課題番号　　:F-14-UT-0010
利用形態　　:機器利用
利用課題名(日本語)　　:架橋カーボンナノチューブにおけるトリオン生成
Program Title (English)　　:Trion generation in air-suspended carbon nanotubes
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1. 概要(Summary)

Carbon nanotubes (CNTs) are candidates for future applications in quantum computation. For this purpouse, it's essential to understand the many-body interactions taking place inside this nearly perfectly one dimensional material. One of these many body interactions is the formation of trions (charged excitons). Previously, trions have been reported in solution-suspended CNTs, using chemical doping.

We have observed trions in single-airsuspended CNTs by means of electrostatic doping. We find significantly higher trion binding energies than previous reports.

2. 実験(Experimental)

We fabricated 1 μm deep and 1 μm wide trenches in p-doped silicon substrate by e-beam lithography and plasma etching. (Figure 1)In a second e-beam step, we patterned 3 nm titanium and 20 nm platinum as electrode materials using e-beam evaporation. In a last e-beam step, we patterned the resist for later catalyst deposition.

By chemical vapour deposition, we then grew CNTs over the trenches of the chip. After electrical characterization, we wire-bonded the sample using a manual wedge wirebonder.

We then characterized the samples in a home-built confocal scanning microscopy system. We selected good CNTs and performed gate voltage dependence photoluminescence measurements on them. With application of gate voltage, the bright exciton peak and the K-momentum dark exciton peak quench. A new redshifted peak appears.(Figure 2)

3. 結果と考察(Results and Discussion)

We analyze the diameter dependence of the energy separation between the bright exciton peak and the new peak for 88 CNTs. The $1/d^2 + 1/d$ behavior we observe is consistent with the behavior expected for trion formation. We characterize the exchange splitting, and trion binding energy, and find that the total energy separation is 45 meV higher than in previously reported solution-suspended CNTs. We attribute the difference to the reduced dielectric screening present in air-suspended CNTs.

4. その他・特記事項(Others)

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5. 論文・学会発表(Publication/Presentation)

[1]A. Popert, M. Yoshida, Y. K. Kato, "Trions in individual air-suspended carbon nanotubes", *The 48th Fullerenes-Nanotubes-Graphene General Symposium*, Tokyo (February 21, 2015).

6. 関連特許(Patent)

なし。

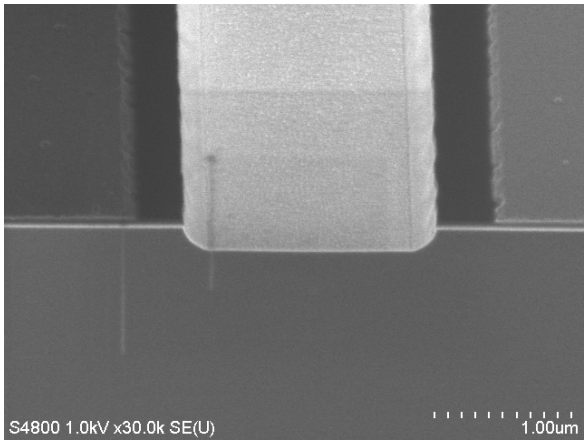

Figure 2: Device with trenches in the silicon substrate.

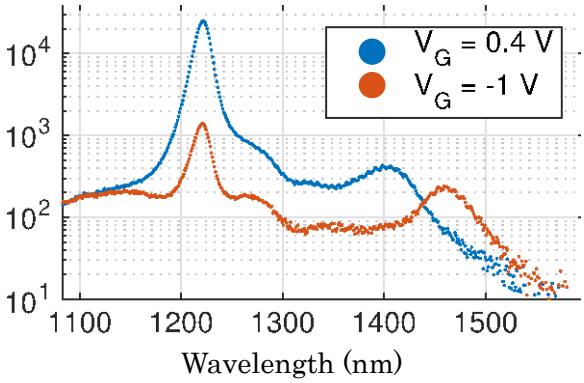

Figure 1: Single CNT spectrum. At high gate voltage, the bright exciton peak quenches and the new trion peak appears.