Alignment of Unpurified, Solution-Processed Single Walled Carbon Nanotubes via Dielectrophoresis Based on Removable Graphene Electrodes

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SWNT/microbe suspension loading

Electric field application
Outlines

I Background and Motivation

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Background and Motivation

- **CNT**(single-walled Carbon Nanotubes)
  - Excellent electrical properties
  - Wide range of applications

- **DEP**(Dielectrophoresis)
  - Electrophoresis is a phenomenon in which dielectric particles move with the formation of electrical dipoles within a non-uniform electric field.
  - Techniques to control carbon nanotubes aligned at desired locations
Background and Motivation

● **DEP(Dielectrophoreisis)**

\[ F_{DEP} = \Gamma \varepsilon_m \text{Re}\{F_{CM}\} \nabla |E_{rms}|^2 \]

\( \Gamma = \) Carbon nanotube shape factor
\( \varepsilon_m = \) Permittivity
\( \text{Re}\{F_{CM}\} = \) The current value of the complex Clausius-mossotti factor
\( \nabla |E_{rms}|^2 = \) Square of change in slope of field rms value

● **Factors to Consider**

- Density
- Time
- Frequency
- Intensity of electric field
Experimental details

- **Material synthesis**
  - Graphene (KIST)

- **Transfer on wafer**
  - Wafer (150nm, high doped N-type)

- **Lithography process**
  - Metal deposition (Cr : Ni = 1 : 50 nm)
  - Isolation (etching)

- **DEP(Dielectrophoresis)**
  - 0.1wt% → 5000:1, 3000:1, 1000:1
  - 0.2wt% → 5000:1, 3000:1, 1000:1
  - Time
Result and Discussion

0.1 wt% 5000:1 _1min
On/off ratio = 1.69E+00
Mobility = 0.4 cm²/V·sec

0.1 wt% 5000:1 _2min
On/off ratio = 3.07E+01
Mobility = 19.4 cm²/V·sec

0.1 wt% 5000:1 _3min
On/off ratio = 8.82E+00
Mobility = 26.3 cm²/V·sec
Summary

● Motivation
  ▪ The channel length of the semiconductor device becomes short (10 nm or less)
    → Physical limits such as source/drain tunneling leakage
  ▪ Ideal properties of 1 nm diameter carbon nanotubes (electrical)
    → Increase research value as a next-generation device

● Advantages
  ▪ Using ultra-thin graphene electrodes
    → Universally flexible for the applications of circuits or versatile gas (or bio)-sensors
    → Minimum residues, Minimum dry etching time, Excellent Ohmic contact properties
    between CNT and graphene electrodes, 1 nm-thick-height of graphene
    → Electrodes can be removed by using graphene as an electrode.

● Future Plans
  ▪ Whole results fully substantiate that feasibility on CNT alignment and electrical properties of CNT FETs are fully accessible.