

# On demand single photon source by nanoscale MIS capacitor

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- Quantum cryptography, governed by the laws of quantum mechanics, is unconditionally secure, and it should bring fundamental impact to future telecommunications. In order to enable data transmission using quantum encryption, it is desirable to have a single-photon source capable of limiting emission of photons to one photon. In other words, an ideal single photon source will produce an "on demand" train of single photons in response to an external trigger.

**BB84 Protocol**

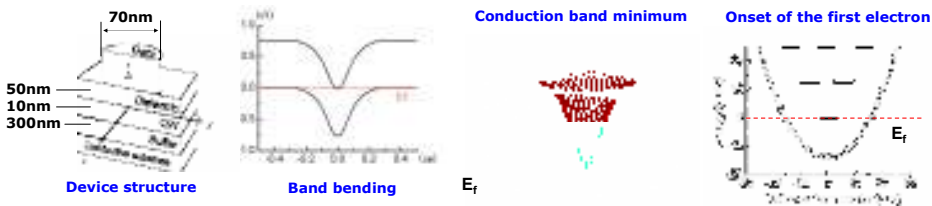
Alice generates random  $\{a_j\}$  and  $\{b_j\}$       Bob generates random  $\{b'_j\}$ , obtains  $\{a'_j\}$

$a_j$	$b_j$	$\psi(a_j, b_j)$	$b'_j$	$a'_j$
0	0	$ 0\rangle$	0	$ 0\rangle$
1	0	$ 1\rangle$	0	$ 1\rangle$
0	1	$ +\rangle$	1	$ +\rangle$
1	1	$ -\rangle$	1	$ -\rangle$

Using the public channel, Alice and Bob compare  $b_j$  and  $b'_j$ , and they only use  $a_j$  and  $a'_j$  when  $b_j=b'_j$ .

**BB84 requires a single photon source to transmit information.**

- The MIS nano-capacitor structure, the calculated two-dimensional confinement parabolic potential and the single electron quantum states

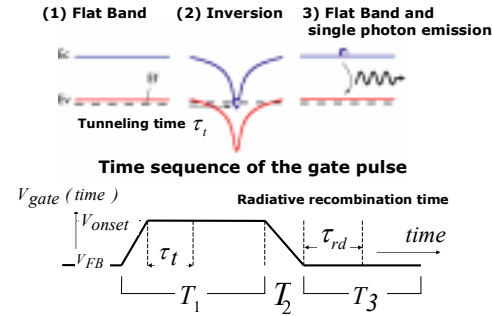


**Assumptions:**

- $\text{In}_{0.53}\text{Ga}_{0.47}\text{As}/\text{In}_{0.52}\text{Al}_{0.48}\text{As}$
- p-type QW:  $\text{In}_{0.53}\text{Ga}_{0.47}\text{As}$   
 Band gap: 0.75eV, Hole concentration:  $10^{11}/\text{cm}^2$

$V_g = 2.56 \text{ V}$        $V_g = 2.63 \text{ V}$ ,  $\eta\omega = 12.5 \text{ meV}$   
 The number of electrons in the quantum dot can be precisely controlled by the gate voltage.

- Single photon generation control sequence
- Polarization control: Zeeman splitting of the lowest electron and hole states



**Repetition rate:**

- $T_1 < 10\text{ns}$ :  $\tau_t \sim 1\text{ns}$ .
- $T_2 < 0.1\text{ns}$
- $T_3 < 10\text{ns}$ :  $\tau_{rd} \sim 1\text{ns}$  in GaAs.
- Repetition rate  $\sim 1/(T_1+T_2+T_3)$
- Estimated repetition rate  $> 50\text{MHz}$

**Radiation efficiency:**

If  $1/\tau_{non} \sim 0$ , by eliminating defects, the single electron to single photon conversion:  $\frac{\tau_{non}}{\tau_{non} + \tau_{rad}} \approx 1$

**Summary**

**1. On demand**

- The only uncertainty in the radiative recombination time.

**2. High repetition rate**

- Repetition rate  $> 50\text{MHz}$ ; The number of photons per electrical pulse conversion efficiency approaches 100%.

**3. Fabrication**

- Artificially patterned by electron-beam lithography.
- Scaling to an array: faster repetition rate.
- Wavelength tunable to match the transmission band of fiber
- More easily integrated with photonic structures..