Luttinger-liquid behavior in single-walled carbon nanotube networks

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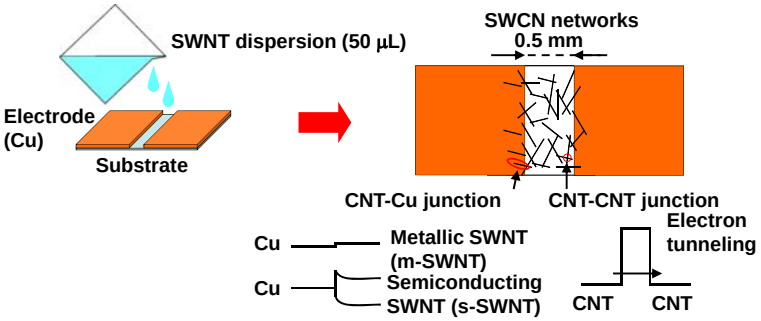
Introduction

Elucidating the electrical transport properties of single-walled carbon nanotube (SWNT) networks

➡ **Making full use of excellent SWNT properties**

Fabrication method

SWNTs were individually dispersed by sodium cholate



Conductance measurement

Conductance before and after soaking

Soaked in water to remove sodium cholate

After soaking

$$G = g_1 \exp[-T_1/(T+T_0)] + g_2 \exp(-E_a/k_BT)$$

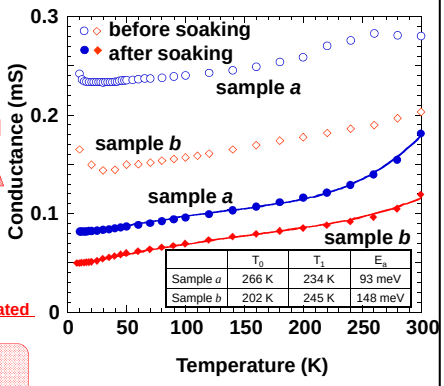
(Fluctuation induced tunneling (FIT) model)

Dominant conduction path at lower temperature

m-SWNTs with ~0 eV barrier

Conduction path activated at higher temperature

m- and/or s-SWNTs with ~0.1 eV barrier

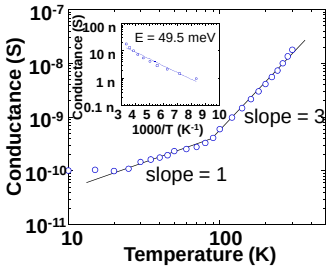


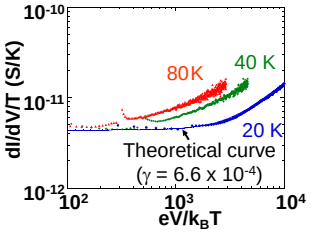
Luttinger-liquid behavior

Sample *a*

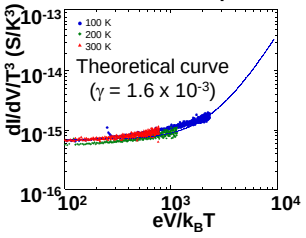
- **Biased at 80 V for 20 h to remove metallic path**
- **m-SWNTs were broken down**
- **Luttinger-liquid behavior at higher temperature**

$$\frac{dI}{dV} \propto T^{\alpha} \cosh\left(\gamma \frac{eV}{2k_BT}\right) \left|\Gamma\left(\frac{1+\alpha}{2} + \gamma \frac{ieV}{2\pi k_BT}\right)\right|^2$$





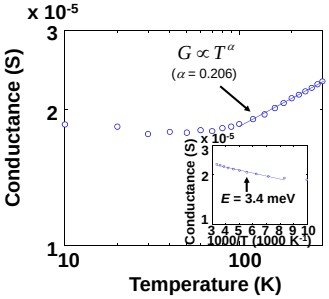
Lower temperature

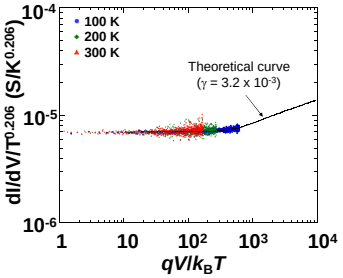


Higher temperature

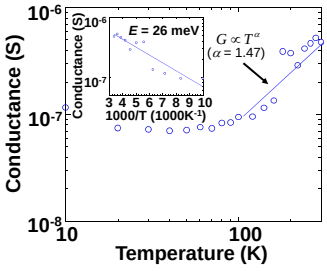
Sample *b*

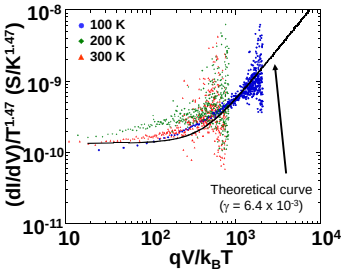
After 1st break down (40 V for 26.5 h)





After 2nd break down (45 V for 2 h)

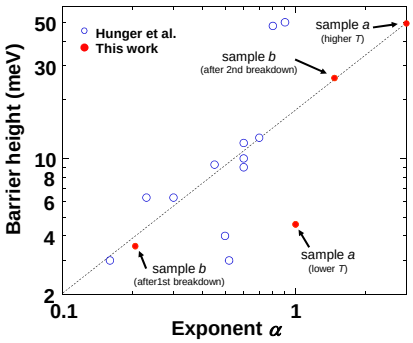




- **Increased exponent α as the breakdown proceeded**

Correlation between Barrier height and exponent α

In good agreement with data reported by Hunger et al.



* Th. Hunger, B. Lengeler, and J. Appenzeller. *Phys. Rev.* B **69**, 195406 (2004)

Conclusion

- **Pristine SWNT networks obeyed FIT and thermally activated conduction.**
- **Electrical breakdown caused Luttinger-liquid behavior.**
- **The relation between barrier height and exponent α was in good agreement with that reported previously.**

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