単一の単層カーボンナノチューブからの電界発光

Electrically driven thermal light emission from individual carbon nanotubes

Objectives

カーボンナノチューブの電界発光は、そのナノスケールの一次元的構造に由来する特徴がオプトエレクトロニクスに利用できる可能性がある。電界発光の機構および原理に対する理解を深めることにより、カーボンナノチューブのオプトエレクトロニクス材料としての評価に役立て、また従来の直接半導体のようにキャリヤー注入により発光する素子の構造を見いだすことを目指す。

Electroluminescence from individual carbon nanotubes has potential applications in optoelectronics because of the characteristics originating from their one-dimensional structure. We fabricate field-effect transistors with channels consisting of an individual single-walled carbon nanotube, and perform micro-electroluminescence spectroscopy. Our aim is to understand the light emission mechanisms, thereby assessing the potential for carbon nanotubes as optoelectronic materials.

Achievements

- 従来は発光しないと考えられていた金属型カーボンナノチューブからの電界発光を観測した。
- 発光強度がデバイス消費電力に対して指数関数的に増大することから、加熱発光モデルを提案した。
- デバイスの電気特性から電子温度を見積り、発光強度および発光スペクトルのモデル計算を行い、実験結果とよく一致することを確認した。
- 雰囲気圧力・基盤温度の依存性も加熱発光モデルに従うことを実験的に確認した。

- We found that quasi-metallic carbon nanotubes show electroluminescence, despite the belief that these species do not show light emission.
- We observed that the emission intensity increases exponentially with power consumption in the device.
- We have developed a thermal light emission model by including the estimated electron temperature, and calculated the light emission intensity and spectra using this model. We found that the calculation yielded good agreement with the experimental results.

Fig. 1

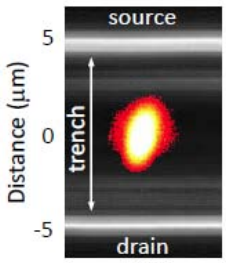


Fig. 2

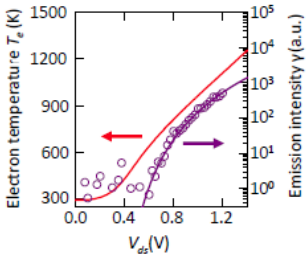
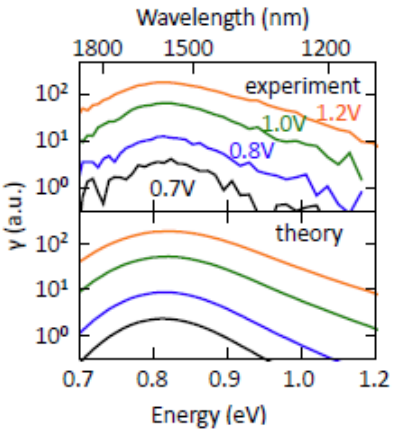


Fig. 1: Image of a carbon nanotube device showing light emission.
Fig. 2: Estimated electron temperature (red solid line) and calculated emission intensity (purple solid line) along with measured emission intensity (open circles) as a function of bias voltage.
Fig. 3: Experimental and theoretical light emission spectra from carbon nanotubes at various applied bias voltages.

Fig. 3



References

1) "Electrically driven thermal light emission from individual single-walled carbon nanotubes", D. Mann, Y. K. Kato, A. Kinkhabwala, E. Pop, J. Cao, X., Wang, L. Zhang, Q. Wang, J. Guo, H. Dai. Nature Nanotech. **2**, 33 (2007).
2) "Electrically driven light emission from hot single-walled carbon nanotubes at various temperatures and ambient pressures", X. Wang, L. Zhang, Y. Lu, H. Dai, Y. K. Kato, E. Pop, Appl. Phys. Lett. **91**, 261102 (2007).