MICRO ELECTRONIC PILLS

a revolution in medical science....... 

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Our Body is a sensitive system. Many times even doctors aren’t able to interpret the disease. Thus it become too late to cure it. To remove this problem scientists discovered electronic capsule (pills) in 1972. Use of discrete & relatively large component’s, poor reliability, short lifetimes & low sensitivity makes it outdated. To overcome all these problems Professor Jon Cooper and Dr Erik Johanessen from Glasgow University, U.K has led to the development of a modern microelectronic pill. When Microelectronic pill is swallowed, then it will travel through the Gastro Intestinal Tract & simultaneously perform multiparameter in situ physiological analysis. After completing its mission it will come out of the body by normal bowel movement. The pill is 16mm in diameter & 55mm long weighing around 5 gram. It records parameters like temperature, pH, Conductivity, & Dissolved Oxygen in real time.
THE VARIOUS PARTS OF MICROELECTRONIC CAPSULE ARE:

1. SILICON DIODE
2. ION SELECTIVE FIELD EFFECT TRANSISTOR (ISFET)
3. DIRECT CONTACT GOLD ELECTRODE
4. 3 ELECTRODE ELECTROCHEMICAL CELL
5. CONTROL CHIP
6. RADIO TRANSMITTER
7. 2 SILVER OXIDE CELLS
8. BIOCOMPATIBLE CAPSULE ENCASING MICROSENSOR
THE CONSTITUENT ASSEMBLY INCLUDES

1. BATTERY
2. ANTENNA
3. ASIC
4. PH-SENSOR
5. ACTUATOR
6. DRUG CONTAINER
1. THE SILICON DIODE:

- It measures the body core temperature.
- Also compensates with the temperature induced signal changes in other sensors.
- It also identifies local changes associated with TISSUE INFLAMMATION & ULCERS
2. ION–SELECTIVE FIELD EFFECT TRANSISTOR (ISFET)

- The ISFET measures pH.
- It can reveal pathological conditions associated with abnormal pH levels.
- These abnormalities include:
  - Pancreatic disease
  - Hypertension
  - Inflammatory bowel disease
  - The activity of fermenting bacteria
  - The level of acid excretion
  - Reflux of oesophagus
  - Effect of GI specific drugs on target organs.
3. DIRECT CONTACT GOLD ELECTRODE

- The pair of direct contact Gold electrodes measures conductivity, by measuring the contents of water & salt absorption, bile secretion & the breakdown of organic components into charged colloids etc. in the GI tract.
- Since the gold has best conductivity among all the elements, Therefore it gives true value of conductivity as measured.

4. THREE ELECTRODE ELECTROCHEMICAL CELL

The three electrode electrochemical cell detects the level of dissolved oxygen in solution.
- It measures the oxygen gradient from the proximal to the distal GI Tract
- It investigates:
  - Growth of aerobic or bacterial infection
  - Formation of radicals causing cellular injury & pathophysiological conditions like inflammation & Gastric ulceration.
  - It develops 1st generation enzymes linked with amperometric biosensors.
ARRANGEMENT OF MICRO ELECTRONIC PILLS ON CHIP

Emulation test board built on FPGA board
Figure 1: (Left) showing the ISFET, temperature and conductivity sensor (Chip 1, a,c) and the electrochemical oxygen sensor (Chip 2, b, d). Figures e and f show detail of the pH and oxygen sensor, respectively;
DESCRIPTION OF THE CHIP DETAILS:

- Schematic (top) and photo (below) of the Glasgow IDEAS capsule.

COMMENTS
Although the capsule is currently too large to swallow, the hybrid approach towards its construction provides considerable experimental flexibility. It is estimated that the volume of the pill could be readily reduced by 40% through careful layout of the packaging and surface mount.

The Figure also shows that there is no signal cross-talk across the capsule, between sensors, despite the fact that they are located proximal to each other on the chip (and share the same microsystem for signal collection and transmission).
4. CONTROL CHIP

- The ASIC (Application Specific Integrated Circuit) is the control unit that connects together other components of the microsystem.
- It contains an analogue signal-conditioning module operating the sensors, 10-bit analogue to digital (ADC) & digital to analogue (DAC) converters, & digital data processing module.
- The temperature circuitry bias the diode at constant current so that change in temperature reflects a corresponding change in diode voltage.
- The pH ISFET sensor is biased as a simple source at constant current with the source voltage changing with threshold voltage & pH.
- The conductivity circuit operates at D.C. It measures the resistance across the electrode pair as an inverse function of solution conductivity.
- An incorporated potentiostat circuit operates the O₂ sensor with a 10-bit DAC controlling the working electrode potential w.r.t the reference.
- Analogue signals are sequenced through a multiplexer before being digitized by ADC.
- ASIC & sensors consume 5.3 mW power corresponding to 1.7 mA of current.
5. RADIO TRANSMITTER

- Size of transmitter = 8 × 5 × 3 mm
- Modulation Scheme = Frequency Shift Keying (FSK)
- Data Transfer Rate = 1 kbps
- Frequency = 40.01 MHz at 20 °C
- Bandwidth of the signal generated 10 KHz
- It consumes 6.8 mW power at 2.2 mA of current.

6. TWO SILVER OXIDE BATTERIES

- 2 SR44 Ag 2 O batteries are used.
- Operating Time > 40 hours.
- Power Consumption = 12.1 mW
- Corresponding current consumption = 3.9mA
- Supply Voltage = 3.1 V
In the Ideas (Integrated Diagnostics for Environmental and Analytical Systems) project’s Laboratory in a Pill, a plastic shell encapsulates the device electronics.
The SmartPill GI Monitoring System
This includes the SmartPill pH.p, a receiver, a docking station, and a PC user interface.
RANGE & ACCURACY

- **RANGE:**
  - Temperature from 0 to 70 °C
  - pH from 1 to 13
  - Dissolved Oxygen up to 8.2 mg per liter
  - Conductivity above 0.05 mScm⁻¹
  - Full scale dynamic Range analogue signal = 2.8 V

- **ACCURACY:**
  - pH channel is around 0.2 unit above the real value
  - Oxygen Sensor is ±0.4 mgL.
  - Temperature & Conductivity is within ±1%.
ADVANTAGES

- It is being beneficially used for disease detection & abnormalities in human body. Therefore it is also called as MAGIC PILL FOR HEALTH CARE
- Adaptable for use in corrosive & quiescent environment
- It can be used in industries in evaluation of water quality, Pollution Detection, fermentation process control & inspection of pipelines.
- Micro Electronic Pill utilizes a PROGRAMMABLE STANDBY MODE, So Power consumption is very less.
- It has very small size, hence it is very easy for practical usage
- High sensitivity, Good reliability & Life times.
- Very long life of the cells(40 hours), Less Power, Current & Voltage requirement (12.1 mW, 3.9 mA, 3.1 V)
- Less transmission length & hence has zero noise interference.
LIMITATIONS (THE DARK SIDE)

- It cannot perform ultrasound & impedance tomography.
- Cannot detect radiation abnormalities
- Cannot perform radiation treatment associated with cancer & chronic inflammation.
- Micro Electronic Pills are expensive & are not available in many countries.
- Still its size is not digestible to small babies
- Further research are being carried out to remove its draw backs.
REFERENCE

WEB REFERENCE:

2. http://citeseerx.ist.psu.edu

BOOK REFERENCE:
