

Sensors and Nanotechnology in the Healthcare Domain

Michael J. McGrath

Senior Technologist - Intel Digital Health



1954 – Regency TR1
4 Transistors

10mm



Ant 5mm

1mm



Pin Head 1-2mm

100um



Human Hair 60-120um

1971 - 4004
2300 Transistors



10um

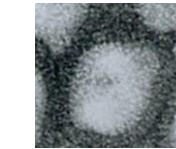


Red Blood Cells 8um

1989 - 486
1.2m Transistors



1um

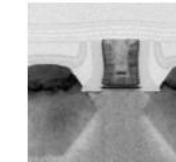


Influenza Virus 100nm

1993 - Pentium III
10million Transistors



100nm

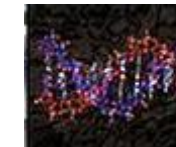


Transistor 45nm

2007 - Quad Core
800million Transistors



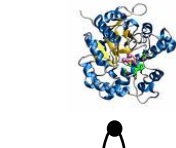
10nm



DNA 3nm

2009
2billion Transistors
32nm test chip
2.9billion 22nm SRAM

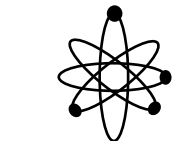
1nm



Protein 0.5nm

2009
Nahalem 8 Core
2.3 billion transistors
45nm technology

1Å



Silicon Atom 0.24nm

Sensors - State of Play

- Key focus areas
 - Healthcare
 - Environment
 - Buildings (Environment and Energy)
 - Utilities
 - National security
- In transition from the research to application domain
- Key Benefits
 - Cost
 - Protocol Innovation
 - Pre-emptive Monitoring

Nano Technology Applications

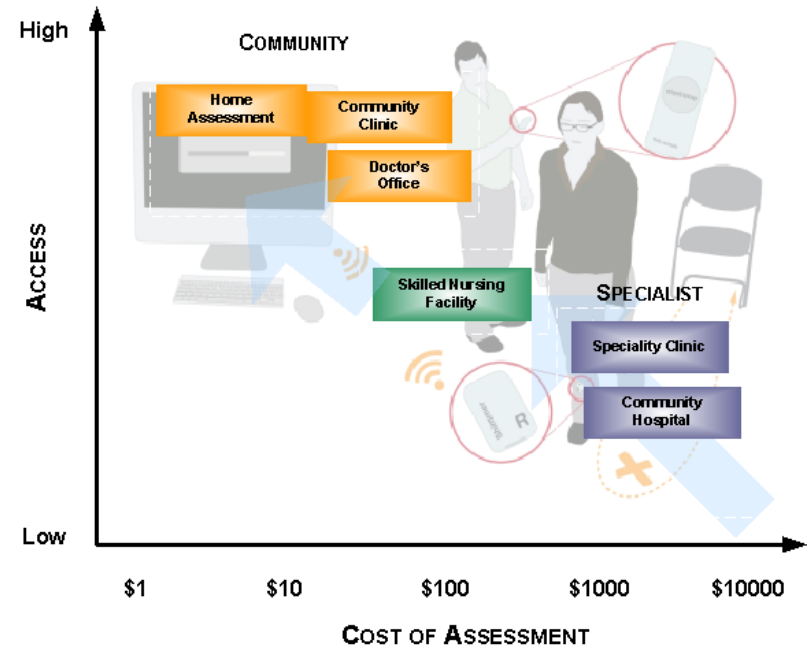
- Nano particles for drug delivery
 - Nano particles for detecting bio markers in blood
 - Functionalisation of medical scaffolds
 - Cell growth
 - Stents
 - Next generation MEMS e.g. accelerometers
 - Sensing Applications
 - Chemical and biological species detection[1]
 - Early radiation damage to cells [2],
 - Nanoshells that detect and destroy tumours [3].
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- 1. Cui, Y., et al., "Nanowire Nanosensors for Highly Sensitive and Selective Detection of Biological and Chemical Species," *Science*, Vol. 293, Aug. 17, 2001, pp. 1289-1292.
 - 2. "Space Mission for Nanosensors," *The Futurist*, Nov./Dec. 2002, p. 13.
 - 3. Cassell, J.A., "DoD grants \$3M to Study Nanoshells for Early Detection, Treatment of Breast Cancer," *NanoBiotech News*, Vol. 1, No. 3, Aug. 13, 2003.

Nano Technology and Sensors

- Nanotechnology Impacts
 - Size e.g. implantable and body worn
 - Cost e.g. SOC
 - Power Reduction
 - Potential for Pervasive Sensing
 - Lower weight
 - Greater sensitivity
 - Better specificity e.g. genetic classification of cancers
 - Affordable sensor redundancy in systems
- Barriers to Adoption
 - Toxicity Concerns
 - Organ damage concerns
 - Interference and noise, both electrical and mechanical
 - Flow control
 - Degradation from foreign substances e.g. protein deposition, heat, and cold.

Sensors Enabling “Shift Left” in Health Monitoring

- New home based protocol innovations
 - Activity Monitoring
 - Location Tracking
 - Falls / Ambulatory Gait Speed
- Community Based Risk Assessments
 - Falls, Frailty, etc.
- Benefits:
 - Reduced costs
 - Improved quality of life
 - Early interventions
- First Generation Products Emerging
- Need scaled market for Nano Tech



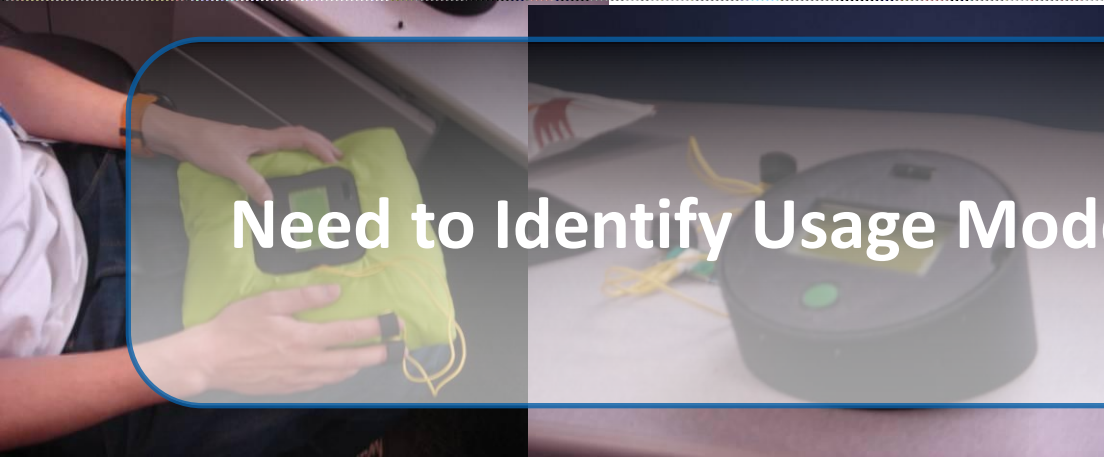
“Shift left” in risk assessments

A Vision for the Future?



The patient must be at the centre of healthcare, not the sensor technology

Focus on Usage Models not just Technology!



Need to Identify Usage Models Nano Tech can Enable



Future Directions



- **Body Worn Sensing**

- Use case and application specific only



- **In Vivo Sensing**

- Power scavenging
- External communications outside body
- Intelligent internally drug delivery e.g. dosage modification
- Regulatory concerns will temper speed of progress



- **Pervasive Environmental Sensing**

- Issues of perception challenging



- **Biological Construction Techniques**

- DNA-based molecular assembly



- **High Performance Silicon and Biological Interfaces**

- Move from macro to cellular interfaces

Healthcare Selected Key Challenges



- **Excessive focus on pilots of existing technologies, slowing rollout**



- **Healthcare organisational changes**
 - Potential for policy impact



- **Personal Health Records**
 - Lack of end to end integration
 - Lack of standards



- **Attitudes and Perception**
 - Design is key!