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Free-Space Reconfigurable Interconnects via Dynamic Multipolar Couplings between Quantum Nano-Structures

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1. Introduction

The time-energy uncertainty principle is shown to be applied for nano-scale circuit design consideration, giving a new vista of quantum integration. The range of virtual as well as real photons mediating interactions between nano-structures is estimated as a product of photon lifetime and its velocity. This suggests wireless reconfigurable interconnects, using the near field electro-photonic interactions in solid, especially the nonradiative internal energy transfer that may be called as resonance dynamic multipole-multipole interaction (RDMMI).

2. Experiments, Analysis and Conclusions

The length of the transition dipole is deduced from our micro-photoluminescence spectra (0.3 meV fine structure) of excitons localized in an individual pair of asymmetric GaAs quantum dots [1]. This dipole length leads to the estimation of potentials and interaction energies (W) of various multipoles. Then the ranges (L) and lifetimes of the RDMMI are derived and plotted as functions of interpolar distance (R) as given elsewhere [2]. Provisional structures of quantum circuits are designed, using these multipolar interactions as the free-space waveguiding mechanism. The difference in the polarization (parity) of the photons as well as the wavelength should result in the selective (directional and tunable) interaction between the legitimate couple of nano-structures as demonstrated in Fig. 1 [2]. Moreover, the Stark type shape modulation of the excitons enables the reconfiguration of the energy transfer route due to the parity conservation, as illustrated in Fig. 2.

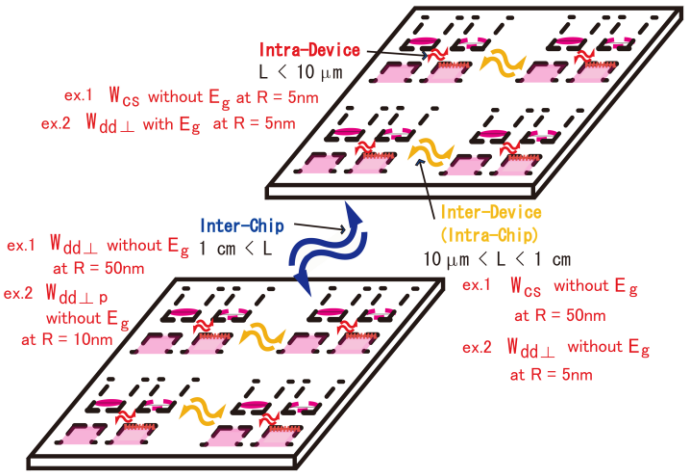

Fig.1 Artist's concept of the intra-device, inter-device (intra-chip) and inter-chip multipolar photonic interconnects, with two examples respectively, where the constituent device is a couple of two level systems which could be a quantum controlled not (CN) logic gate.

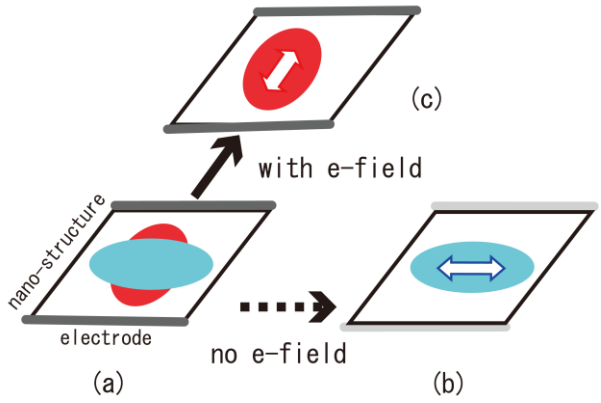

Fig. 2 Concept of the reconfiguration of the energy path by the Stark type shape modulation of the exciton. When no electric field is applied by the top and bottom electrodes, the exciton is assumed to be horizontally elongated as in blue (a), and the coupling photon is generated (RDMMI) towards the right neighbor having same shape (parity) (b). If electric field is applied, the exciton becomes elongated upwards as in red (a), and the photon will be generated towards the upper neighbor (c).

References

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[2] Hideaki Matsueda, "Estimation of Photonic Multipolar Coupling Ranges among Quantum Dots on the basis of Time-Energy Uncertainty", Journal of Russian Laser Research, Volume **30**, Issue 5, pp. 525-532 (2009).

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