A single walled carbon nanotube based optical glucose sensor for continuous in vivo glucose detection

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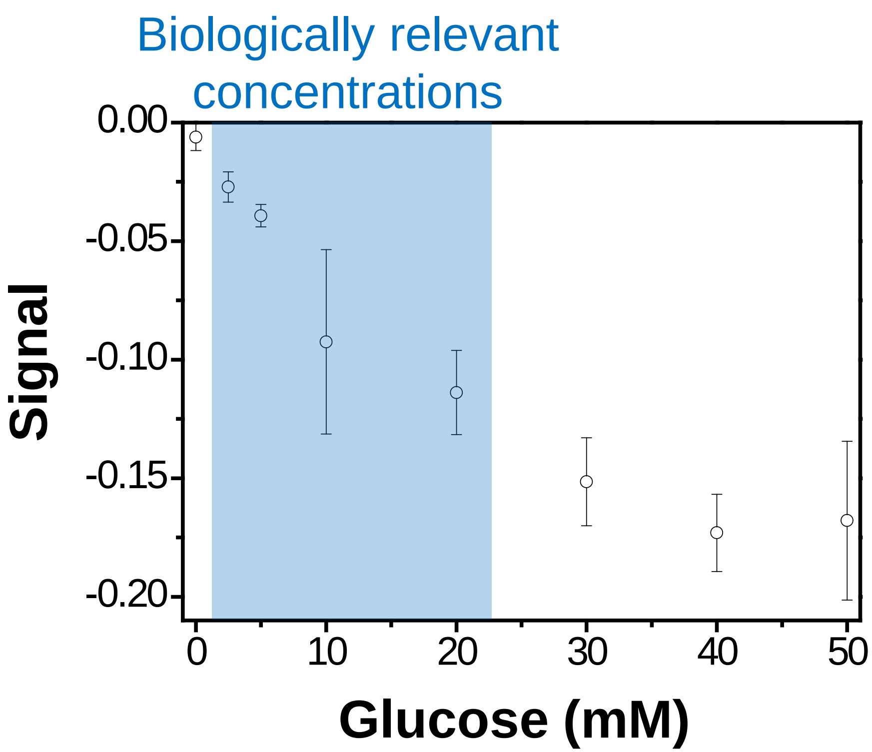
Opportunity

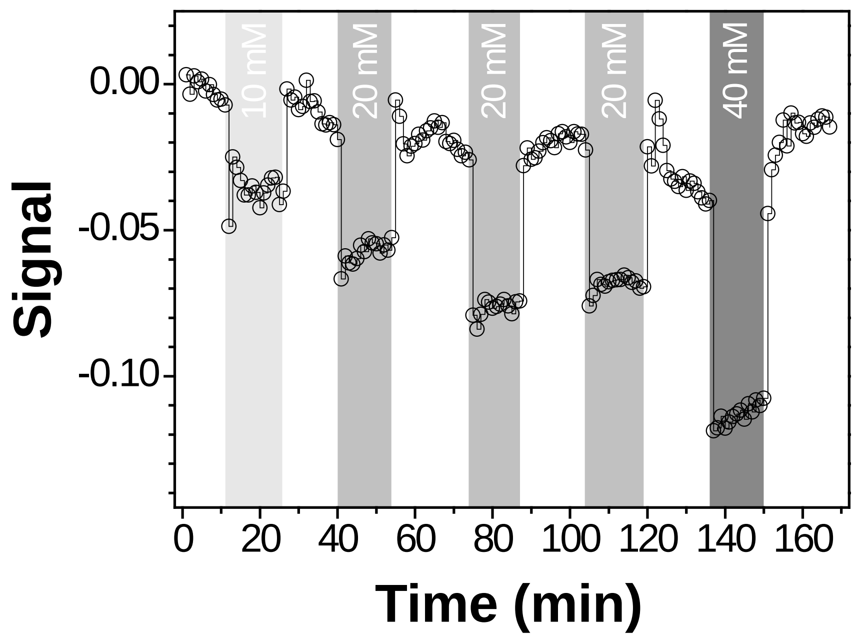
- **Diabetes Mellitus**
  - Affects *17.9 million people* in U.S (5-10% Type I).
  - *1.6 million new cases* are diagnosed each year
  - *7th leading cause of death* in 2006

- **Need**
  - Simple and reliable sensor for *real-time glucose detection* (< 10 min per measurement)
  - Help patients meet *targets in blood glucose* to reduce complications

Technology

Use single-walled carbon nanotube near infrared fluorescence to monitor glucose





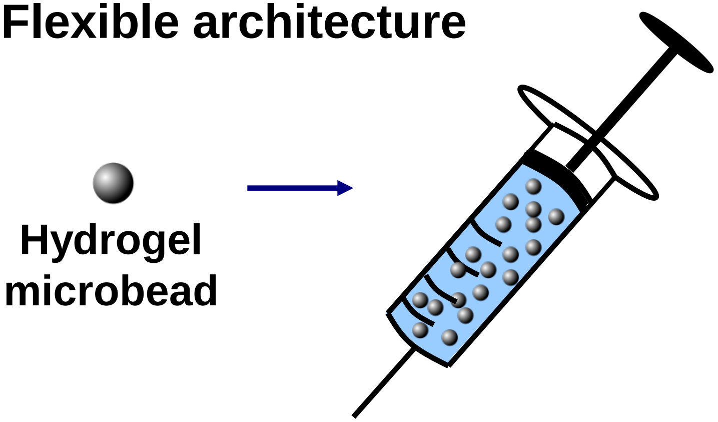
First reversible, non-photobleaching, near-infrared glucose sensor

Application of Technology

A passive, minimally invasive device for long term, *in-vivo* detection of glucose

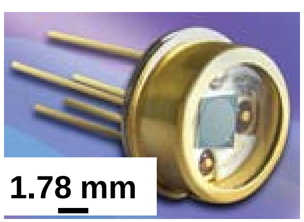
Sensor advantages
- Non-photobleaching
- Less susceptible to biofouling
- Simple / inexpensive optics
- Non-surgical implantation
- No open wound

Flexible architecture



Subcutaneous injection = "glucose sensing tattoo"

Simple optics required for hardware



nIR photodiode detector

+

laser photodiode

+ filters

Competition

Commercially Available Devices

Company	Technology	Sensor Lifetime	Initialization (h)	Calibration Frequency
MiniMed	Guardian CGMS	3 Days	2	2, 6 then every 12 hr
Dexcom	SEVEN CGM	7 Days	2	Every 12 hr
Abbott	Freestyle Navigator	5 Days	10	After 10, 12, 24 and 72 hrs

Disadvantages (CGMS)

- Sensor lifetime (3-7 days)
- Frequent calibration
- Open wound
- More susceptible to biofouling

sensor inserted beneath skin

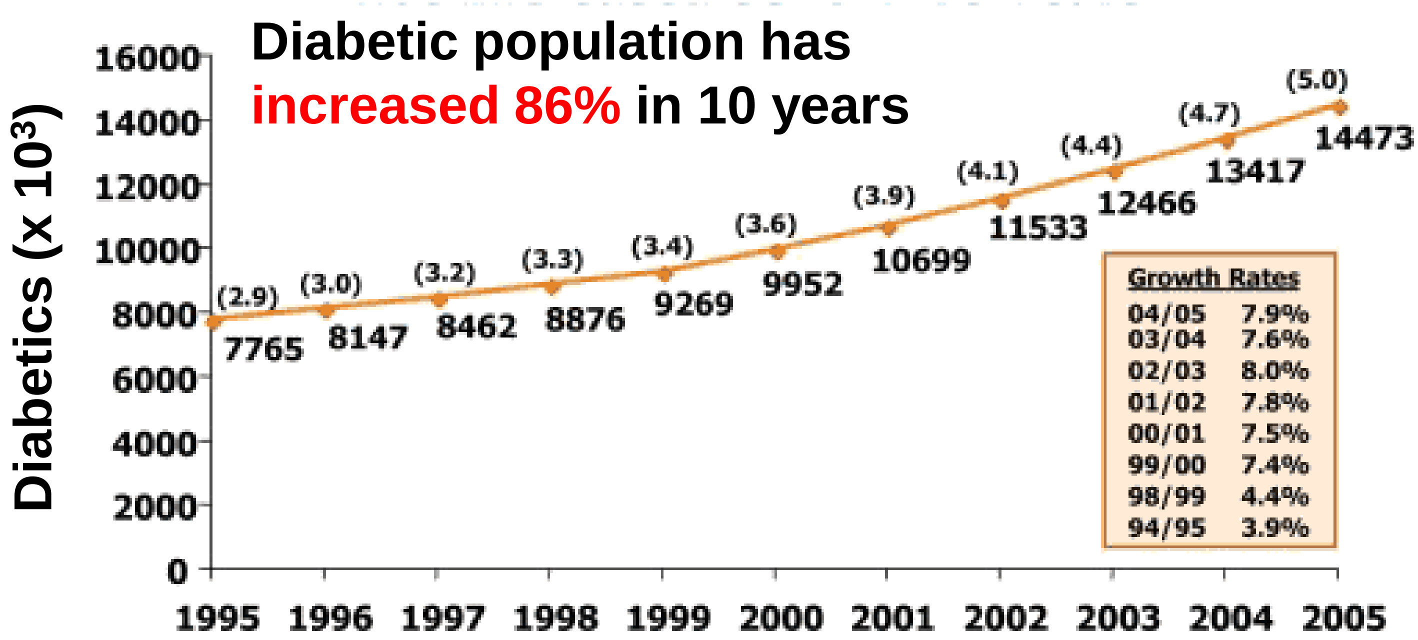
Receiver

Devices in Development

- AI Medics HypoMon
  - does not measure glucose
- Cybiocare OHD
  - only applicable for hypglycemia
- Sensors for Medicine and Science Inc. glucose sensor
  - requires surgical implantation
- Echo Therapeutics Symphony DMS
  - only operates for 24 hrs
- Smart Holograms glucose sensing contact lens
  - measurement in tear fluid, not truly continuous

Market

- **Costs of diabetes**
  - $116 billion direct medical costs in the U.S. in 2007.
  - $5 billion spent on glucose monitoring devices world-wide.

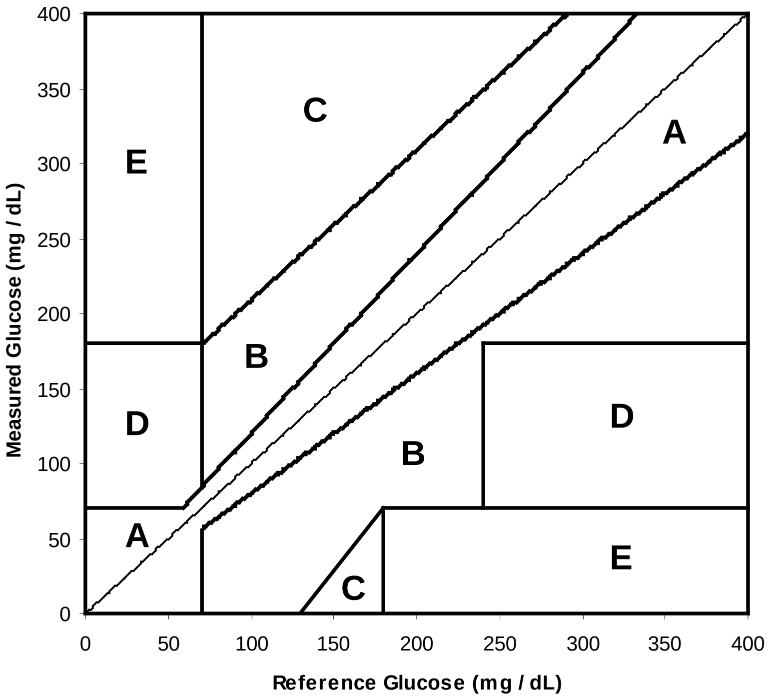


- **Estimate of market potential**

1% of diabetics @ $500/device, 6 mo. replacement → $200 million

Next Steps

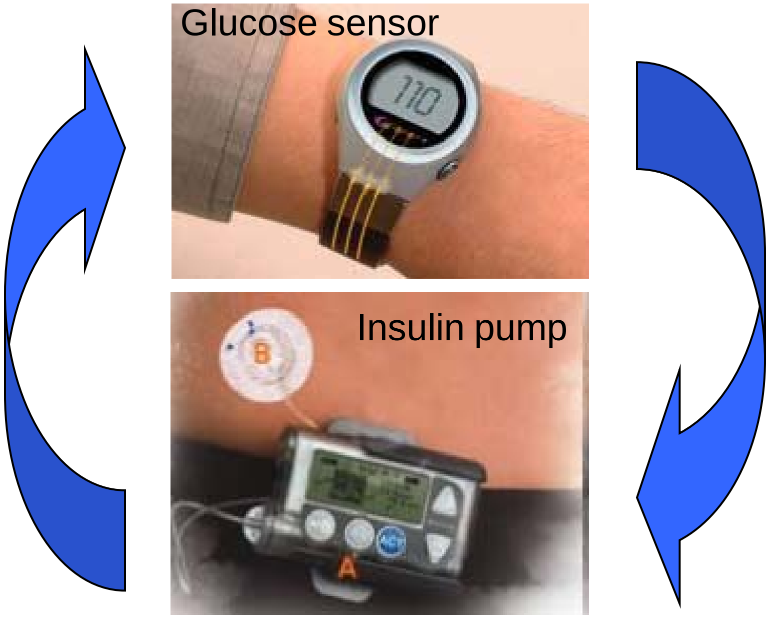
- Optimization of sensor platform
- Measurement of an *in vitro* Clarke Error Grid



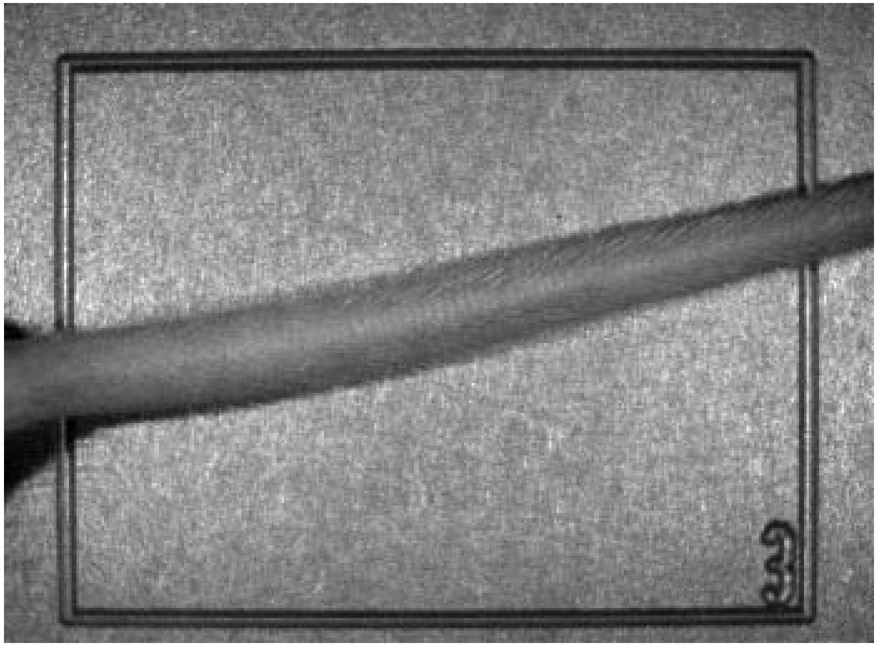
- Preliminary *in vivo* testing

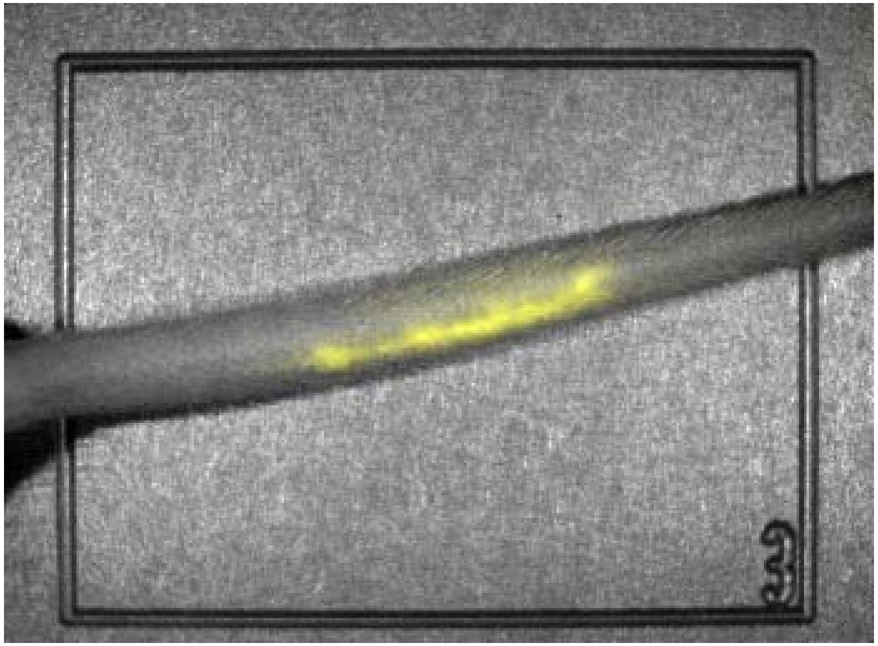
Summary

- *Problem:* lack of real time glucose detection for diabetes
- *Approach:* use single-walled carbon nanotubes for a passive, minimally invasive and long term *in-vivo* glucose sensor
- *Opportunity:* glucose monitoring market is large >$5B
- *Potential Impact:* closed loop “artificial pancreas”



In Vivo *Fluorescence Measurement*





Injected nanotubes in the tail of a mouse for a fluorescent “tattoo”.

Demonstration of SWNT fluorescence from the tattoo form factor.