Flowchart of How ISFET Based pH Sensor Works

Most ion sensors are potentiometric sensors, which means that the electrical potential difference, $\Delta \psi$, at a solid/liquid interface as function of the ion concentration to be determined is measured.

$$\Delta \psi = (RT/F) \cdot \ln \left( \frac{a_{i1}}{a_{i2}} \right)$$

Finally,

$$V_{FB} = \text{Constant} - \psi_0$$
Flowchart of How CNT Is Applied to ISFET Based pH Sensor

- CNT Based Ion-Sensitive Field Effect Transistor (ISFET)
- Carbon nanotube transistor ‘is better than Si’
- Semiconducting SWNTs make p-type FETs
- MWNTs replace inversion layer

Commercial application for increasing interests in monitoring and controlling of pH

- Lower costs and smaller products
- Periphery circuit unnecessary
- High voltage gain
- Drain current increases

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**ISFET**

- ISFET used to measure ion concentrations in solutions
- ISFET very similar to Metal-oxide Semiconductor FET (MOSFET)
- Inversion layer formed at SiO$_2$/Si interface
- Electrons supplied by the n$^+$-source region
- n$^+$-drain region needed to make electrons flow
- Electron flow constitutes drain current $I_D$
- Gate voltage controls the number of electrons
- ISFET based pH sensor application
- CNT-based ISFET to enhance pH sensing performance
- Metallic ones as nano-wire
- Semi-conductive as transistor

**Schematic diagram of a composite gate, dual dielectric ISFET:**
1. drain; 2. source; 3. substrate; 4. insulator; 5. metal contacts; 6. reference electrode; 7. solution; 8. electroactive membrane; 9. encapsulant; 10. inversion layer.

**Schematic of CNT based ISFET:**

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