

USC Viterbi School of Engineering

Ming Hsieh Department of Electrical Engineering

Large-scale complementary macroelectronics using hybrid integration of carbon nanotubes and IGZO thin-film transistors Haitian Chen, Electrical Engineering

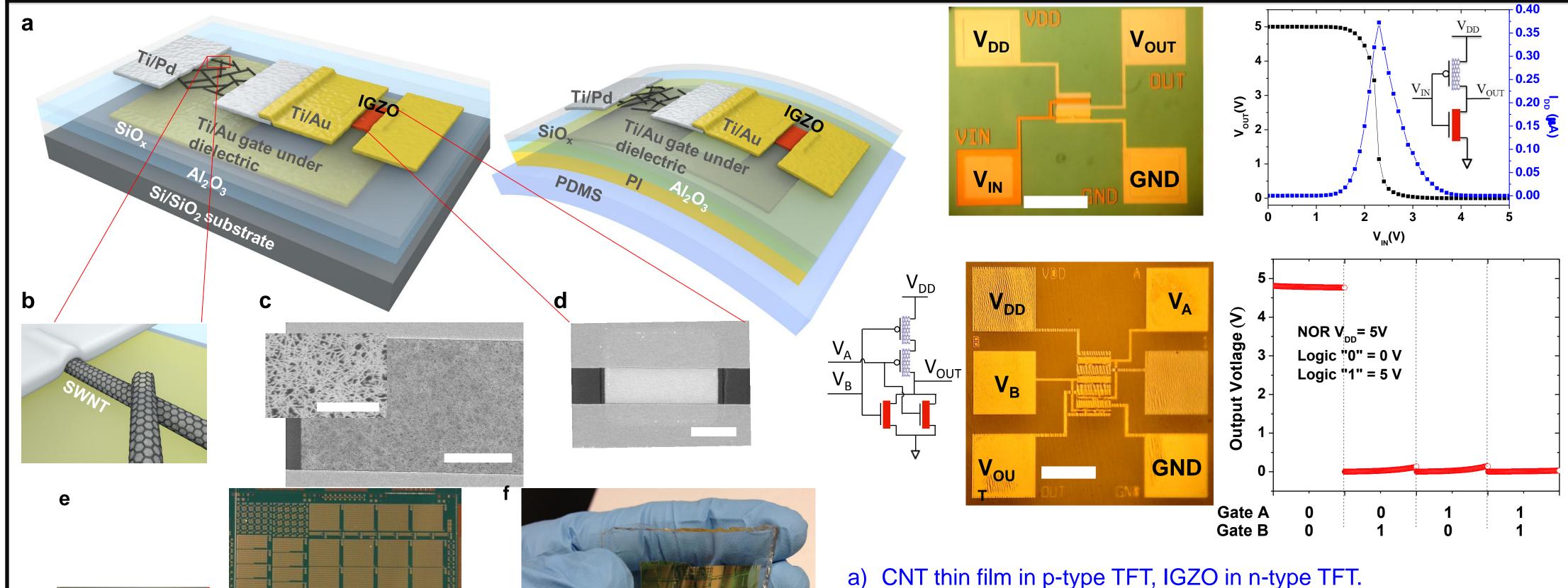
Carbon Nanotube - The Future of Macroelectronics and Flexible Macroelectronics

- Carbon nanotube (CNT) TFT Mobility (40 cm²/Vs); CNT TFT high operational stability; CNT TFT flexible, transparent and printable.
- CNT TFT is **p-type** difficult to obtain **n-type** for complementary mode circuits, which exhibit low steady state power dissipation property.
- Oxide semiconductor TFT, indium gallium zinc oxide (IGZO) is n-type TFT Difficult to obtain stable p-type
 TFT.
- 1) Hybrid integration scheme to achieve robust complementary macroelectronics using CNT/IGZO TFTs
- 2) Complementary hybrid CNT/IGZO inverter, NAND and NOR gates on rigid and flexible substrates
- 3) Large scale (>1000 TFTs) complementary hybrid CNT/IGZO ring oscillators

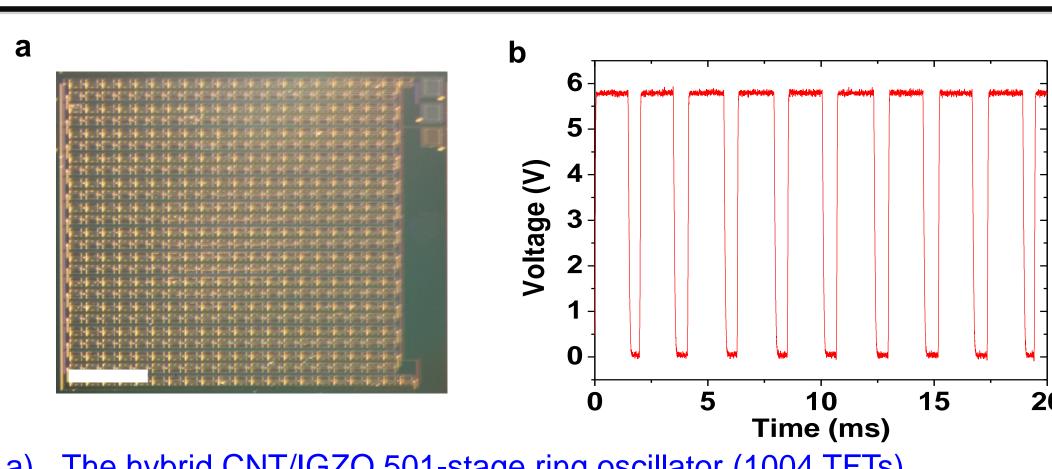




CNT/IGZO complementary inverter and NAND gate on rigid and flexible substrate



501-stage (1004 TFTs) ring oscillator



- a) The hybrid CNT/IGZO 501-stage ring oscillator (1004 TFTs) demonstrates the quality of high-yield of the transistors
- b) This large scale integration of two thin film materials demonstrates the potential of using this hybrid circuit configuration to achieve more sophisticated CNT-based circuits on rigid and flexible substrates.

Discussion & Future Work

Demonstrated hybrid complementary CNT/IGZO inverter and

NOR gate returns logic "1" only when both of the inputs are "0"

NAND gates – building block for modern electronics.

CNT/IGZO inverter with rail-to-rail output voltage

- 1) We have demonstrated circuits operating in complementary mode based on CNT and IGZO thin film transistors.
- 2) We have successfully demonstrated various logic gates using this structure on both rigid and flexible substrates.
- 3) We have demonstrated the first large scale (>1000 TFTs) integrated macroelectronic based on CNT/IGZO TFTs

Future Work:

- 1) Using CNT/IGZO complementary circuits as control circuitry for flexible pixel driver for AMOLED
- 2) Improve performance of CNT TFTs.