Quantum-π pedometers

quantum precision instruments

Disruptive entry into mass consumer market

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Quantum Precision Instruments Asia
Private Limited, Singapore

Quantum Precision Instruments Asia Private Limited

Quantum-Pi is a high-tech company founded in 1999 and developing Nano Electro-Mechanical (NEMS) sensors, wireless sensor networks and atomic precision metrology nanoTrek® devices especially useful in:

- oil and gas industry,
- security, defense and military,
- medicine and biotechnology,
- aviation, maritime and navigation,
- precision manufacturing and microelectronics fabrication equipment, nanotechnology and scientific industries, and in
- consumer products.

Quantum-Pi received the 2009 Frost & Sullivan Award for Technology Innovation in Integrated Nano-Sensing

Quantum-π product will reach MANY markets

	Oil & Gas	Buildings, Roads, Utilities, Dams	Micro-electronics	Manufacturing & Mining	Automotive & Aviation	Medicine	Defence & Security
Vibration sensors	✓	✓	✓	✓	✓	✓	✓
Seismometers	✓	✓		✓			✓
Accelerometers		✓	✓	✓	✓	✓	✓
Microphones	✓			✓		✓	✓
Flow, pressure meters	✓	✓	✓	✓	✓	✓	✓
Positional metrology			✓				

Quantum-π nanoTrek® technology has clear advantages over competitors

Device Type	Sub-micron Process capable	Linear Response	Ease of use	Low cost
Capacitance	NO	YES	YES	YES
Piezoelectric	YES	NO	YES	NO (not at nanometer resolution)
Optical	YES	YES	NO	NO
Cantilever Tunnelling	YES	NO	NO	NO
*nano*Trek®	YES	YES	YES	YES

BUT ....

Quantum-π plans to enter
low-hanging fruit, lower-tech spec,
mass market of
sports shoes pedometers
to realise

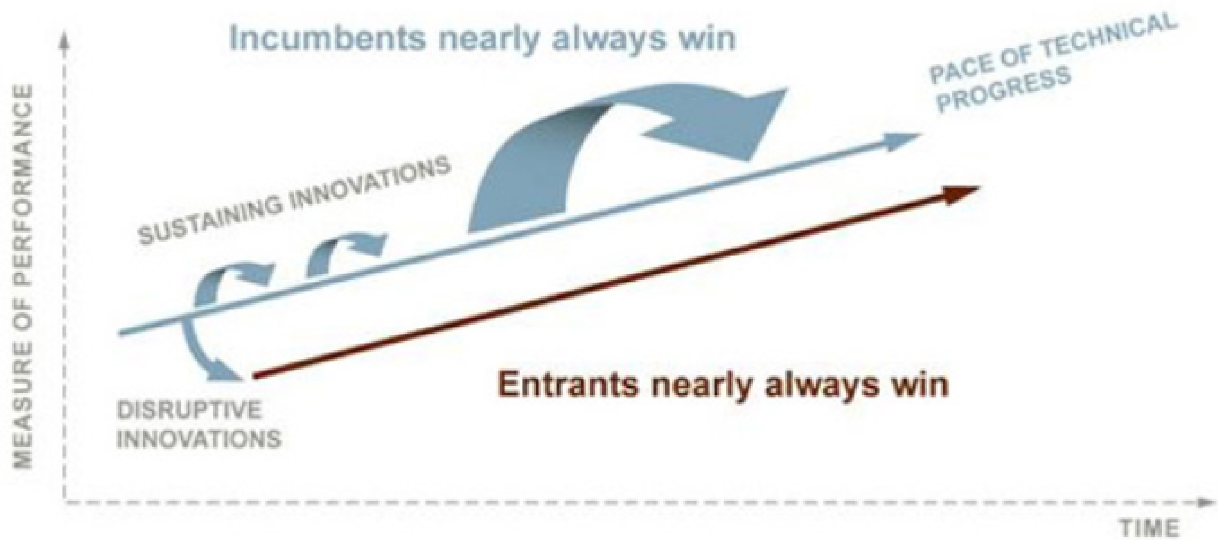
disruptive innovation

and to take over consumer space currently
(almost) EMPTY !

Key Concepts - Disruptive Innovation

Disruptive innovation, a term of art coined by Clayton Christensen, describes a process by which a product or service takes root initially in simple applications at the bottom of a market and then relentlessly moves 'up market', eventually displacing established competitors.

An innovation that is disruptive allows a **whole new population of consumers** access to a product or service that was historically only accessible to consumers with a lot of money or a lot of skill. Characteristics of disruptive businesses, at least in their initial stages, can include: lower gross margins, smaller target markets, and simpler products and services that may not appear as attractive as existing solutions when compared against traditional performance metrics.



Because companies tend to innovate faster than their customers' lives change, most organizations eventually end up producing products or services that are too good, too expensive, and too inconvenient for many customers. By **only pursuing "sustaining innovations"** that perpetuate what has historically helped them succeed, **companies unwittingly open the door** to **"disruptive innovations"**.

2011 market projections for inertial sensor market for consumer electronics

Executive Summary

Overview

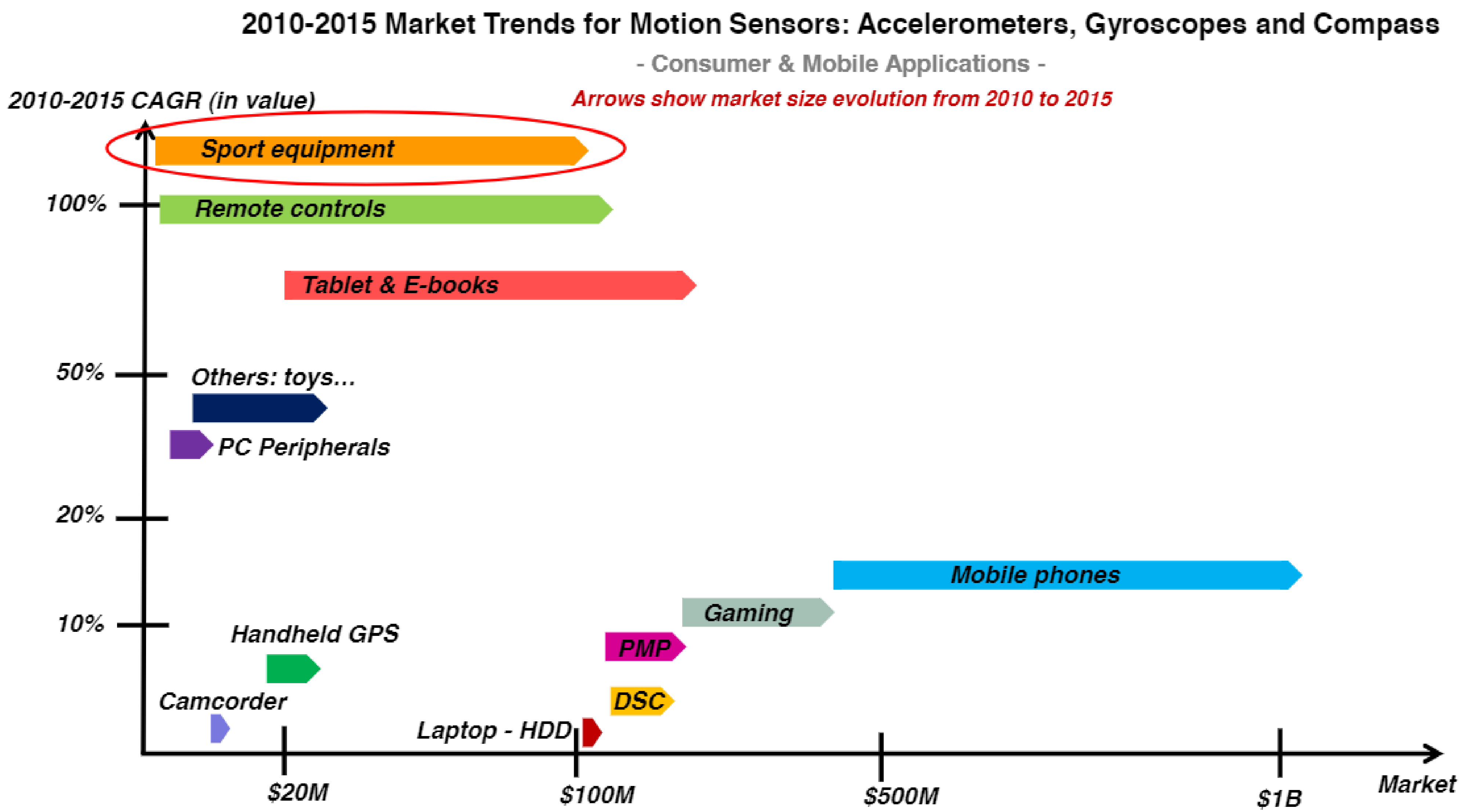
- The inertial sensor market for consumer electronics is growing very quickly due the fast adoption of accelerometers, gyroscopes and magnetometers in mobile phones, tablets, game stations, laptops.... Indeed 20.3% annual growth is expected: from $847M in 2009, the motion sensor market will reach $2.56B in 2015!

- The MEMS accelerometer market will show very nice business opportunities in the coming years. Moreover this market will be strategic because many applications are expected to rely on 3-axis accelerometer + 3-axis gyroscope in a single package within 2015. There is thus a strong synergy between accelerometer and gyroscope technologies and players.

"Motion Sensors for Consumer & Mobile Applications: Accelerometers, Gyroscopes, Compass and Sensor Combos proliferate"
Yole Development 2011

2009-2015 market overview

Motion sensors application trends



The trends above DO NOT

take into account seismic market shifts

caused by

disruptive innovation

Quantum-π will bring by

entry to shoe sole market

PEDOMETERS: Current situation

Brands: Omron Sportline Yamax Nike Accusplit
Stores: Bodytronics Walmart Sports Authority Target Amazon
Types: digital watch talking running wrist

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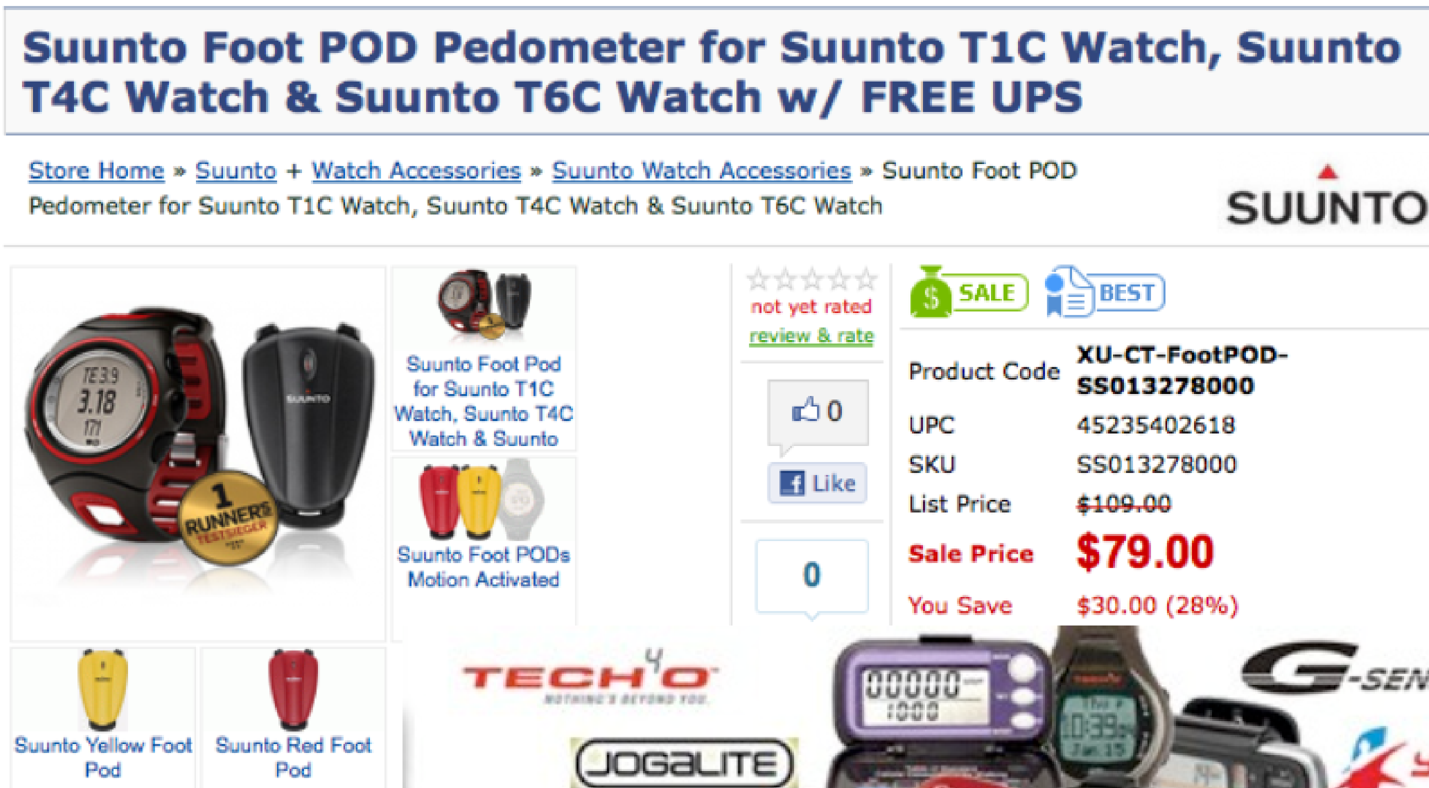
PEDOMETERS: Current situation

ALL are bulky, add-on extra fixture external to a sports shoe!



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PEDOMETERS: Nike + iPod Sports Kit

Nike + iPod Sport Kit

Close

$29.00

Ships: Within 24hrs

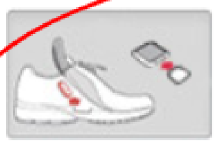
Add to Cart

Sign up for 1-Click

Gift package available

Overview

Thanks to a unique partnership between Nike and Apple, your iPod nano, iPod touch (2nd generation or later), iPhone 3GS, or iPhone 4 becomes your coach. Your personal trainer. Your favorite workout companion.



Tune

Insert the wireless sensor inside the custom, built-in pocket beneath the insole of your Nike+ shoe, then plug the receiver into the Dock connector on your iPod nano. The iPod touch (2nd generation or later), iPhone 3GS, and iPhone 4 include built-in support for the system — no receiver necessary.

Run

Now start your workout. As your run or walk, the sensor sends information to your device, tracking your time, distance, pace, and calories burned. If you choose, real-time, spoken feedback can even alert you to milestones throughout your workout.

Sync

Back at your computer, sync your iPod nano to transfer your workout data to iTunes and nikeplus.com; on iPod touch, iPhone 3GS, and iPhone 4, you can sync your data wirelessly. At nikeplus.com, you can evaluate your performance history, set goals, and even challenge other runners to a virtual race.

What's in the Box

- Wireless sensor for Nike+ shoes
- Wireless receiver for iPod nano
- Printed documentation

Requirements

- iPod nano, iPod touch (2nd generation or later), iPhone 3GS, or iPhone 4
- Nike+ shoes
- iTunes 10 or later (available via free download)
- A Mac with a USB 2.0 port and Mac OS X version 10.3.9 or later; or a PC with a USB 2.0 port and Windows 7, Windows Vista, Windows XP Home or Professional (SP3) or later
- Internet access and a free Nike.com account

Specifications

Sensor*

- Size: 1.37 x 0.95 x 0.30 inches
- Weight: 0.23 ounce
- Broadcast frequency: 2.4GHz

Receiver

- Size: 1.03 x 0.62 x 0.22 inches
- Weight: 0.12 ounce

Quantum-π's Plan for Pedometers Market Entry

1. Create partnership with Chinese sports shoe sole manufacturer
2. Build simple and cheap 1-axis, digital accelerometer, with simple display and data transfer mechanism
3. Create mobile devices applets for data transfer
4. Commercialise through shoe sole manufacturer, starting from LOW end of market
5. Create new type of product: functionalised shoe

Benefits Considerations

1. Currently add-on pedometers, or wrist wearable pedometers sell for $15 to $300
2. Nike + iPod sells for US$ 29, but is locked-in to Apple devices
3. Quantum-Pi device would be very cheap to manufacture (~$1 per piece)
4. It will be made to "talk" to iPone (through applet), Android, HTC, LG devices, and PCs
5. There wil be cheap self-contained display built into shoe (optional)
6. Quantum-Pi pedometers would have similar life-span as a shoe - no need to change batteries, parts, fix anything
7. Quantum-Pi pedometers will only marginally add to a price os a sports shoe
8. The volume of shoes is estimated to be > 100 mil annually

Quantum-π pedometers will change mass consumer sports shoe market and will be a great success!

Appendix

1. Quantum-Pi: Devices, Patents, Concepts
2. Patents and IP details
3. Patent Group 2 - Stage of Development
4. Dynamic nanoTrek sensor (basis of shoe pedometer)
5. Technical Targets
6. Key Technical Factors
7. Proven Fabrication Process
8. Fabless Company with Access to Excellent Facilities
9. Collaborators
10. Founder/CTO's Background

Quantum-π: Devices, Patents and Concepts

1. nanoTrek® - a quantum tunneling linear encoder of position, motion and alignment

2. dynamic nanoTrek® – Nano Electro-Mechanical Systems (NEMS) sensors for measurements of vibration, acceleration, pressure, flow, etc.

3. new designs for the AFM cantilevers that do not require optical metrology to measure bending and torsions but utilize quantum tunnelling

4. 2-D tuneable diffraction gratings for atom beams, or a new type of an atom optics chip

5. quantum tunneling photo-detector cross-grid arrays

Quantum-π: Patents & IP – details

1. "Measuring Using Tunneling Current Between Elongate Conductors" (PCT/AU99/00733; US 09/786,641) granted in the USA, Europe (UK, Germany, France), Russia, China, Israel, Singapore, Australia, Canada and South Africa, pending in Japan and Brasil. (Group 1)

2. **"Quantum tunneling transducer device" (WO2004094956A1), filed in 2004, at National phase in the US, Europe, granted in Singapore and Japan. (Group 2)**

3. "Particle optics and waveguide apparatus" (WO2006029450A2), inventor: M.T. Michalewicz, for Atom Optics, nanotechnology processing and instruments, National phase in Europe and Japan. Granted in the USA (US 11/662,523) and in Singapore. (Group 3)

4. "Sensor Device and Method" PCT/SG2007/000278. (Group 4)

5. "Quantum Tunneling Photodetector array" (USA, Japan, Europe, China) (separate, held in name of M.T. Michalewicz)

6. Trademarks: nanoTrek, Quantum-Pi.

7. Technical know-how for processes, materials, technology, market intelligence, etc.

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Quantum-π's Patent Group 2: dynamic nanoTrek®

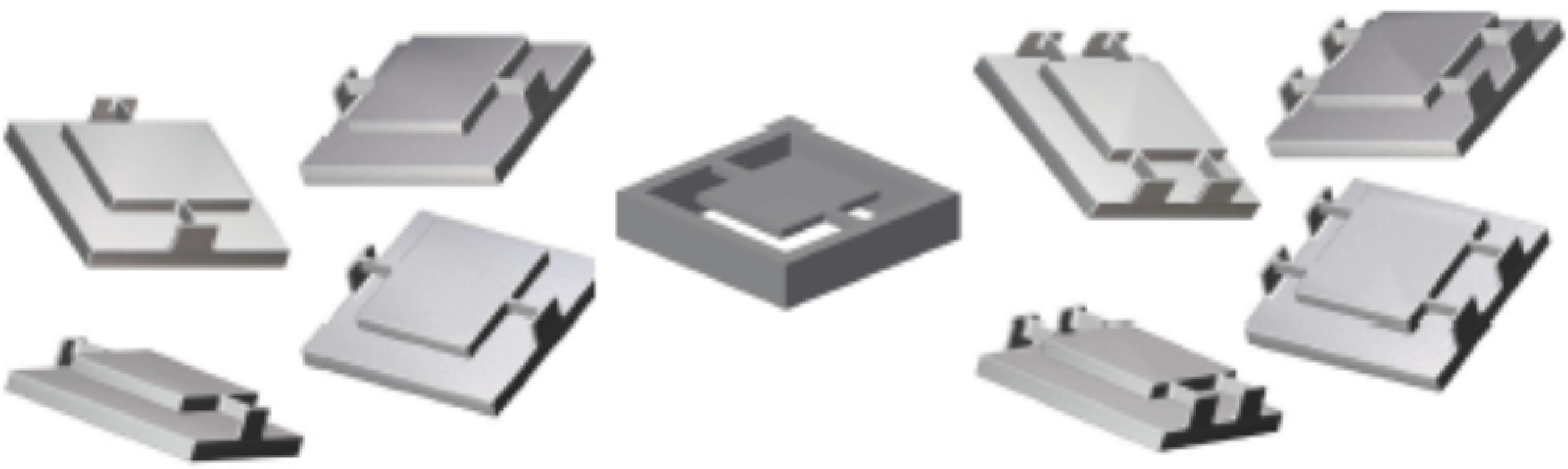
Nano Electro-Mechanical Systems (NEMS) sensors for measurements of vibration, acceleration, pressure, flow, etc

Stage of development:

1. Partial proof-of-manufacturability (all intermediate steps proven)
2. Fab in Singapore ready to run the first fabrication
3. Strong IP protection (patents in Japan, Singapore, about to be granted in USA pending in Europe)
4. SIMTech Lab in Singapore ready for shaker and performance testing

Need strong partner to complete product development and enter market.

Dynamic nanoTrek® devices *concept drawings*



Not to scale. Size of top plate 20 micro-meters to 50 micro-meters. Actual devices do not protrude from wafer flat.

Quantum-π's dynamic nanoTrek® Technical Targets

Technical Criterion	Target	Explanation
Atomically smooth substrates	<1 nm	Required to avoid formation "micro-tip" tunneling electrodes
Tunneling current signal level	>1nA	Required for compact DSP electronics
Variation in peak quantum tunneling current between devices	10%	Required for uniformity in mass scale product
Device noise floor	$<10ng/\sqrt{Hz}$	Includes thermal noise, quantum tunneling current noise and readout circuit
Shock resistance	20g	Required for device robustness
Network of many sensors	> 20	Depending on application
Distance between each sensor in distributed wireless network	> 5 m	Required for large engineering structures monitoring
Power for each sensor in wireless network sustained for at least	1 year	Required for maintenance free operation (ideally energy harvesting power sources should be used)

Quantum-π's dynamic nanoTrek® key technical factors

Key Factors	Proposed Technical Targets	Requirements for Commercial Success	Current Practice	Associated Technical Barriers	Innovative Technical Approaches
Production of atomically smooth surfaces	<1 nm	No "micro-tips" formation	Achievable e.g. CMP process	Entire wafer area undulation, especially 8" wafers	Sensor area very small – undulations "not visible" at this scale
Maintenance of proof mass to substrate spacing	< 1 nm variation	Related to spring constant of proof mass (very stiff in direction parallel to normal to two plates)	No known applicable current practice.	Very detailed NEMS mechanical modeling, nanometer dimensions tolerances	Use of soft matter spacer or novel MEMS structure (QPI patent pending)
Low thermal noise structure	$10ng/\sqrt{Hz}$	$50ng/\sqrt{Hz}$	$90ng/\sqrt{Hz}$	Low damping	Structure with low damping; vacuum packaging

Proven Fabrication Processes

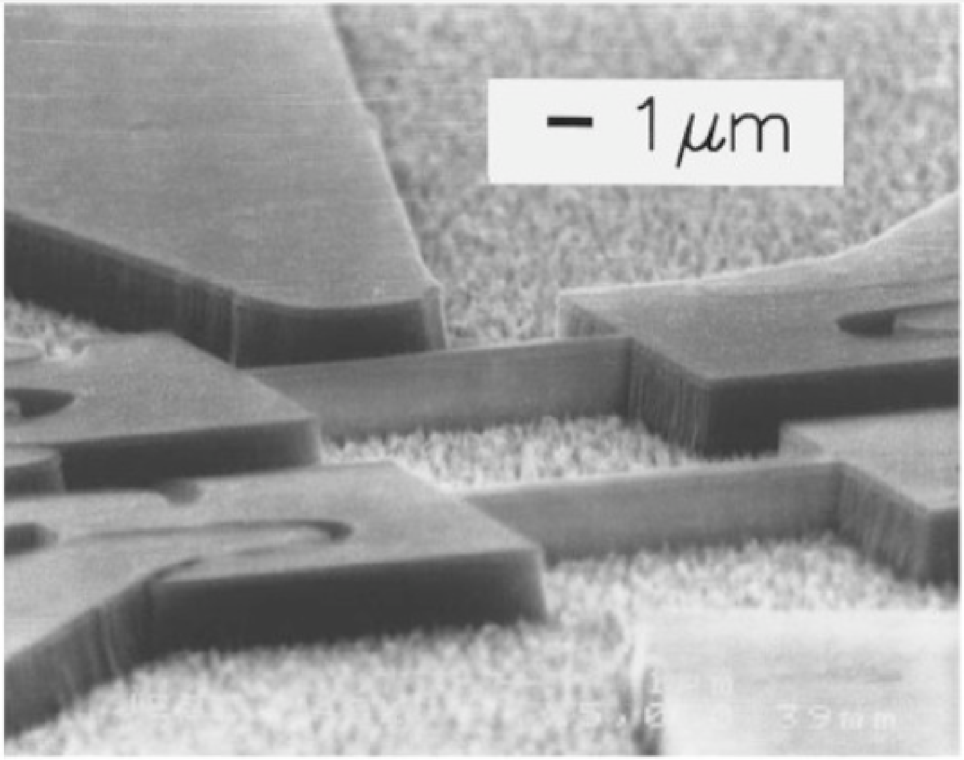


FIG. 2. SEM micrograph of the structures following the anisotropic Si etch.

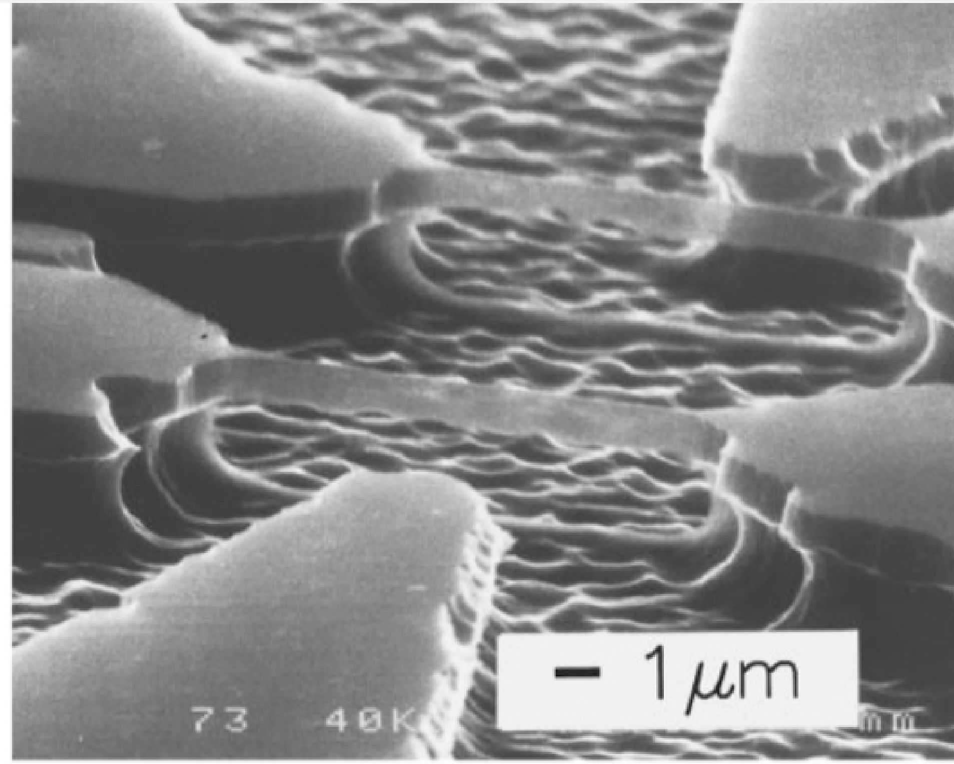


FIG. 3. SEM micrograph of an undercut Si beam, with length of 7.7 μm, width of 0.33 μm, and height of 0.8 μm. Some scalloping is visible along the bottom edge of the beam.

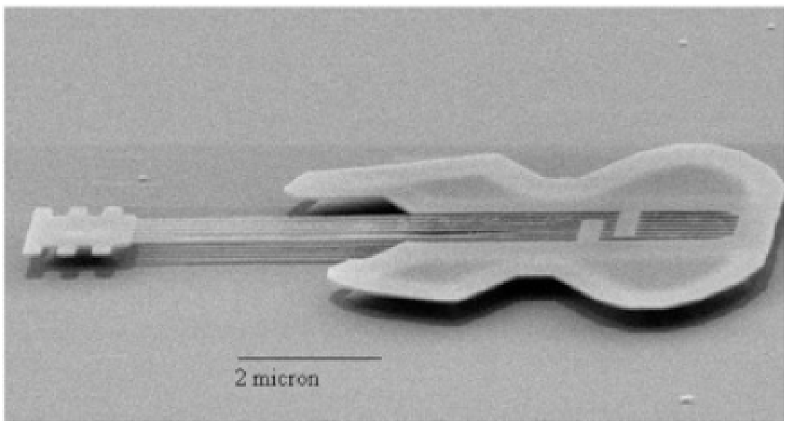
Cleland & Roukes, UCSB & CalTech

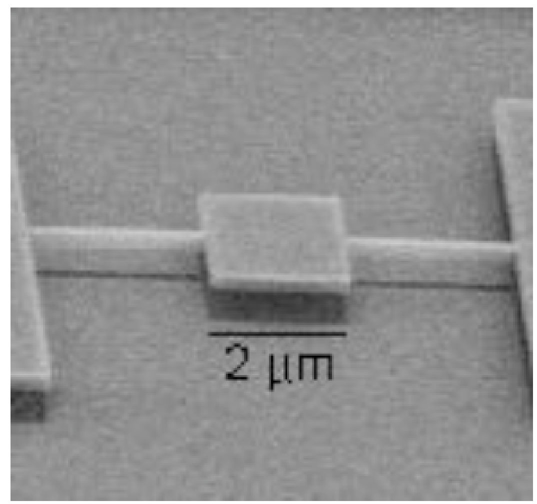
Proven Fabrication Processes

Greatest challenges:

Cutting the quantum tunneling gap. But it's been done!

Transfer of knowledge to Singapore from Cornell U. USA, Prof. H. Craighead





H. Craighead et. al. Cornell University

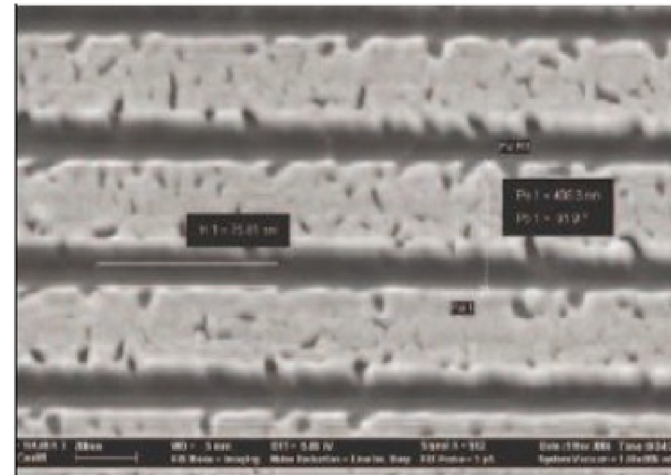


Figure 2. FIB machined 75 nanometre trench structures in gold coated alumina.

Focussed Ion Beam milling:

example from University of Wales

Institute of Microelectronics have confirmed all process steps.

The detailed process has been documented in IME-Quantum-Pi project plan.

Quantum-Pi POC is to build functional devices using these established processes.

Quantum-π facilities in Singapore

Collaborations:

SSLS: Singapore Synchrotron Light Source

A*STAR
  Agency for Science Technology & Research
IMRE
  Institute of Materials Research & Engineering
IME
  Institute of Microelectronics
DSI
  Data Storage Institute
SIMTech
  Singapore Institute of Manufacturing Technology

Collaborators

Piotr Glowacki[1] Piotr Slodowy[1] Dr Miroslaw Walkiewicz[1] Dr Ewa Radlinska[1,2] Dr Nancy Lumpkin[1,3] Dr Steven Bremner[1,3] Dr Frederic Green[4] Prof Zygmunt Rymuza[5] N. Singh[6] Dr S. Balakumar[6] N. N. Gosvami[7] Prof Dr. Herbert O. Moser[8] Dr Ao Chen[8] Dr Linke Jian[8] Dr Shahrain bin Mahmood[8] Dr Jong Ren Kong[8] Dr A. B. T. Saw[8] Dr Zhang Jun[9] Dr Chen Wenjie[10] Tsung-Chi Chen[11] Prof. Arvind Raman[11] Prof. Ron Reifenberger[11]	1: Quantum-π 2: Australian National University, Canberra, Australia 3: Cavendish Laboratory, University of Cambridge, UK 4: University of New South Wales, Sydney, Australia 5: Institute of Micromechanics and Photonics, Warsaw University of Technology, Warsaw 6: Institute of Microelectronics, Singapore 7: Institute of Materials Research and Engineering, Singapore and Department of Mechanical Engineering, National University of Singapore 8: Singapore Synchrotron Light Source, National University of Singapore 9: Data Storage Institute, Singapore 10: Institute of Manufacturing Technology, Singapore 11: Birck Nanotechnology Laboratory, Purdue University, USA

Dr Marek T. Michalewicz
Founder & Chief Scientific Adviser

Marek is the Director, A*STAR Computational Resource Centre (ACRC) at Agency for Science Technology and Research (A*STAR) - the main government funded research agency in Singapore. He is responsible for operations and delivery of High Performance Computing resources to researchers from all 14 Institutes and all Centres at A*STAR. The A*STAR Computational Resource Center (ACRC) operates computers with total computational power of ~100 TFlops and ~3,000 TBytes of data. There are more than 700 users. Marek is also adjunct researcher at the Institute of High Performance Computing, Advanced Computing where he is involved in research in general area of High Performance and Parallel Computing, and Quantum Physics methods. Inventor of all six patents held by Quantum-Pi.

PhD (Theoretical Physics), Institute of Advanced Studies, Australian National University, Canberra (1987)
MSc (Theoretical Physics), LaTrobe University, Melbourne (1984)
University of Wroclaw, Poland (4 years, Physics) (1981)
University of Minnesota, Minneapolis, USA (Research Associate, 2 years)
24 years research experience following a PhD degree
30 years experience of scientific and commercial computing
Computational Sciences expert in the Commonwealth Scientific and Industrial Research
Organisation (CSIRO) Supercomputing and High Performance Computing (10 y)
1997-2000 Principal Research Scientist at the CSIRO Mathematical and Information Sciences Division - High Performance Computing

Edited two books on Computational Life Sciences & Medicine and authored over 35 scientific papers and book chapters and some 60 conference presentations in 12 countries
Fellow of The Australian Institute of Physics
Member of The American Physical Society and Association for Computing Machinery
Senior Associate Foresight Institute (for Nanotechnology)