Improving Operating Temperature of Gas Sensors by Forming Heterojunctions

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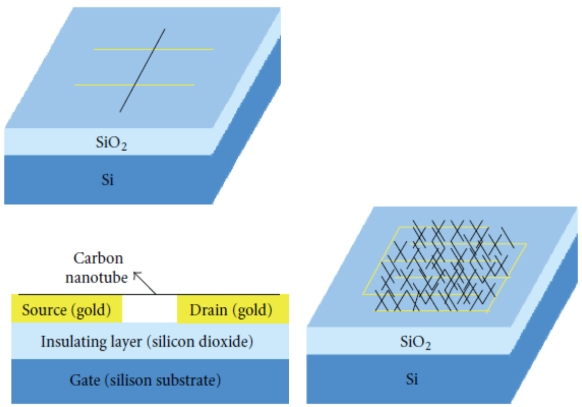
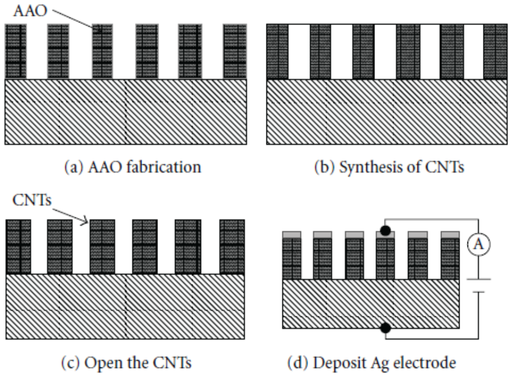
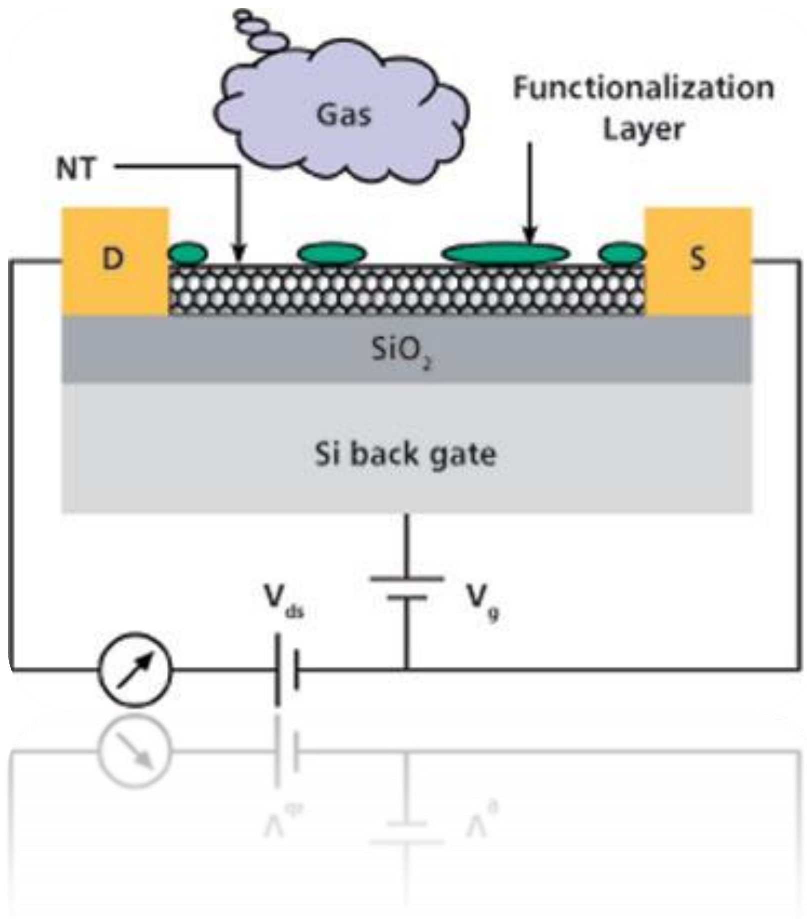
- ***Summary from 1st Presentation***
  - CNT FET based Gas Sensors are:
    - Smaller in size
    - Consume less power
    - Have quick response
    - Great electronic properties



- ***Drawbacks***
  - Slow and incomplete recovery
  - Low sensitivity
  - Require to be of defined structure and property
  - Poor selectivity

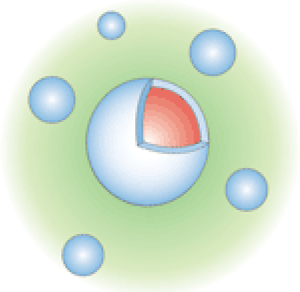


- ***State of the Art CNT Gas Sensor***

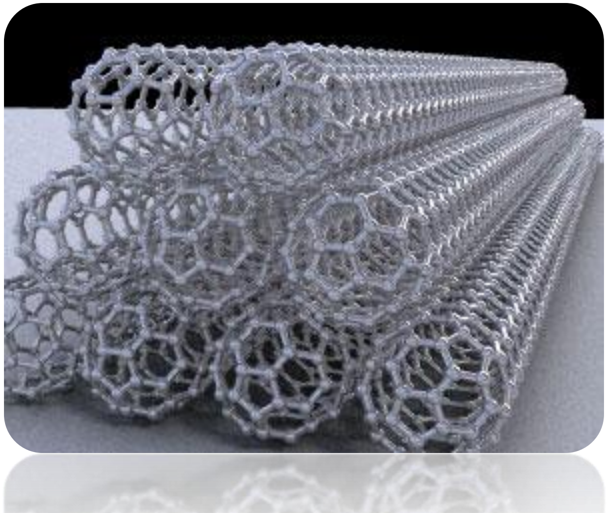


- ***Background***
  - Pure MO gas sensors at operated at 200-800 °C
  - Pure CNT gas sensors have slow response and recovery

- ***Solution***
  - Combine the two sensors to form a hybrid!
  - Examples: SWCNT and SnO_2/TiO_2 nanocomposites
    - Incorporate SWCNT into MO substrate
    - Spin/Drop coat metallic solution dispersed with SWCNTs
    - MWCNTs/MO - core/shell nanostructures to form p-n heterojunctions
    - Heat treatment to fuse composite



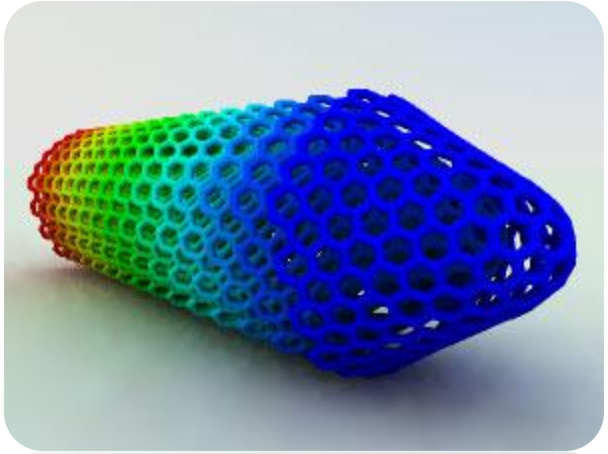
- ***Expected Improvements***
  - Much higher response
  - Quicker recovery
  - Detect NO_2, H_2, NH_3, LPG, EtOH at room temp.
    - not possible previously
  - Therefore reduces working temp.

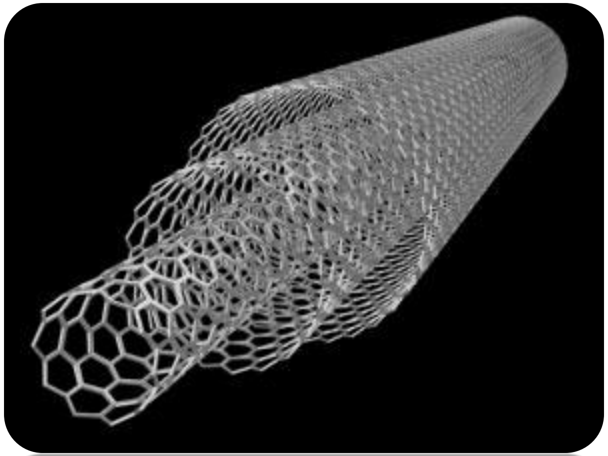



- ***Rationale***
  - Composite yields improved electrical transport mechanism
  - Resistance dominated by barriers among MO grains and grain boundaries
  - SWCNTs will form “nanopasses” → Improve conduction
  - Electrons travel in MO grains, then conduct in SWCNT with low R

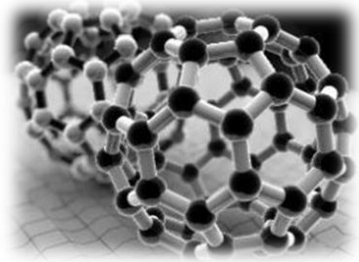
  - Depletion layer at CNT/MO interfaces
  - Depletion layer at metal oxide grains
  - Gases adsorbed → Modulation of depletion layer → Change in resistance
  - Gases like NH3 will bind less tightly to SWCNT improving recovery time

- ***Design Predictions***
  - Reducing molecules act like n-type dopants when interacting with CNTs
  - Leads to decrease in resistance
  - Leads to increase in response





- ***Design Considerations***



  - Electronic conduction in the hybrid material
  - Preparation process of film
  - Film thickness *t* (300nm or 600 nm?)
    - Larger t → less diffusion → smaller response
  - Wt % of MWCNT (5% or 25%?)
  - Diameter *d* of MWCNT (60nm or 100 nm ?)
    - Larger *d* increases # of gas molecules adsorbed
  - Annealing temperature T
    - High T → better contact between MO and CNTs
    - Too high T → burning of CNTs and structural damage
  - Functionalization of CNT
    - Hydroxyl, oxygen, oxygen plasma, etc.

Thank You

Questions?