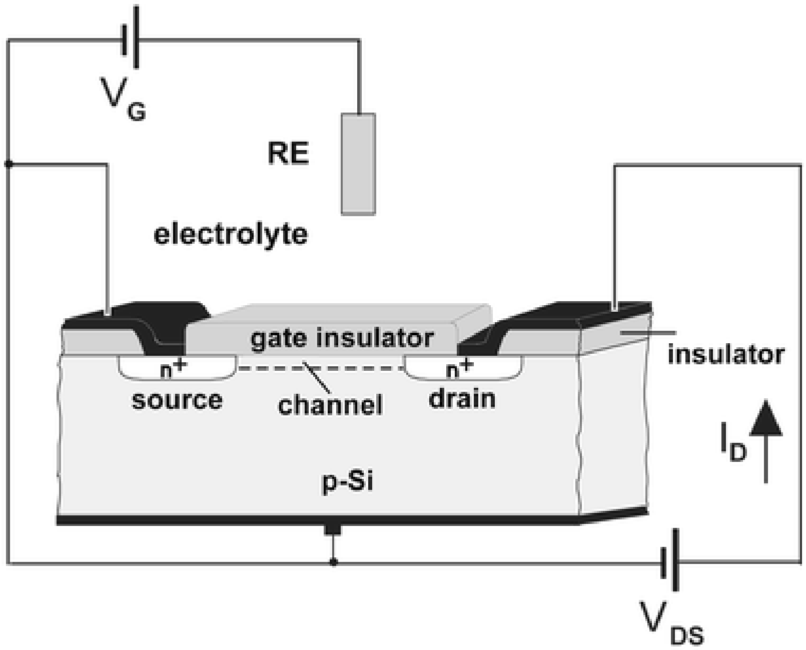
Ion-Selective Field Effect Transistors (ISFETs)

Common transducer in commercial pH meters.

Gate insulator materials:
Si_3N_4, Al_2O_3, Ta_2O_5

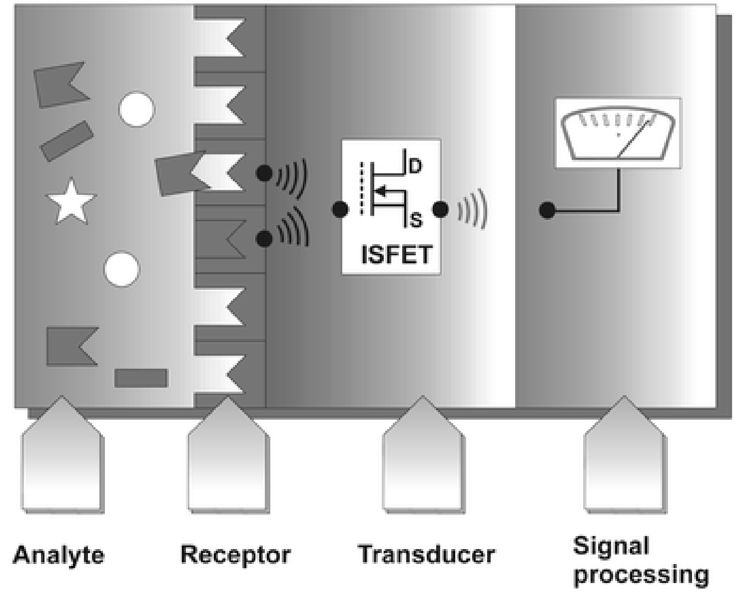
Surface of gate insulator becomes hydrolyzed in aqueous solution.

-OH groups on surface experience varying degrees protonation depending on the surrounding pH



BioFET

What about BioFETs?



- Sensitivity to any electrical interaction nearby the gate insulator can be extended to biosystems.
- Any biochemical reaction that leads to chemical or electrical changes at this interface can be measured.

→ ISFET coupled with a bioreceptor

iMINT

Basic Mechanisms for Potential Generation

1. Potential changes caused by a catalytic reaction product
   between enzyme and substrate

2. Potential changes caused by surface polarization effects or through change in dipole moments
   antigen-antibody affinity reactions
   DNA hybridization

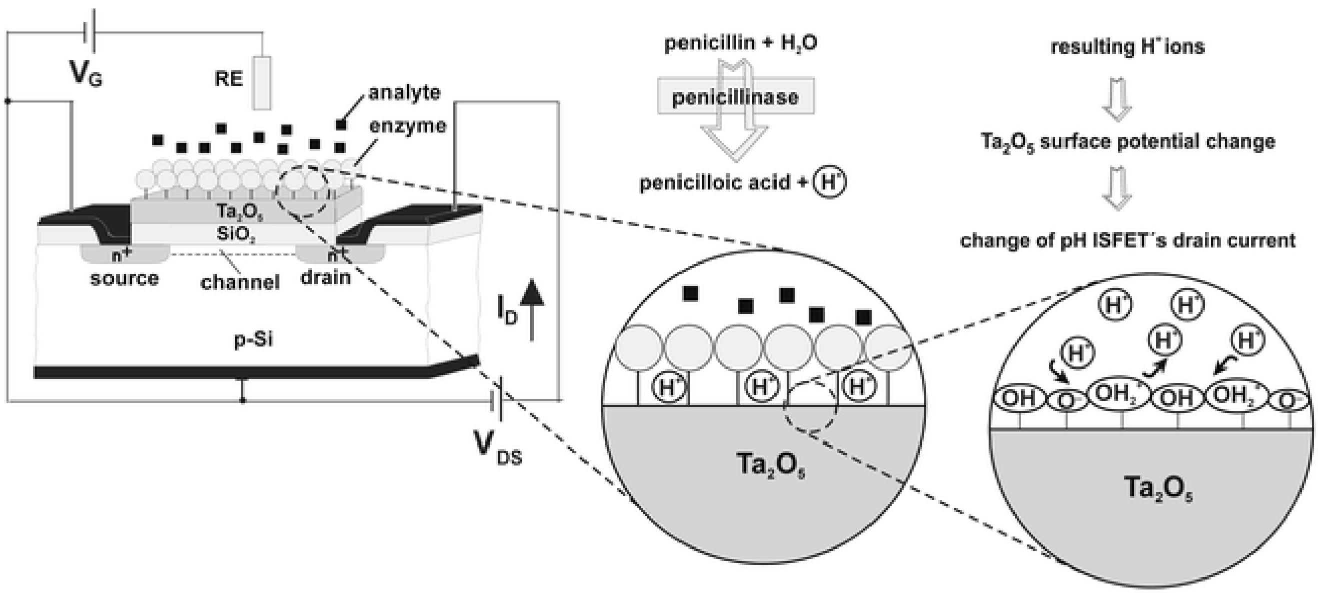
3. Potential changes caused by biological processes as a results of more sophisticated (bio)chemical processes
   action potential of nerve cells

Example: Enzyme -modified FET (EnFET)

- Enzyme used as bioreceptor due to specific binding

- Enzymes are bound to gate insulator through a number of ways:
  - physical or chemical adsorption
  - entrapment within polymeric matrices
  - cross-linking through cross-linking agents

- General working principle: during the enzymatic reaction with the substrate, products are generated which change the local solution concentration. This change is monitored by the ISFET



EnFET

Table 2 Recently developed EnFETs including the enzyme system used and the analyte to be detected

Analyte	Enzyme system
Glucose	Glucose oxidase[90-98,100,129,130]
	Glucose oxidase/MnO_2 powder[99]
	Glucose dehydrogenase[101]
Urea	Urease[87,95,101–108]
	Penicillin penicillinase[109–113,115]
	Penicillin G acylase[114]
Sucrose	Invertase/mutarotase/glucose oxidase'
	Invertase/glucose dehydrogenase[101,1]
Maltose	Maltase/glucose dehydrogenase[101]
Ethanol	Alcoholdehydrogenase/aldehyde dehydrogenase[101]
Lactose	β-Galactosidase/glucose dehydrogenase[116]
	β-Galactosidase/galactose dehydrogenase[101]
Ascorbic acid	Peroxidase[98,118]
Creatinine	Creatinine deiminase[126]
Formaldehyde	Alcohol oxidase[124,125]
Acetylcholine	Acetylcholinesterase[95,119]
Organophosphate compound (paraoxon)	Organophosphate hydrolase[122]
Fluorine-containing organophosphates	Organophophorus acid anhydrolase[123]

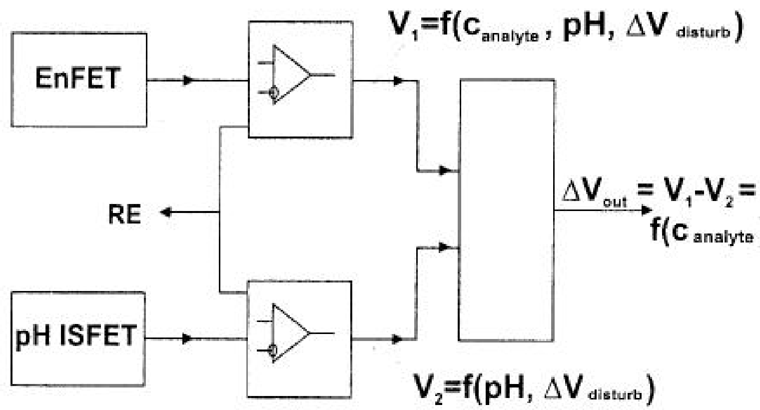
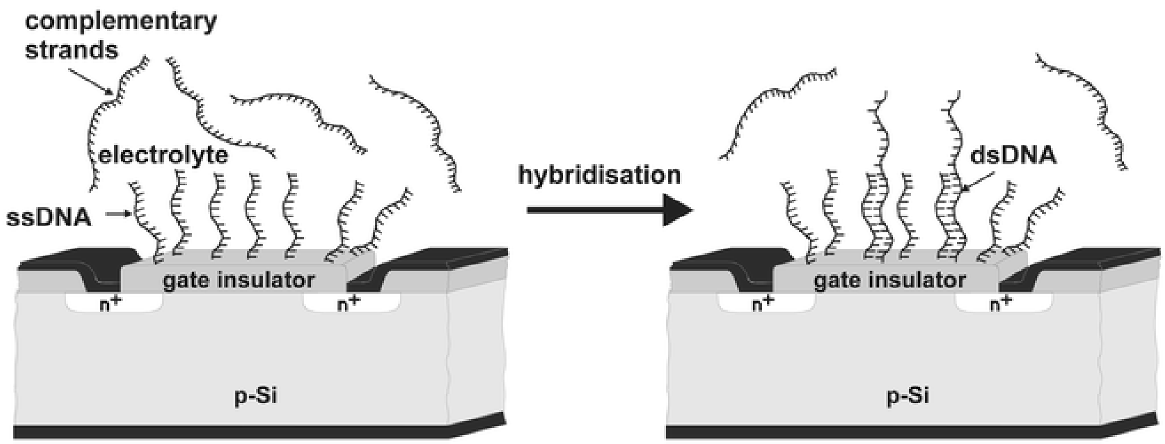


Fig. 5 pH ISFET/EnFET differential arrangement. The pH ISFET acts as 'reference' system; it is buit-up in the same way as the EnFET but without immobilised enzyme membrane.

Example: Gene -modified FET (GenFET)

- Fast, simple and inexpensive analysis of nucleic acid samples

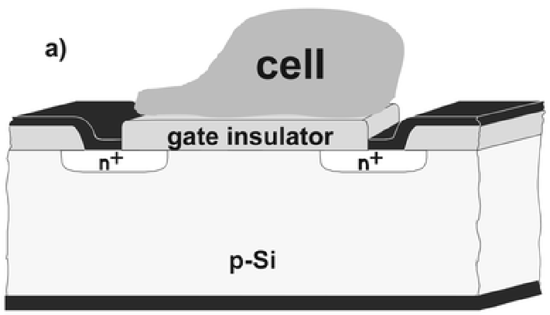
- Applications including diagnosis of genetic diseases, detection of infectious agents, drug screening, etc.

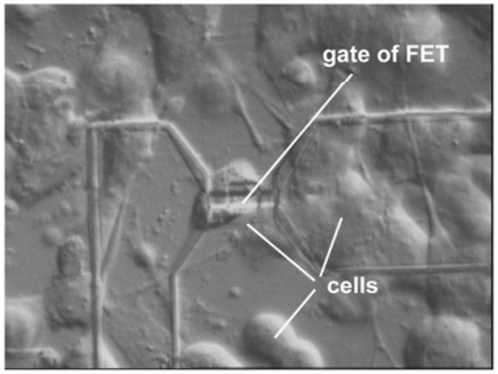


- Immobilize well-defined sequences of DNA onto transducer
- Specific recognition occurs between two DNA strands through hybridization
- Hybridization event (which induces a dipole Δ) converted into a measurable signal
  - ✓ Remains relatively unexplored as a DNA-based sensor
  - ✓ Counter ions can interfere with measurement

Example: Cell-based BioFET

- Whole cells are used as the recognition element
- A single cell or cell system is coupled to the gate insulator of a ISFET
- Applications include the study of the effects of chemical and physical stimulus on the biological system.
- Examples include pharmaceutical compounds,toxic substances, pollutants, etc.





- Changes monitored by the ISFET include extracellular pH, ion concentration,O_2 consumption, CO_2 production, redox potential, other metabolic products, neuronal potentials, …