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Electrical analysis of single-walled carbon nanotube as gigahertz on-chip interconnects

Key words: Interconnect; Carbon nanotube; Current density; Propagation constant; Characteristic impedance; System-on-chip

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Motivation

- Increasing logic and memory density in high-end SoCs and Microprocessors require high speed interconnects at lower dimensions.
- Performance of conventional Copper based interconnects degrades with decreasing dimension.
- Single walled CNT is a promising candidate for high speed interconnects.
- Analysis of single walled CNT emphasizing electrical properties is not concrete.

Main idea

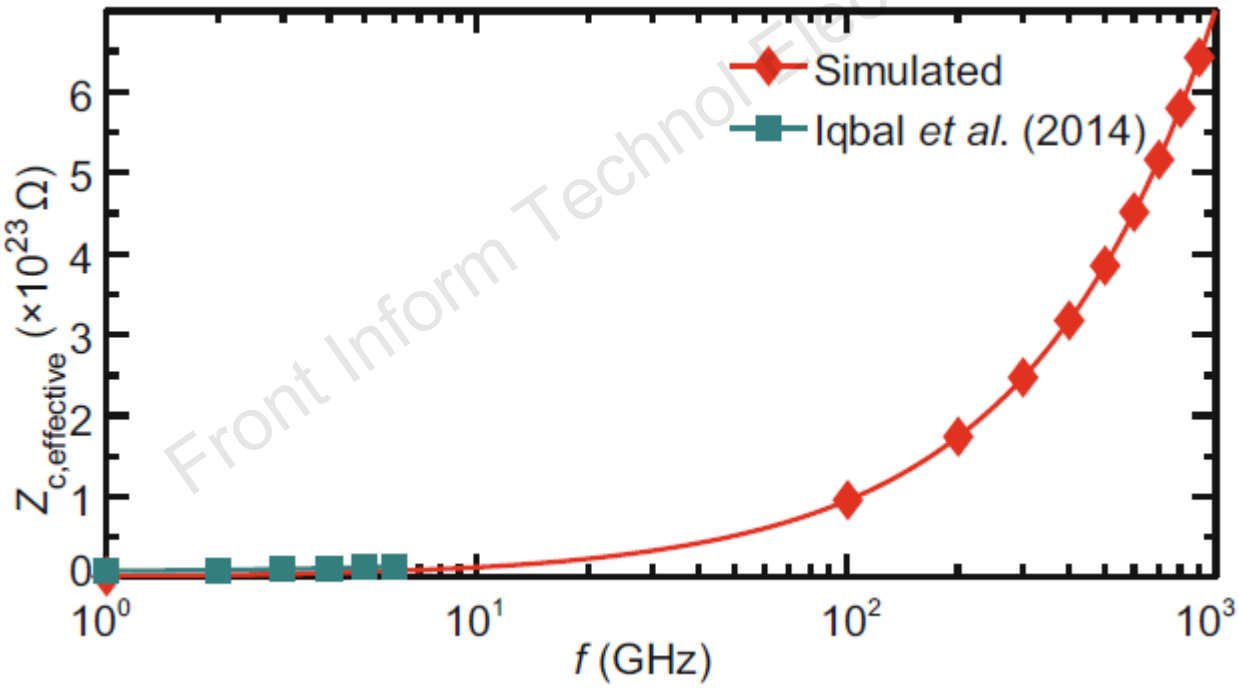
- Luttinger's model of CNT considers CNT as a collection of interacting electrons
- This gives rise to an equivalent electrical model for single walled CNT
- This model is used in analyzing different electrical properties with different physical parameters.

Method

1. Four parameters are analyzed: nanotube impedance, attenuation and phase delay constants, current density, and signal delays.
2. The relation between physical parameters and signal frequency are derived through mathematical expressions.
3. These 4 parameters are observed while the physical parameters and frequency are being varied.

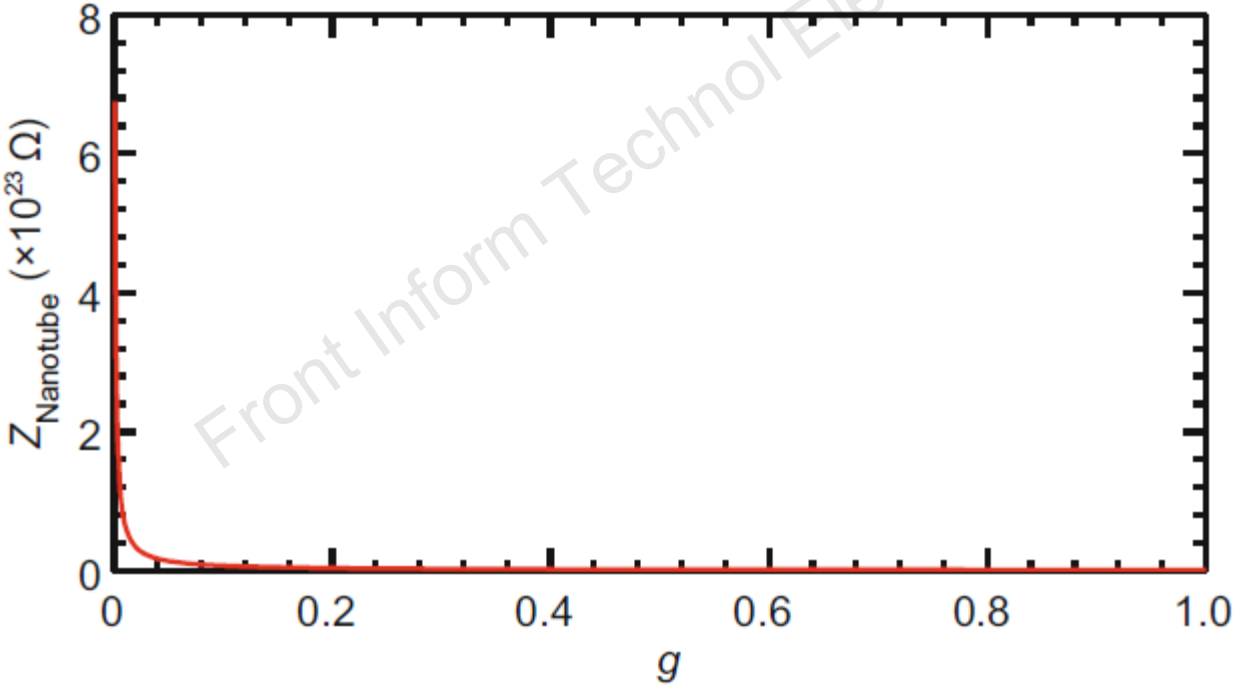
Major results

- Characteristic impedance increases exponentially with frequency.



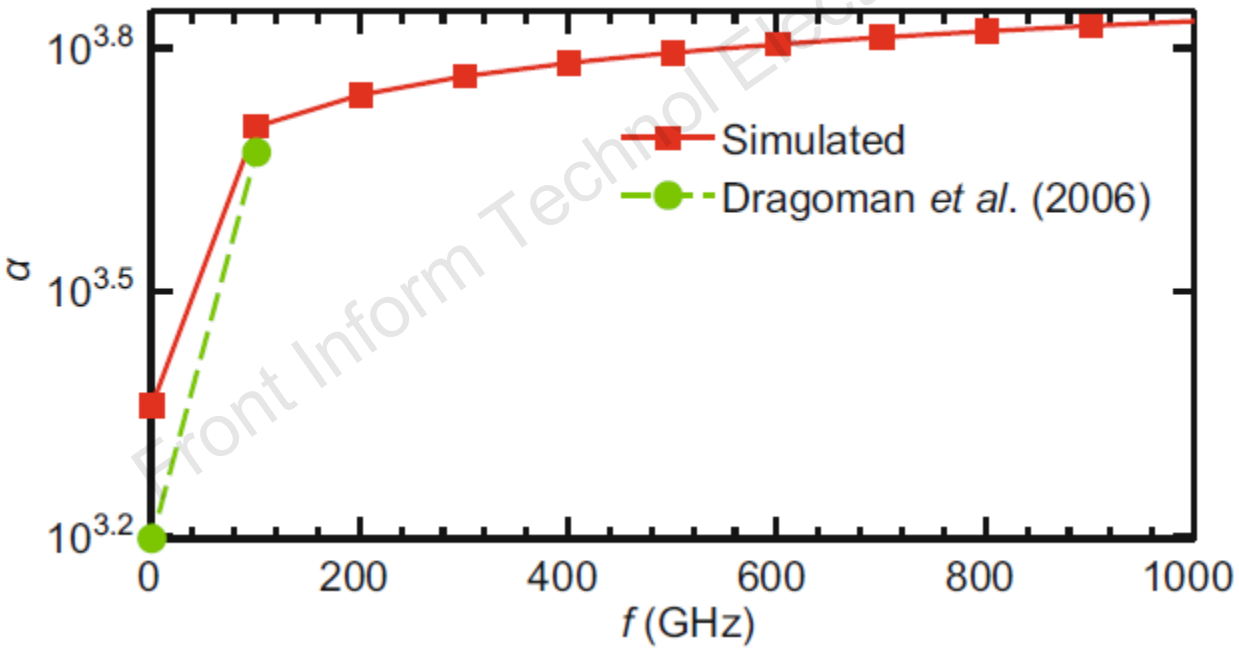
Major results

- Increasing interaction between electrons decreases Nanotube impedance.



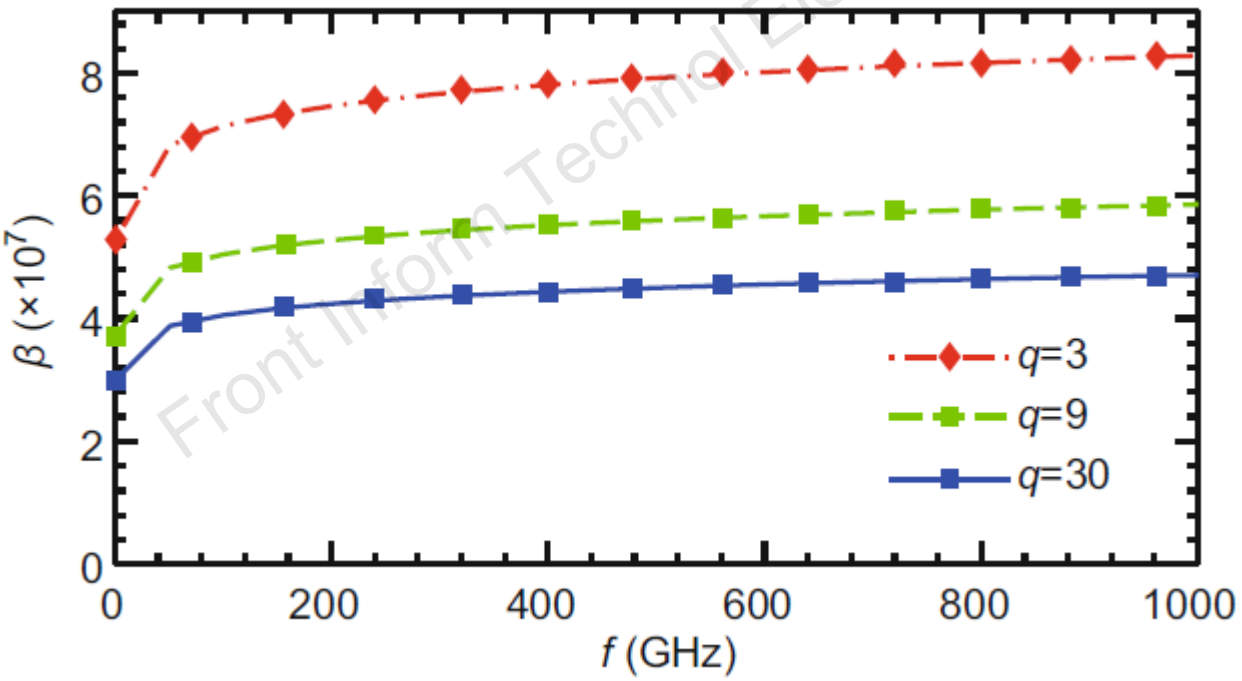
Major results

- Attenuation constant increases with frequency



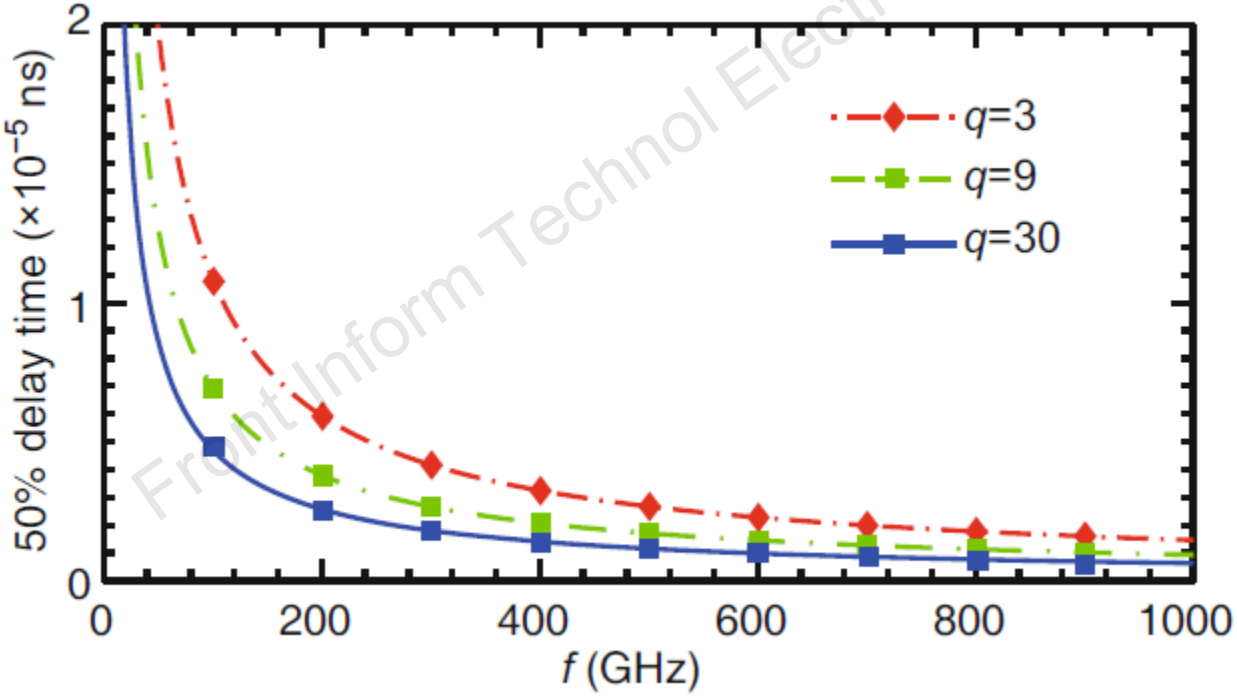
Major results

- Phase delay exhibits increasing trend with frequency and structural ratio. and frequency



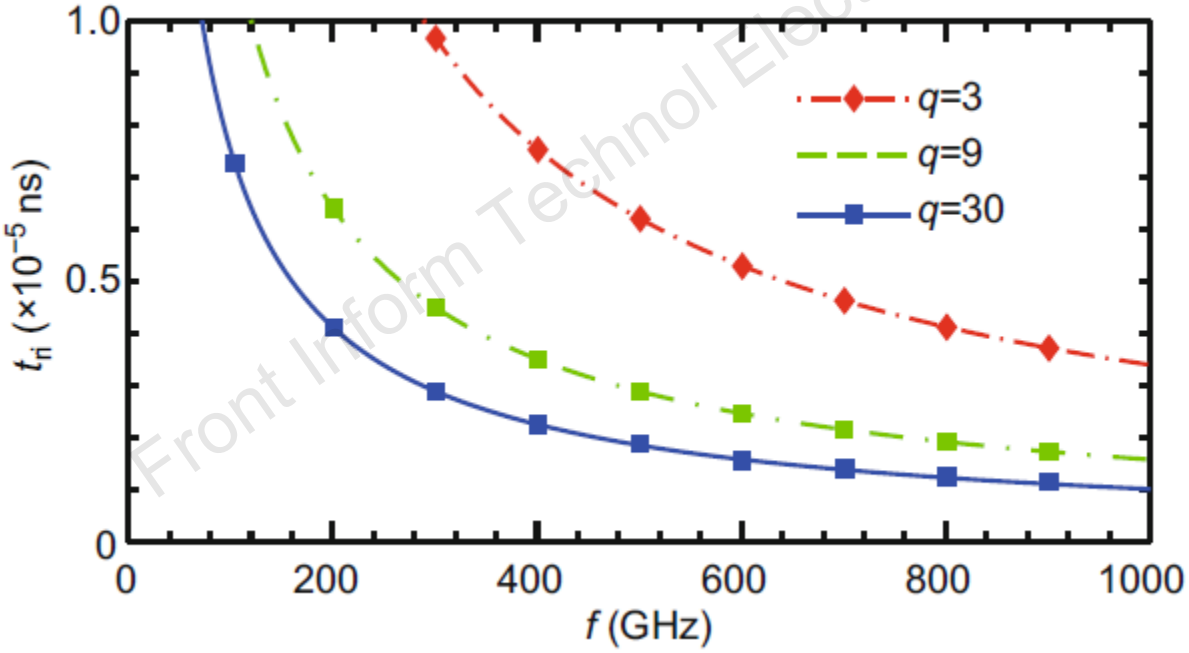
Major results

- Change of 50% delay time with frequency and structural ratio



Major results

- 50% rise time changing with frequency and structural ratio



Major results

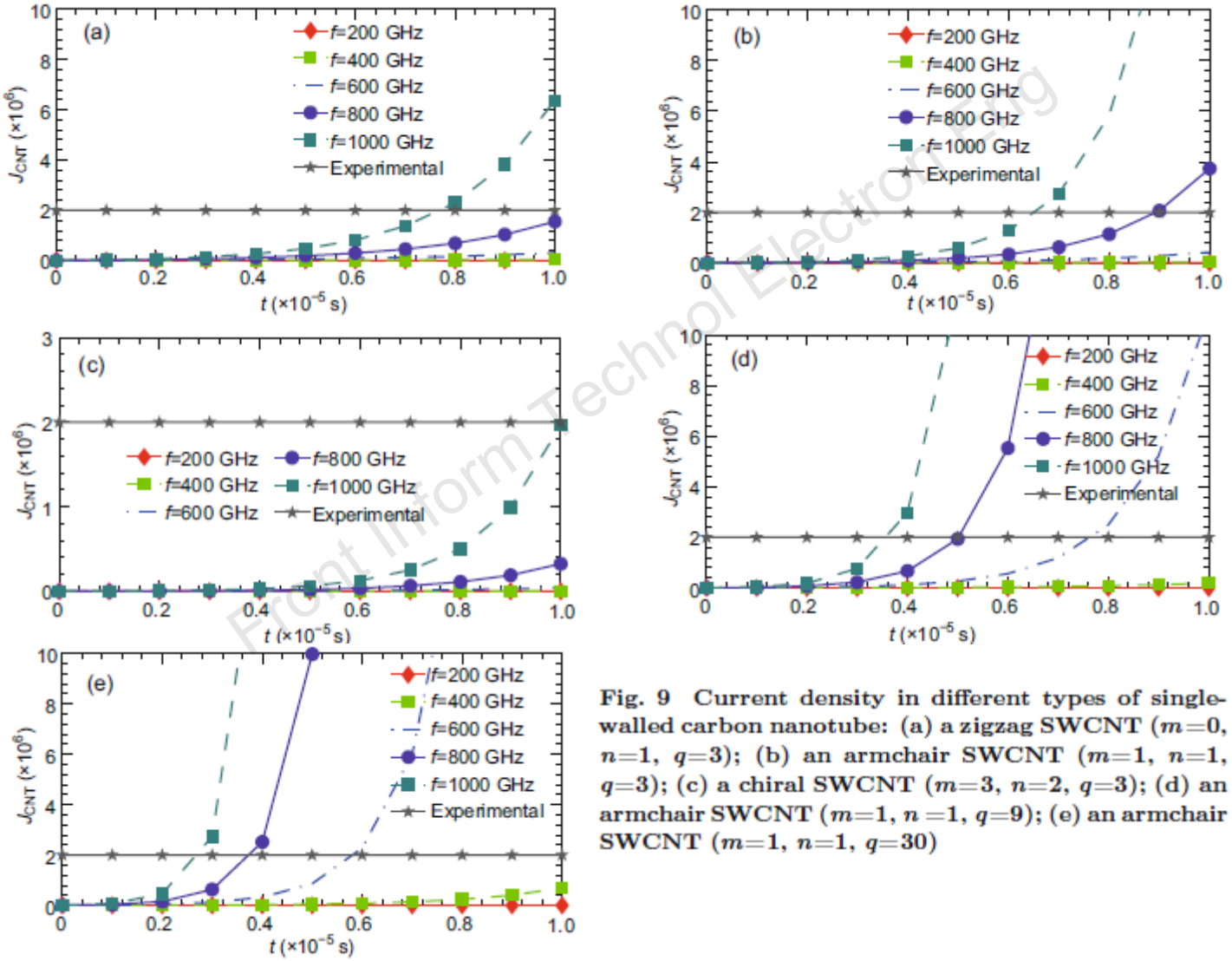


Fig. 9 Current density in different types of single-walled carbon nanotube: (a) a zigzag SWCNT (m=0, n=1, q=3); (b) an armchair SWCNT (m=1, n=1, q=3); (c) a chiral SWCNT (m=3, n=2, q=3); (d) an armchair SWCNT (m=1, n=1, q=9); (e) an armchair SWCNT (m=1, n=1, q=30)

Conclusions

- Different structural ratios and frequency affects electrical parameters of CNT significantly
- Careful design is needed to meet the system specifications
- The work presents a framework to understand these relations.