The Abdus Salam
International Centre for Theoretical Physics

United Nations
Educational, Scientific and
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IAEA
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2140-5

Workshop on Entrepreneurship for Physicists and Engineers from Developing Countries

3 - 7 May 2010

Start-up experiences

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Start-up Experiences

Professor Peter Dobson

Oxford University Begbroke Science Park

Trieste 5th May 2010

Examples of Oxford spin-outs at Begbroke

•Oxonica: formed in 1999, from Engineering Science. Invented nano-phosphors, sunscreens, diesel fuel additives and biotags. Floated on AIM July 2005. cap. £60m

•Oxford Gene Technology: formed in 1995 from Biochemistry, came to site in 2000: gene array technology.

•Oxford Biosensors: formed in 2000 from Engineering Science and Chemistry, makes point of care sensors based on enzyme electrochemistry and microelectrodes. Moved to Yarnton in 2004 to manufacture.

•Hardide: formed in 2000 from Russia, making hard coatings, moved to Bicester

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How Oxonica started: the original vision

- Research on manufacture of luminescent nanoparticles in the late 1990s led to belief that we could offer low voltage nanoparticle phosphor materials to the field emission display industry.
- This idea was flawed, because industry wanted a complete solution and not a small part of the solution.

  Note a field emission display needs electron emitters, the phosphors, a screen, fully integrated into a product.
- Attention was then given to nanoparticle sunscreens and diesel fuel catalyst additives. The former had strong internal University IP, the latter did not.

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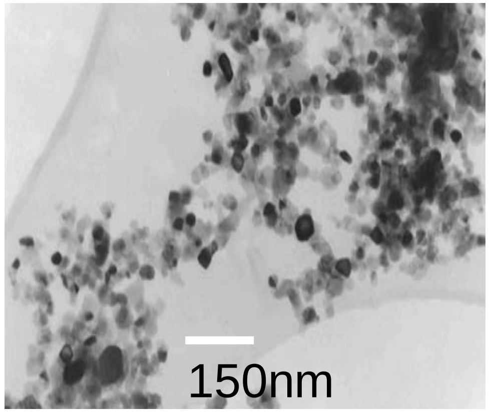

Oxonica

"Optisol" doped titania nanoparticles used in sunscreen to give uv protection and safeguard against free radical damage

- University of Oxford spin-out formed 1999 after 7 years background research originally to make and sell nanoparticles for display applications
- Focus on Energy, Environment and Healthcare especially via sunscreens, fuel additives and biodiagnostics
- "Solution Provider" ethos
- Revenue generating from 2002
- Tailoring nanoparticles for customer applications, building revenues based on IP generation
- Floated on AIM 20-7-05, market cap. £35M
- Took over Nanoplex (US) 20-12-05
- Transferred biodiagnostics to US operation during 2007 and sold off some in 2009

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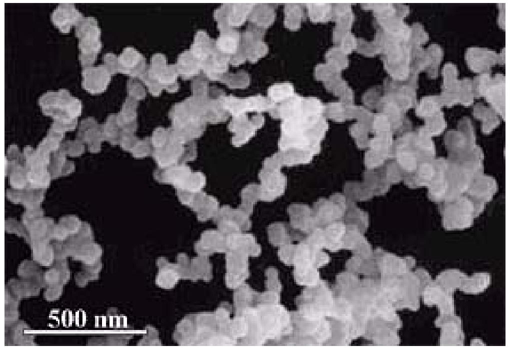
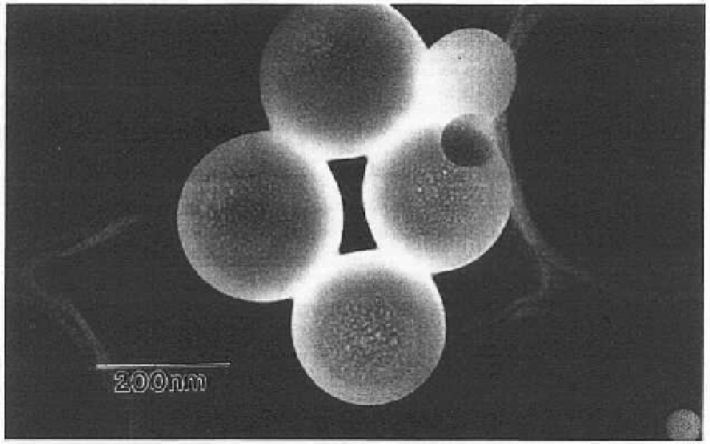
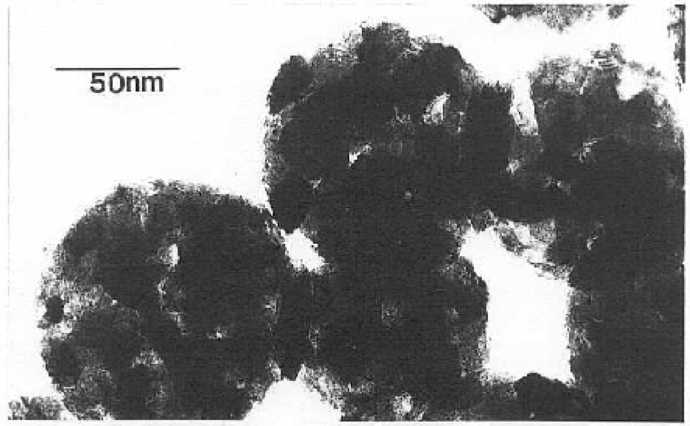
"Envirox": nanoparticles of cerium oxide used in diesel fuel at ~5ppm to eliminate soot and improve fuel efficiency



Nanophosphor particles Y_2O_3:Eu (an early product)

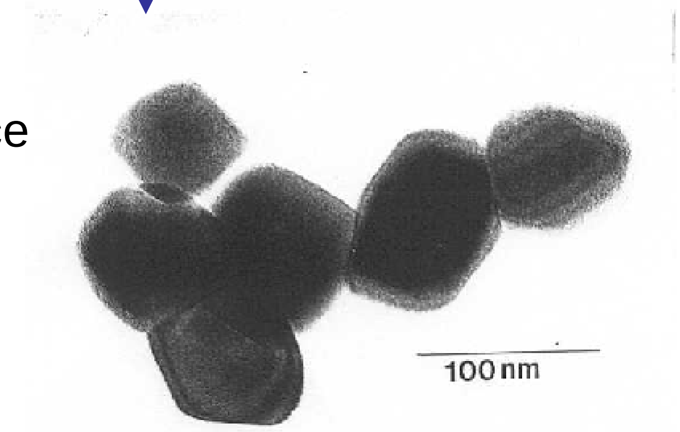


Mild anneal

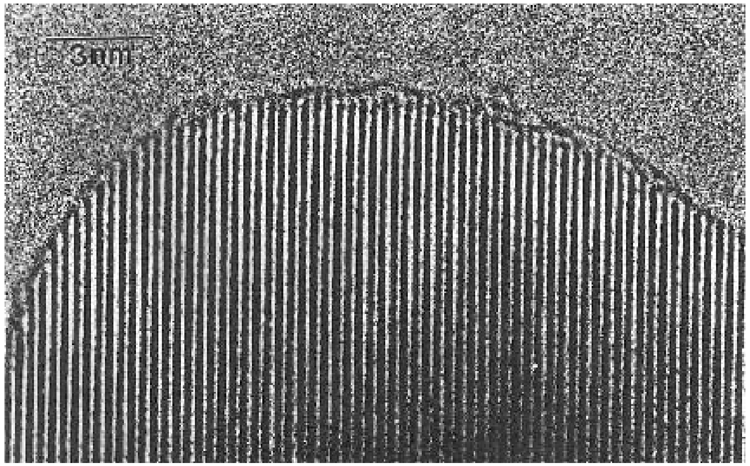


OXONICA

High temperature heating



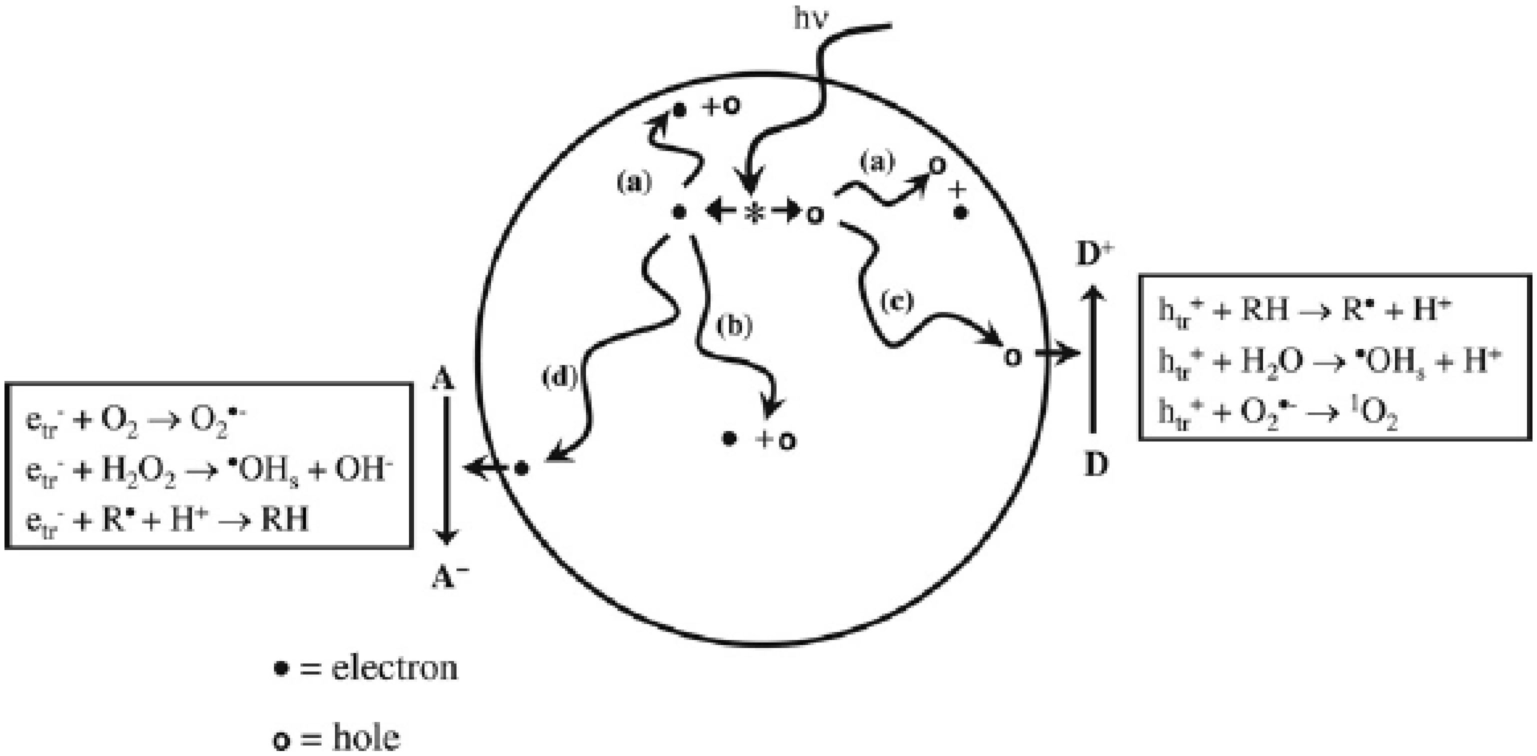
Detail of surface



The early lessons

- Discard the idea of pushing clever nanotechnology
- Try to provide a complete solution to a market need
- Quantum dots were "fashionable" but where is the market? (this is true today!)

Photo-processes in titania particles



Fujishima et al, Surface Science Reports **63**, 515, (2008)

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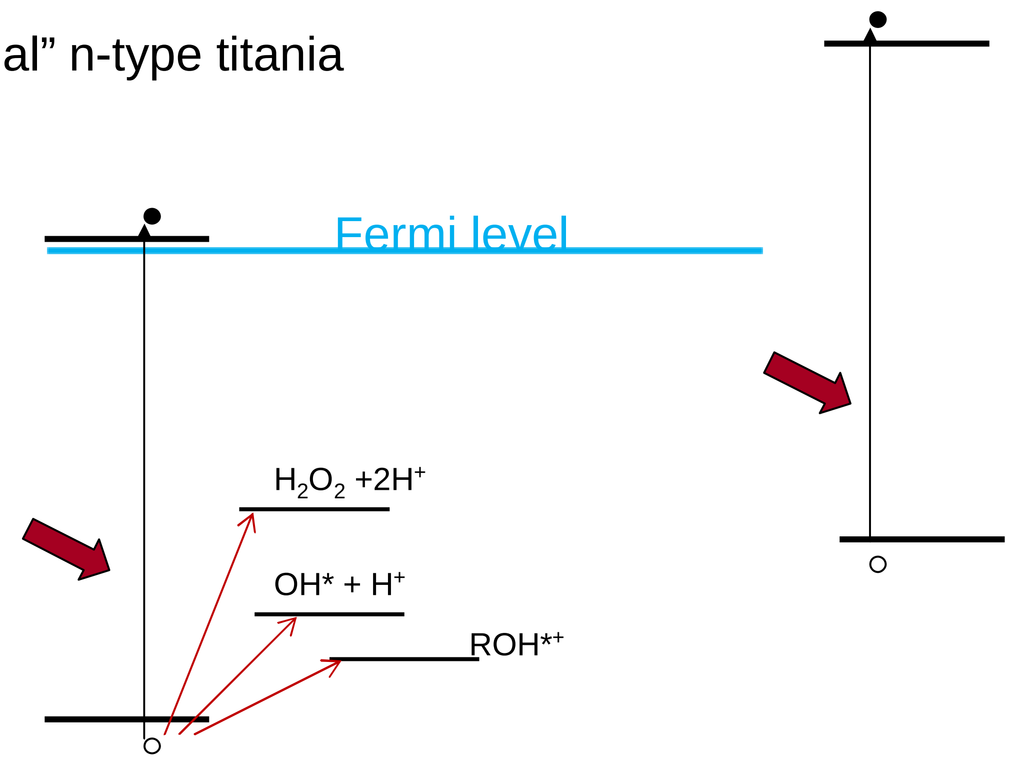
Doped p-type titania as the basis for a safe sunscreen

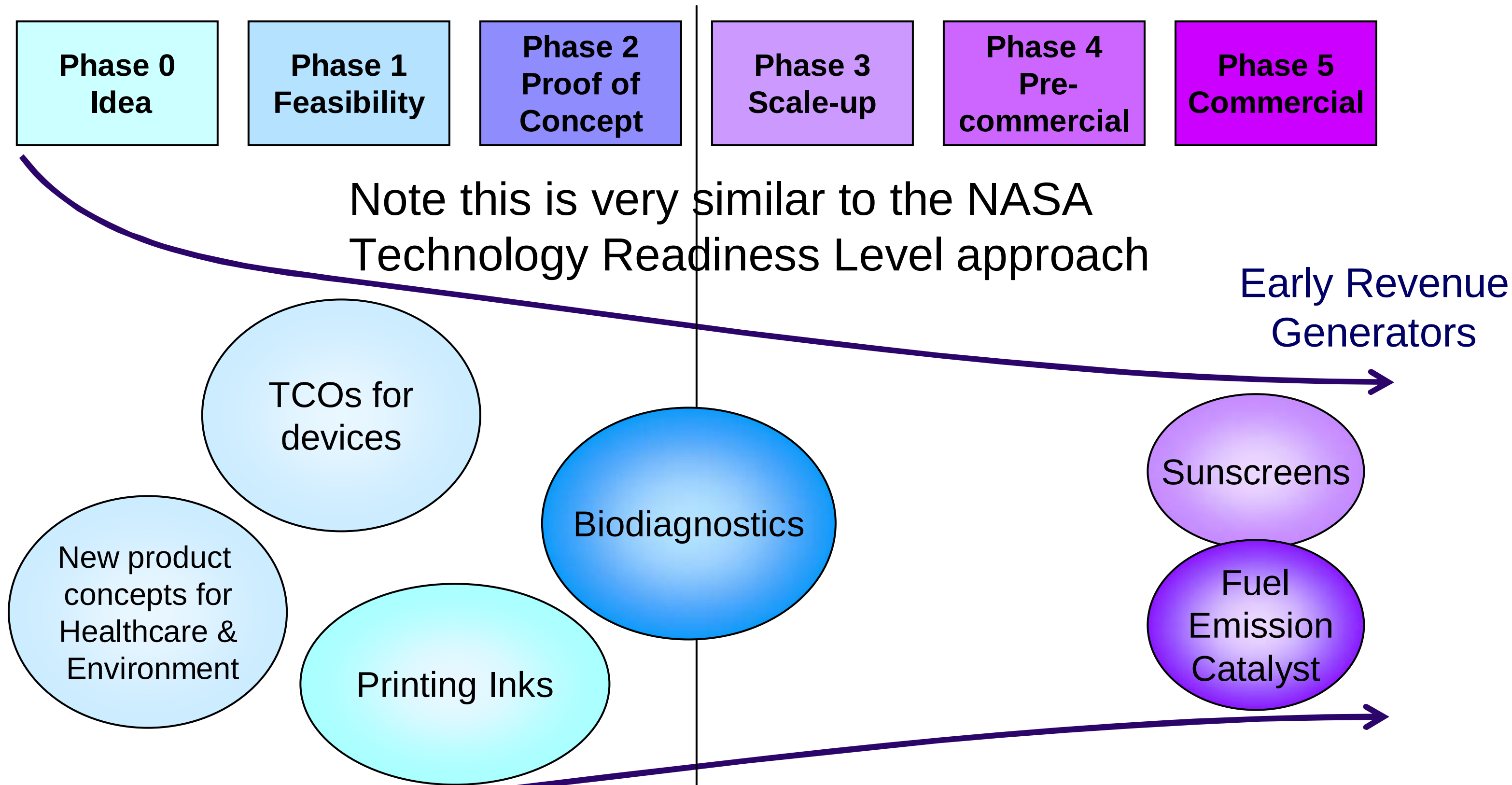
p-type Mn-doped titania

“Normal” n-type titania



The shift in Fermi level due to the doping makes the free radical generation unlikely or impossible

Oxonica product pipeline (an excellent idea for an SME!) situation in 2007



Biodiagnostics is risky unless you have quantified the market need and supply chain, and looked at regulatory issues

TCOs are transparent conducting oxides and have become a very important market need for displays and solar cells

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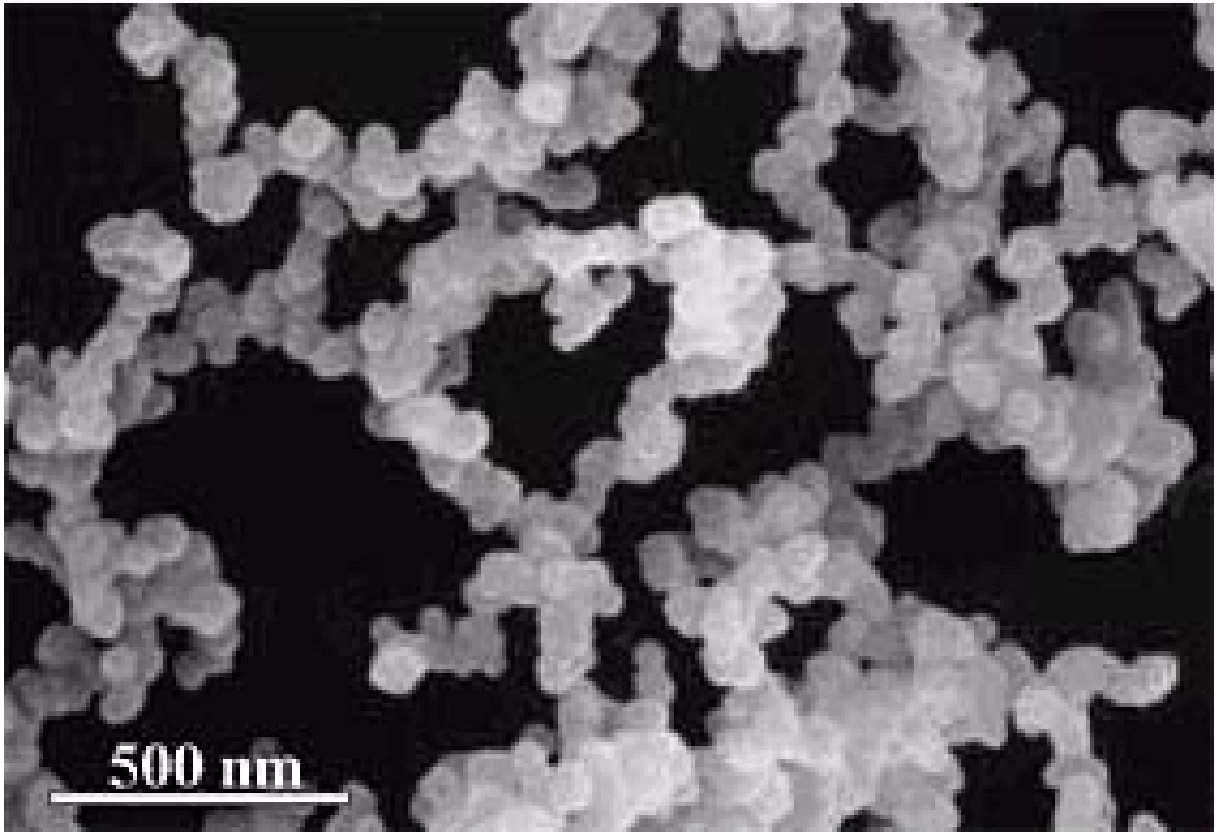
Cleaning up diesel exhaust



Examples of diesel exhaust particles

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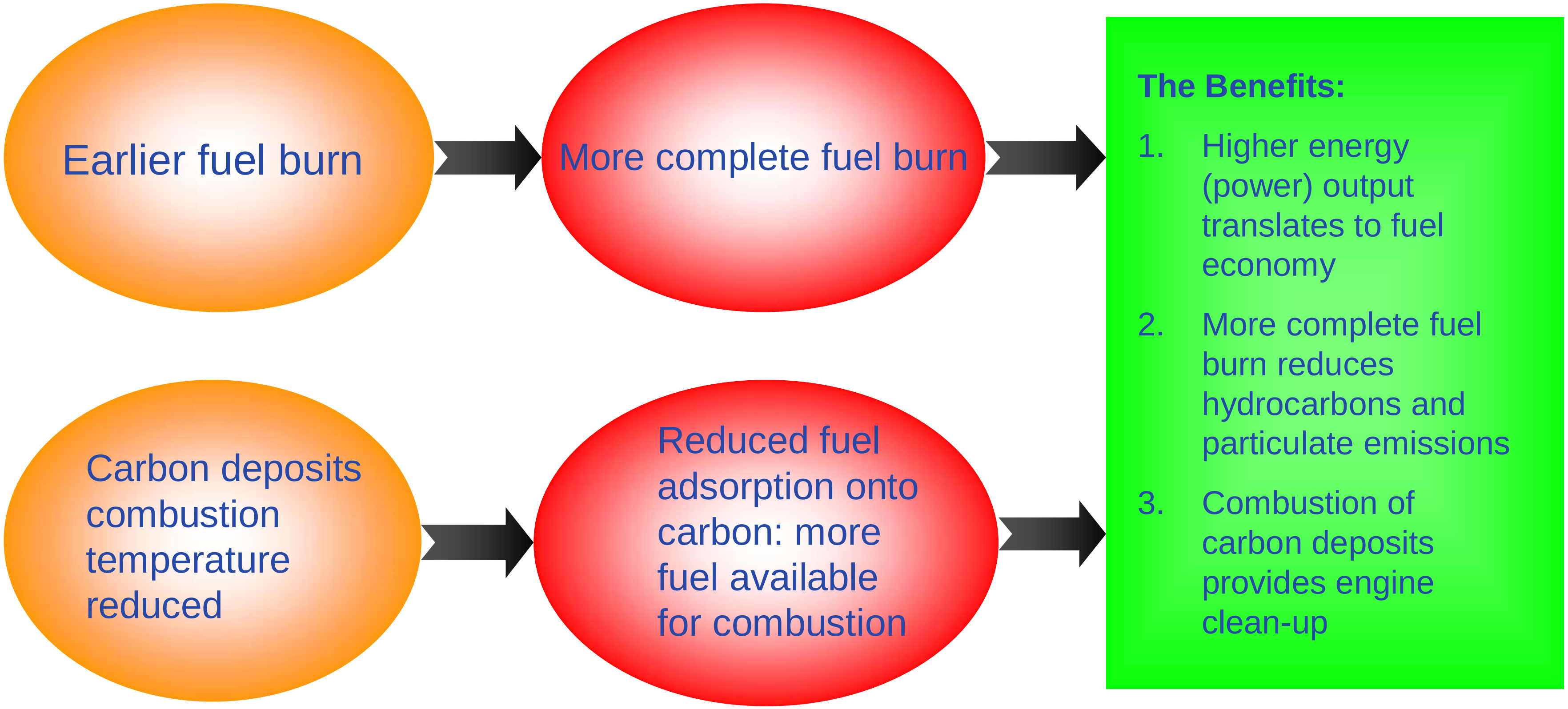
Envirox Technology reduces diesel particulates

- **Based on a Cerium Oxide dispersed in hydrocarbon solvent**
  - Fuel-borne additive
- **Nanoscale particle size**
  - Extremely high catalyst surface area
- **Direct addition to diesel fuel:**
  - Fuel-borne catalysis
- **Approx. 5ppm Cerium Oxide**
  - Low application rate – only 1 litre of Envirox to 4000 litres of fuel
  - No engine modifications required

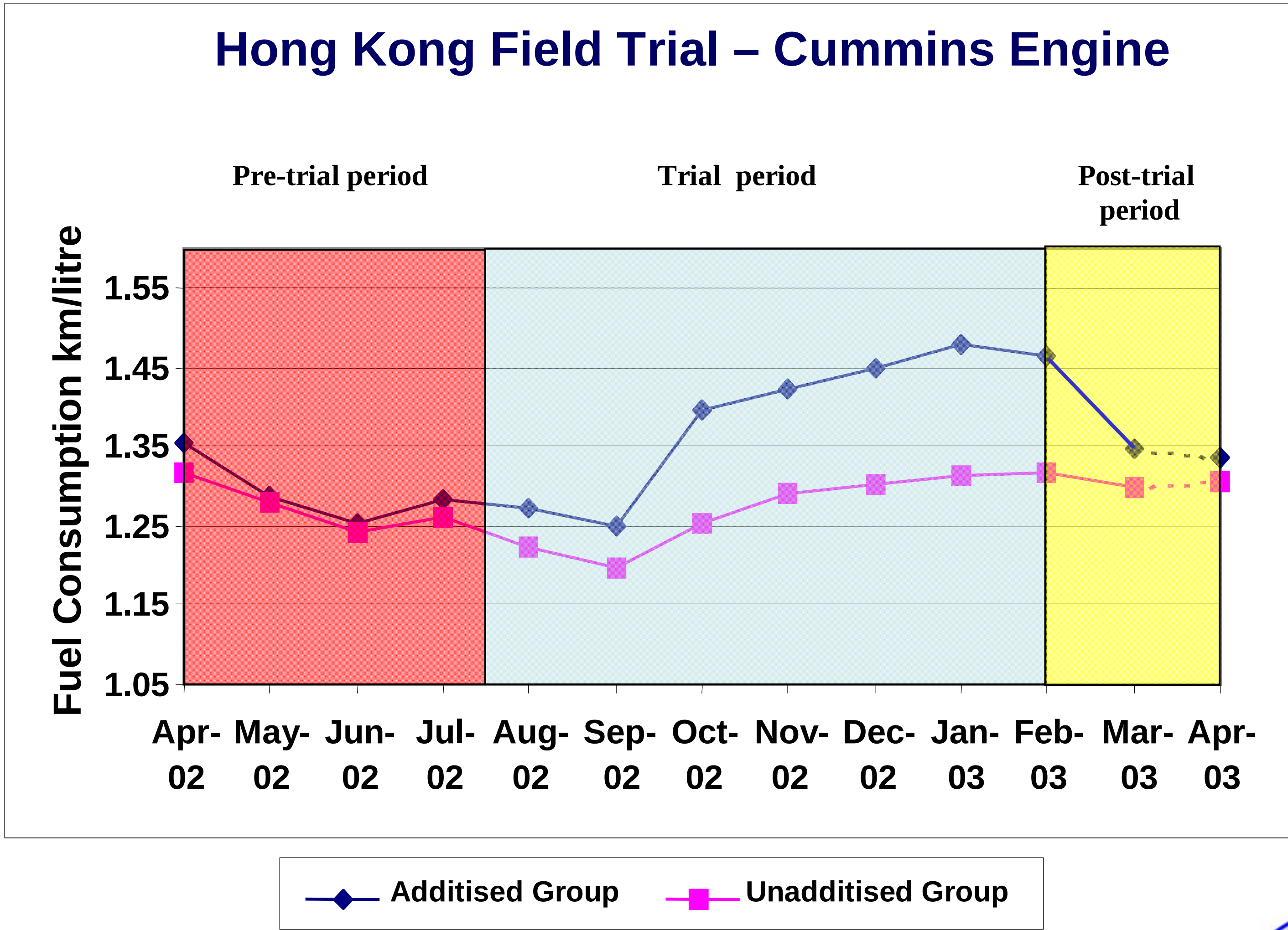
OXONICA

Envirox™: The Process



OXONICA

Envirox™ : Fuel Economy Performance



Has Envirox worked?

- Yes, it has proved its value in conventional diesel engines and turbodiesels.
- But, it is not effective in high sulfur content fuels
- It may yet find other applications as an "in situ" combustion catalyst

Envirox Future

- Need to expand into biodiesel and other heavy oils for transport
- Possible uses in oil-fired heating and coal-fired applications?
- Can cerium oxide be enhanced?
- Can it be adapted to cope with high sulfur content fuels?

This business is now owned and managed by a separate company: Energenics ltd and it is expanding

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Lessons from my Oxonica experience

- Early revenue generation is important for a start-up company
- For licensing, establish the needs of customers and companies and ensure your idea will “deliver”
- Remember the scale-up issue!
- Keep confidence in your technical capability; people as a resource are valuable
- Keep a pipeline of activity and try to keep ideas flowing, using new funding routes and new market needs
- **Be a “solution provider”**

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Oxford Biosensors

- Based on electrochemical sensing using enzymes coupled to microelectrodes
- Enzymes provide for high selectivity of important biomolecules
- Microelectrodes give a fast response time and simplified interpretation
- Proof-of-concept done with silicon-based structures
- Technology was based on printed ink-on-plastic
- Target was 3%CV and 5% accuracy with 4 analytes for cardiac risk
- Company folded in June 2009

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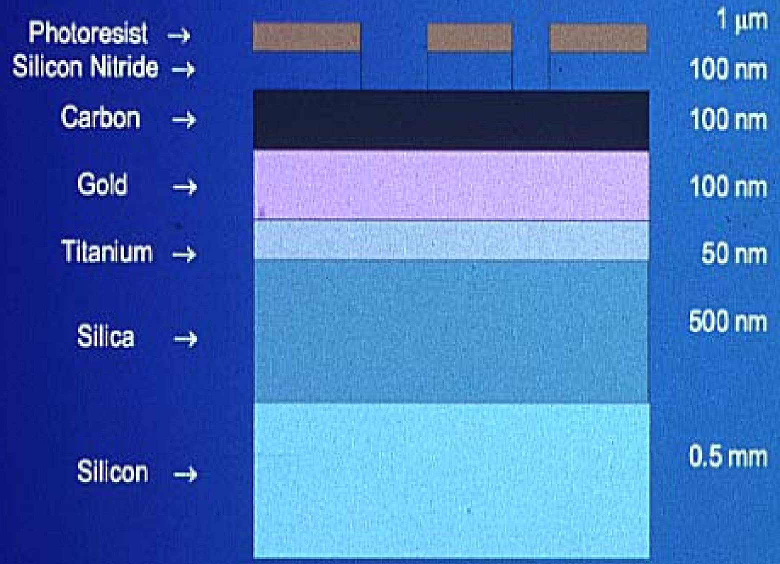
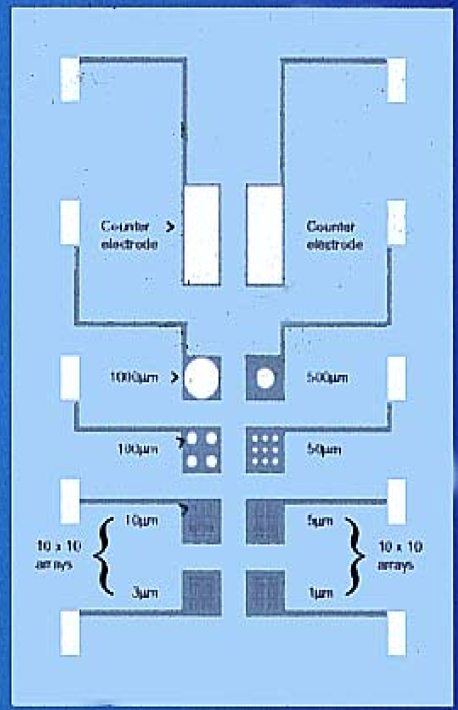
Silicon-based devices

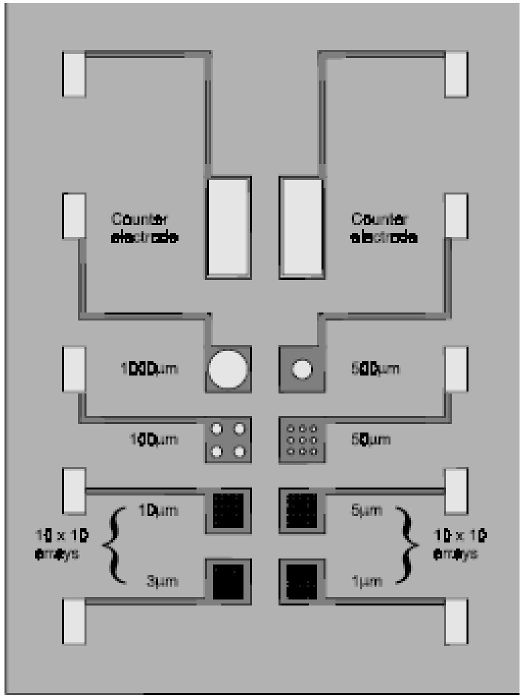


The composition of the sputtered carbon wafer



The design of a multi microelectrode array (MEA) chip

Microelectrode test structure



Microelectrode test structures made on silicon with silicon nitride isolation.

Ideal microelectrode behaviour shown for sizes less than 5 microns.

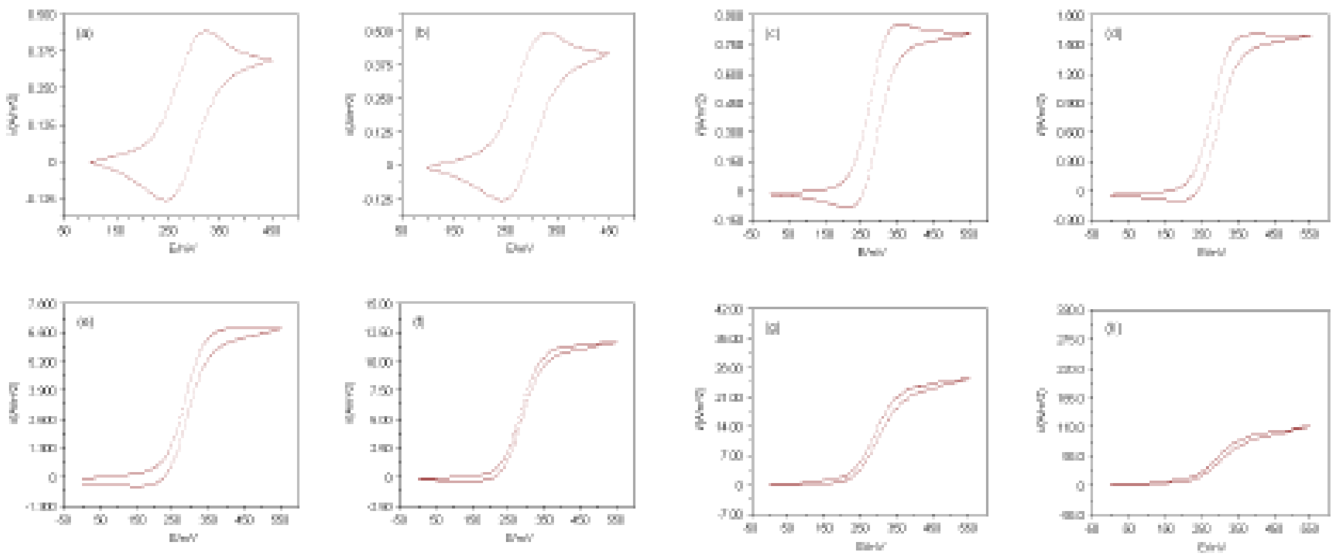


Figure 2. Cyclic voltammograms for oxidation of 400µM FMCA in 50mM phosphate buffer (pH 7.0) at Multi MEAs and microdisks with diameters of (a) 1000µm, (b) 500µm, (c) 100µm, (d) 50µm, (e) 10µm, (f) 5µm, (g) 3µm and (h) 1µm; potential scan rate, $20mVs^{-1}$.

Kudera et al. Sensors vol 1, 18-28 (2001)

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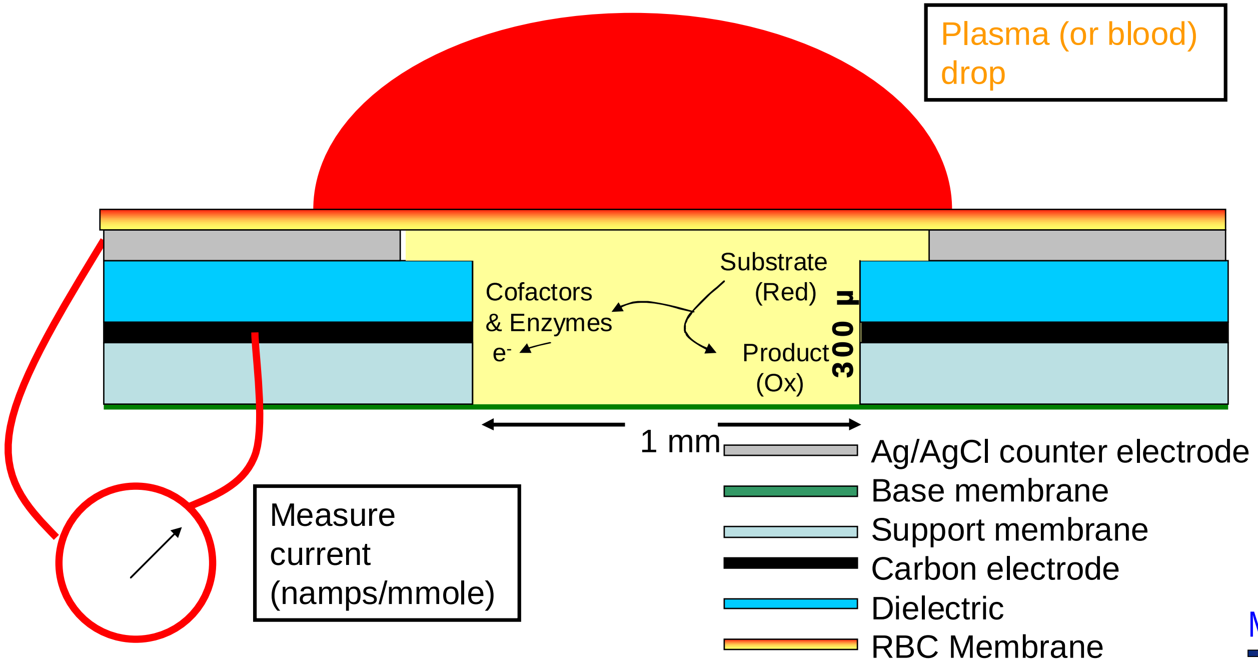
The lessons from these test structures

- Silicon-based devices would be too costly for a use-once disposable device
- Dimensions of smaller than 5 microns are not needed and this opens up many new ways to make the electrodes
- Conductive ink on plastic by screen printing is one possibility and this was the approach that was adopted

Core Technology



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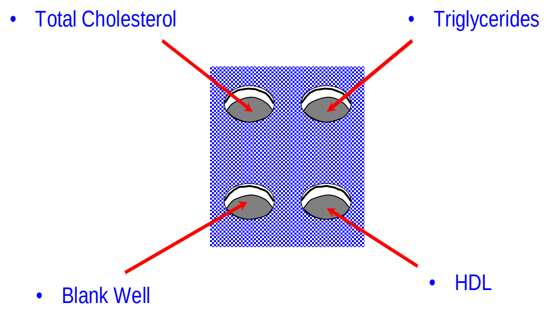
Multi-analyte strip



Oxford Biosensor's Multi-Analyte Platform

PROFESSIONAL (POINT OF CARE) DIAGNOSTIC SYSTEM - CLIA waived:

- Hospital
- Doctor's Office
- Clinics (diabetes, renal etc)
- ER

FUTURE MARKETS:

Consumer - 'Empowering the patient'

e.g. Management of Cardiac Risk

"More than 200 million people worldwide meet the criteria for treatment, but fewer than 25 million take statins." Dr.Eric J. Topol, "Intensive Statin Therapy -- A Sea Change in Cardiovascular Prevention", <u>New England Journal of Medicine</u>, April 8, 2004.

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Oxford Biosensor lessons

- The technology was too “disruptive” for any license deal
- The complexity increased as the improvements to performance to achieve a 3% CV were made
- Many questions of basic science and technology were identified, eg: polymer cutting, machining, bonding, surface wetting, drying, printing…
- The time to market is long because of FDA approval issues. Make sure that the investor(s) understand this!!

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Summary of overall experience

- It was worthwhile in spite of disappointing outcomes
- Be market-led, ie: a “Solution Provider”
- Have a balanced team
- Ensure good communication between CEO and investor and the team
- Best to assess the company structure as the company grows.....change CEO to suit?
- Keep the passion!

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