



M I C R O S E N S

## Product Specific Data Sheet

# Ion Sensitive Field-Effect Transistor - ISFET

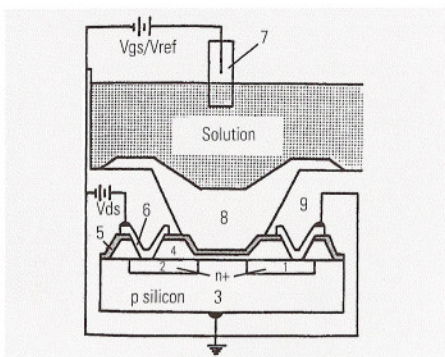
- MSFET 3310  $\text{Si}_3\text{N}_4$  gate
- MSFET 3320  $\text{Al}_2\text{O}_3$  gate

■ The ISFET devices are realized with microelectronic technology compatible with CMOS processes.

■  $\text{Si}_3\text{N}_4$  and  $\text{Al}_2\text{O}_3$  insulating gate ISFET base devices are measuring the pH value in a wide range from basic to acidic solutions.

■ The measurement of ion concentrations such as  $\text{K}^+$ ,  $\text{Ca}^{2+}$  is realized with an additional organic ion-selective membrane photopolymerized on the insulating gate of the sensor.

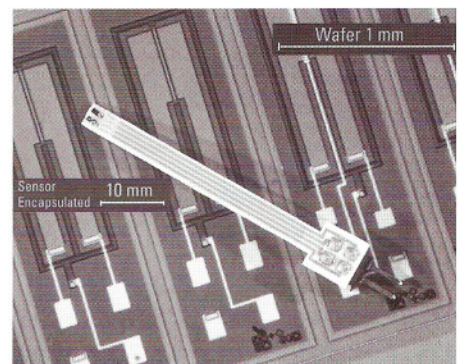
## ISFET principle



### Legend:

- |   |                                    |
|---|------------------------------------|
| 1. drain  | 6. metal contacts                  |
| 2. source   | 7. reference electrode             |
| 3. substrate  | 8. ion selective membrane (option) |
| 4. $\text{SiO}_2$ insulator                                     | 9. encapsulant                     |
| 5. $\text{Si}_3\text{N}_4$ or $\text{Al}_2\text{O}_3$ insulator |                                    |

## ISFET device



ISFET encapsulated on a ceramic based Printed Circuit Board (PCB)



# S e n s o r   S p e c i f i c a t i o n s

## Measured chemical species

### MSFET 3310

pH  
K<sup>+</sup>, Ca<sup>2+</sup>, Mg<sup>2+</sup>, with additional ion selective membrane

### MSFET 3320

## ■ Sensor construction

(3310)

(3320)

### Base structure

- Sensor base materials
- Technology used

Silicon, polysilicon, Si<sub>3</sub>N<sub>4</sub>,  
4" planar CMOS process

Al<sub>2</sub>O<sub>3</sub>

### Sensitive membrane

- pH-sensitive material
- ion selective membrane

Si<sub>3</sub>N<sub>4</sub>  
Ionophores doped polysiloxane

Al<sub>2</sub>O<sub>3</sub>

### Sensor dimensions

- Chip dimensions
- Packaged sensor:
  - DIL
  - PCB (typical)

0.6 x 4.5 x 0.3 mm

20 x 8 x 2 mm (pins not included)  
50 x 4 x 1 mm

## ■ Sensor Specifications

### Sensitivity:

- pH:
- K<sup>+</sup>:
- Ca<sup>2+</sup>:

50 mV/pH unit  
58 mV/pK  
30 mV/pCa

### Concentration range:

- pH:
- K<sup>+</sup>:
- Ca<sup>2+</sup>:

1 - 12  
10<sup>-7</sup> - 1 (M)  
10<sup>-6</sup> - 1 (M)

### Accuracy

0.01 pH (or 0.1%)

### Stability

0.1 pH/day (or 1%)

### Operating temperature

-45° C + 120° C

### Response time

< 1 sec. (90%)

## ■ Reference-electrode

A miniaturized Ag/AgCl Reference Electrode is realized together with the packaged ISFET chip acting as metal gate electrode and providing a stable reference potential. For specific applications, an Integrated Reference Electrode (IRE)\* has been developed which is manufactured on the same

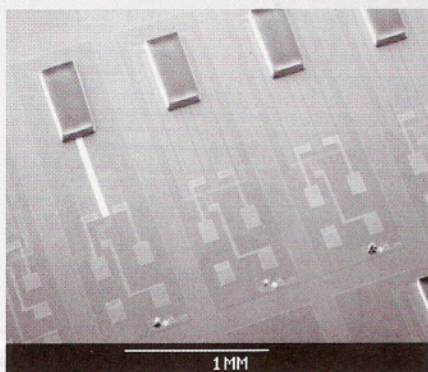
chip together with the ISFET.

The Ag/AgCl electrode is then deposited on the reversed side of the ISFET device and a silicon-structured cavity is containing the KCl Electrolyte. The liquid junction of the IRE is obtained by a porous silicon membrane manufactured on the ISFET front-side chip.

\* Patent US 06/7757669.



# Typical Sensor Characteristics



**K<sup>+</sup> ion selective membranes on planar CMOS ISFET**

## Photopolymerised ion-selective membranes

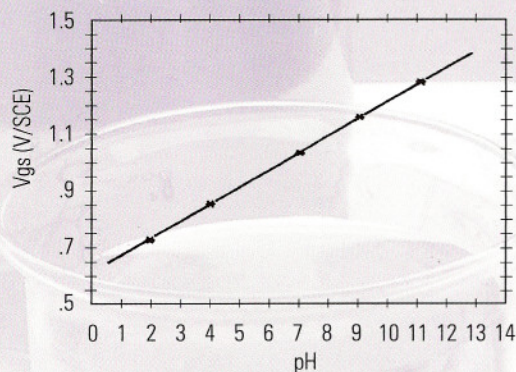
Highly selective organic membranes for different ion-concentration measurements such as K<sup>+</sup>, Ca<sup>2+</sup>, Mg<sup>2+</sup> are deposited and structured with a wafer-scale photolithographic technique. Thanks to the very good adhesion and stability of these membranes the specific ion selective FET can be used for ion-concentration monitoring with a good sensitivity and a linearity within a wide range of concentration down to 10<sup>-6</sup> M.



**DIL packaged ISFET multi-sensor device for flow through measurement**

## Flow through cell measurement configuration

The ISFET single or multi-sensor chip is mounted on a standard DIL package. The disposable sensor can be used for single or multiple use in a flow through cell measurement system.



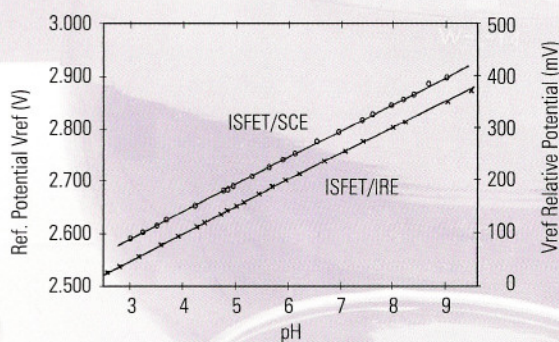
## Al<sub>2</sub>O<sub>3</sub> gate ISFET pH sensitivity

Saturated calomel reference electrode

buffer solutions pH 2 to 11

Slope = 53.7 mV/pH

V<sub>ds</sub> = 1 V I<sub>ds</sub> = 50 μA

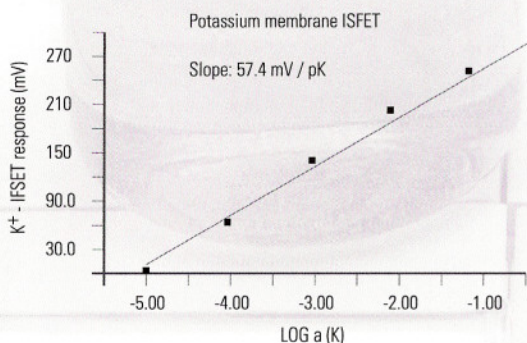


## ISFET pH sensitivity

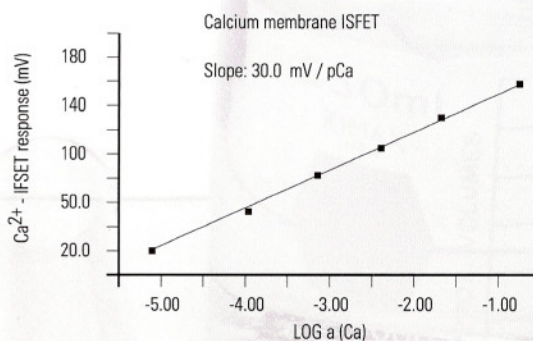
Al<sub>2</sub>O<sub>3</sub> gate device referenced towards saturated calomel electrode (SCE) and Ag/AgCl

integrated reference electrode (IRE)

V<sub>ds</sub> = 1.5 V I<sub>ds</sub> = 100 μA



**ISFET K<sup>+</sup> ion concentration sensitivity**



**ISFET Ca<sup>2+</sup> ion concentration sensitivity**

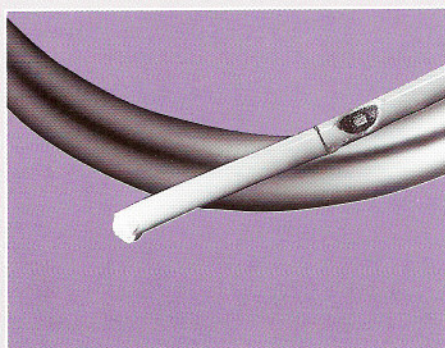




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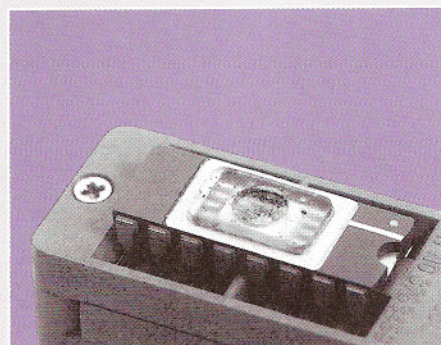
## Packaging

■ ISFET-chips are mounted, micro-bounded and sealed in hermetic encapsulant to be used as sensor devices for different applications. Application specific packages, such as hermetically sealed PCB (Printed Circuit Board) as well as DIL (Dual In Line) standard package, are available.



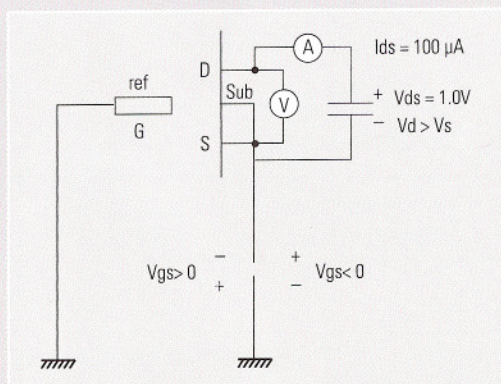
**ISFET encapsulated in a catheter for medical "in vivo" pH monitoring**

PCB or Kapton based circuits boards are used for the packaging of pH sensors in 2 mm diameter catheters.



**DIL Packaged ISFET for flow through cell measurement system.**

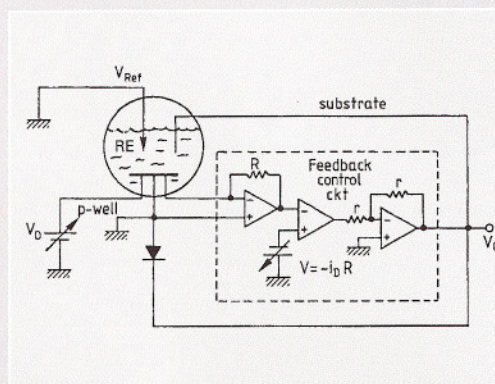
Specific DIL packaged ISFET are manufactured with silicone encapsulant providing on hermetic interface with the tubing of a flow through cell system.



**Electrical connections of ISFET devices**

Legend:

- D : Drain
- S : Source
- Sub : Substrate
- G : Reference electrode



**Schematic electronic circuit diagram**

This circuit configuration is used for a constant drain current operation of the ISFET device.

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