STRONG ELECTROLUMINESCENCE FROM CARBON NANOTUBE FIELD-EFFECT TRANSISTORS

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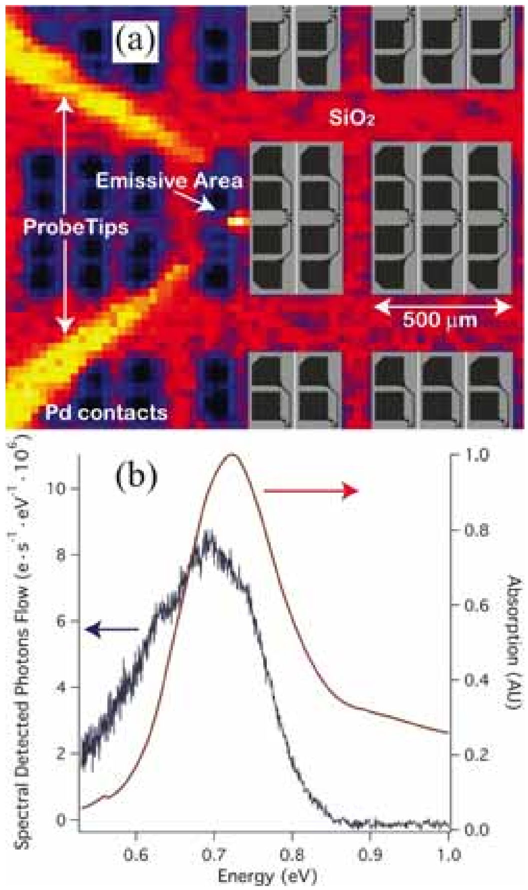
The discovery of electroluminescence (EL) from ambipolar Carbon Nanotube Field-Effect Transistors (CNFET) [1] demonstrated the potential use of Single-Wall Carbon Nanotubes (SWNT) for promising optoelectronic devices. The mechanism proposed involved the radiative recombination of excitons produced by electrons and holes injected simultaneously from each ends of the SWNT. More recently, EL from unipolar CNFET has also been reported [2, 3] and the impact excitation by hot carriers was discussed as an important mechanism to explain the excitonic emission. In this contribution, we present an update of our EL measurements on unipolar CNFET. The devices are made from three different SWNT sources: HIPCO, CVD (CoMoCat) and laser ablation.

The spectrometer used to obtain spectra and images is the Spectrometer Infrared of MONtreal (SIMON), an infrared spectrometer designed to usually fit on the Mont-Mégantic astronomical telescope. The SIMON detector is a 1024 x 1024 HgCdTe array with a spatial resolution 30μm/pixel. The spectral detection range of this detector is 0.50 to 1.55 eV.

We obtain very bright EL emission from SWNT network devices and this is true for any of the sources tested so far (see figure). Strong light emission from these networks (compared to single tube devices) brings new opportunities for efficient CN-based optoelectronic devices. The EL is however specific to the diameter distribution of the nanotube source, which is deduced from the absorption spectra taken on the bulk samples. A significant energy redshift is observed between the main emission peak compared to the main absorption peak for the large diameter distribution source (CoMoCAT) suggesting that only large diameter tubes emit light. Resonant energy transfert mechanism is proposed to explain this observation. In fact, this work demonstrates that EL spectra from CNFET-networks can be tuned in wavelength by varying the diameter distribution of the SWNT.

Secondly, light emission mechanism is discussed according to observation of the light emitting light spot as a function of the voltage applied. Light emission is located in the region around the minority carrier injector electrode. These results suggest that light emission in our unipolar transistors involved radiative recombination of excitons produced by electrons and holes injected simultaneously from each ends of the SWNT instead of impact excitation.



(a) A typical near-infrared image obtained with SIMON using the H filter (0.70 to 0.83 eV) with an exposition time of 30 s. The EL light emission area of the connected transistor is visible on the center of that image. The right part of that image is superimpose with an optical microscope image of the same zone but with a higher resolution. (b) Typical near-infrared electroluminescence spectra for a CNNFET made with laser ablation tubes with the following experimental conditions: Vd=-110V, Vg=-20V, texp=2 min. The absorption curve of laser ablation source is also shows for comparaison.

References

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