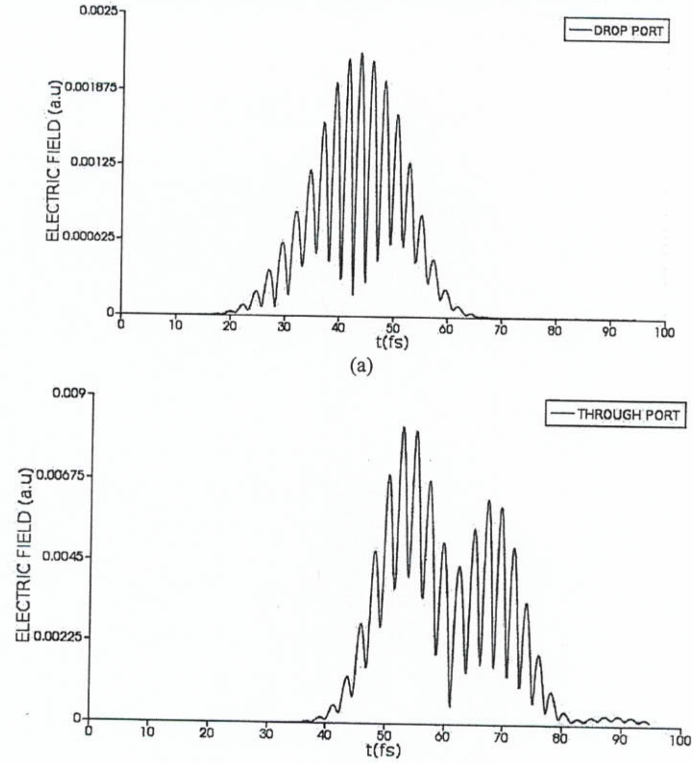


Figure 1: Showsa monolayer of graphene-based PANDA ring resonator



(a)

(b)

Figure 2: Shows the electric field outputs, where (a)drop port and (b) through port, respectively

Table 1: Simulation parameters of PANDA structure

	Material	Length (x span)	Height (y span)	Width (z span)
Substrate	SiO_2	6.0 μm	5 μm	4.0 μm
Waveguides	Graphene	6.0 μm	0.000335 μm	0.18 μm
Ring resonator	Graphene	1.55 μm (radius)	0.000335 μm	0.18 μm
Left Nano ring	Graphene	0.6 μm (radius)	0.000335 μm	0.18 μm
Right Nano ring	Graphene	0.6 μm (radius)	0.000335 μm	0.18 μm
Other parameter	Gap = 0.1 um, Simulation time = 4ps, Simulation temperature = 300 K			

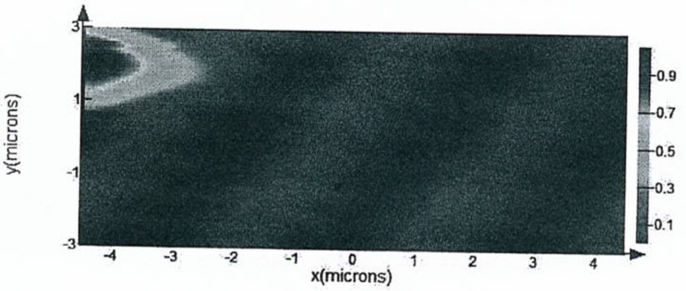
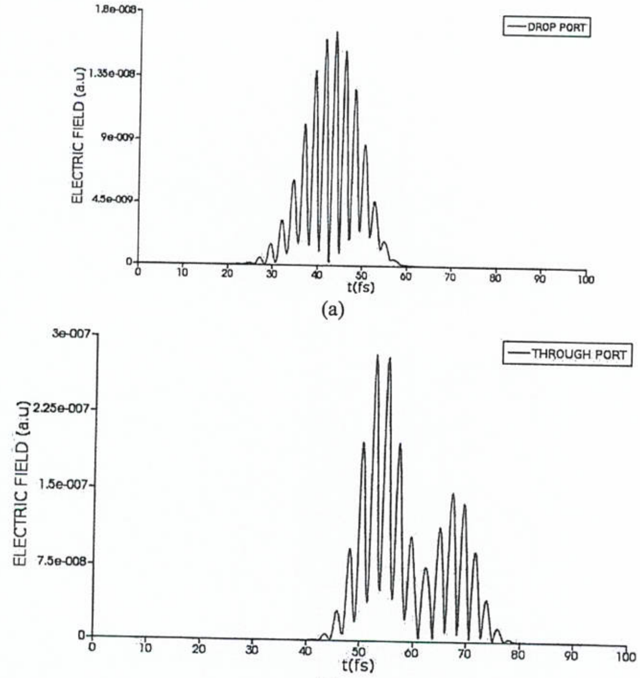


Figure 3: Show the full profile electric field using Opti-wave program



(a)

(b)

Figure 4: Shows the output power, where (a) drop port and (b) through port, respectively

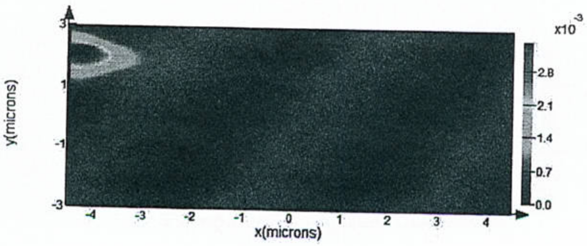


Figure 5: Show the full profile output power using the Opti-wave program

4. Peer to Peer LiFiAd HocNetwork

A system for ad hoc network communication and security proposed in Figure 6, each node connect to another nearby node by using the transmission in two channels the first channel is the quantum channel and the second channel is the classical channel. The quantum channel is the line of sight optical path is running by the polarization photon and the classical channel using the optical wireless for down link and up link communication channel. The quantum channel is generating the high capacity of quantum bits (qubits) within the graphene micro ring resonators and the cloning unit, which is operated by the add/drop filter, the schematic diagram in Figure 7. An information data can be modulated and encoding by the controller node, which is encoded by the quantum secret codes. Then can transmit together with the qubits via down link by through port. On the other hand, the required data can be retrieved via the drop port of the add/drop filter, whereas the quantum secret codes can be specified between Alice and Bob [4].

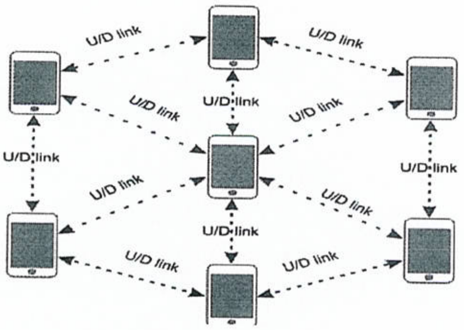


Fig. 6: A schematic of the LiFiad hoc communication, down-link, up-link and quantum code

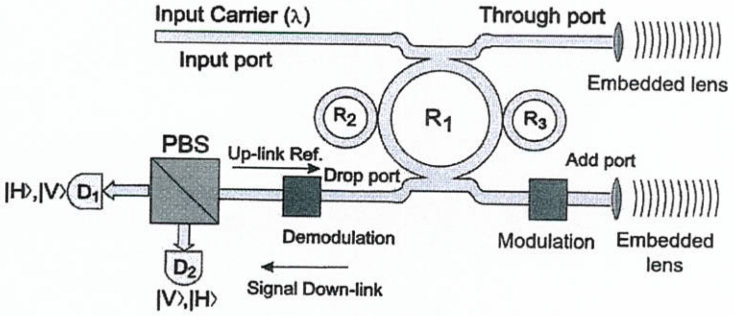


Figure 7: A schematic the graphene ring resonator used as a transceiver for the LiFi Ad Hoc communication, where in this proposed system, in which the two major polarization entangled photons are formed by the polarizing beamsplitter.

5.Conclusion

This paper proposed Ad Hoc optical wireless communication and quantum cryptography base on graphene ring resonator system to increase the channel capacity and security. The system consists of two parts, where firstly, the transmission part can be used to generate the high capacity of quantum codes within the graphene ring resonators and sent via the through port. Secondly, the receiver part can be used to detect the quantum bits from optical wireless(LiFi) by a photodiode (PD). The reference states can be recognized by using the cloning unit which is operated by the add/drop filter. A quantum code (two add/drop filters that are in two parts) can be used to form Alice and Bob states in the link, respectively. The secret codes can be formed in the system, which is allowed to retrieve the secret codes by the end users, where the quantum code and decode (CODEC) are embedded within the quantum transceiver.

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