Six-Terminal Carbon Nanotube Relays

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Abstract: Carbon nanotube (CNT) relays are promising NEMS devices due to CNT’s low mass, small dimension, high Young’s modulus, and high current density. Previously, CNT clamped-clamped relays have been fabricated using a bottom-up integration scheme. This process involves resist-assisted assembly, where single-walled metallic CNTs are self-aligned into electron-beam resist trenches using ac-dielectrophoresis (DEP). These devices have shown excellent ON/OFF current ratios, low off-state current, high yield, and high endurance. Using this same process, we demonstrated a novel six-terminal (6T) CNT relay for low power applications in this work.

Process Flow

Previous Three-Terminal CNT Relays

Support Information

This work was funded by National Science Foundation Award ECCS-0939514.

Conclusions and Future Work

Six-terminal CNT relays have been demonstrated for the first time. We will further explore their electrical characteristics, such as: on-current, off-current, pull-in voltage, and endurance.

Acknowledgements: I would like to thank my mentor Dr. Ji Cao, Professor H.–S. Philip Wong, Stanford Nanofabrication Center, Stanford Nano Center, E3S, and the NSF.

References:

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Six-Terminal CNT Relays have demonstrated Ion/Ioff ~ 10⁷, Ioff~ 10⁻¹⁴A, and endurance > 10² cycles.

Truth Table

<table>
<thead>
<tr>
<th>Gate 1 Voltage</th>
<th>Gate 2 Voltage</th>
<th>S/D 1 Current</th>
<th>S/D 2 Current</th>
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AC-Dielectrophoresis

• Result of an optimal e-beam dose and resist develop
• Underexposure leads to incomplete removal of resist
• Overexposure causes wider features, thus poor resolution

Final Well-Aligned 6T CNT Relays

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