Oxford University
Begbroke
Science Park

Nanotechnology Spin-off: Oxonica

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Oxford's spin-off culture.

- The change in IP management in the university helped with the formation of Oxonica
- Oxonica's original vision and how it changed
- The fuel combustion additive
- The sunscreen
- The lessons

Begbroke Science Park

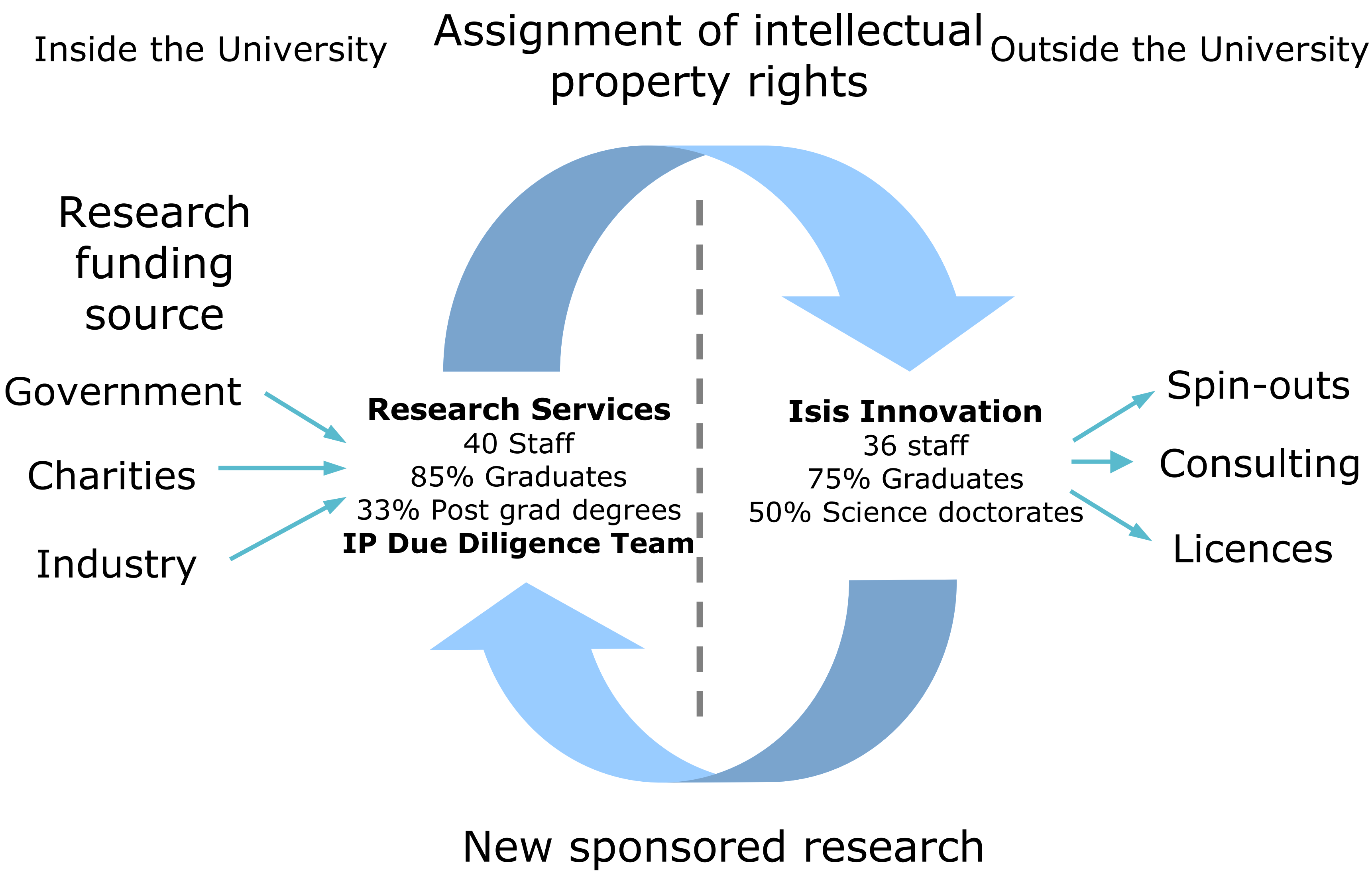
6 miles north of Oxford

city centre

- Purchased 1998 with 7500m^2 lab/office space.
- Initially mainly Materials Dept. and spin-off activities
- Being expanded to 13,000 m^2
- Investment ~£35M (2005) from University, JIF, SRIF, Industry sources
- Prof Peter Dobson Academic Director (2002)

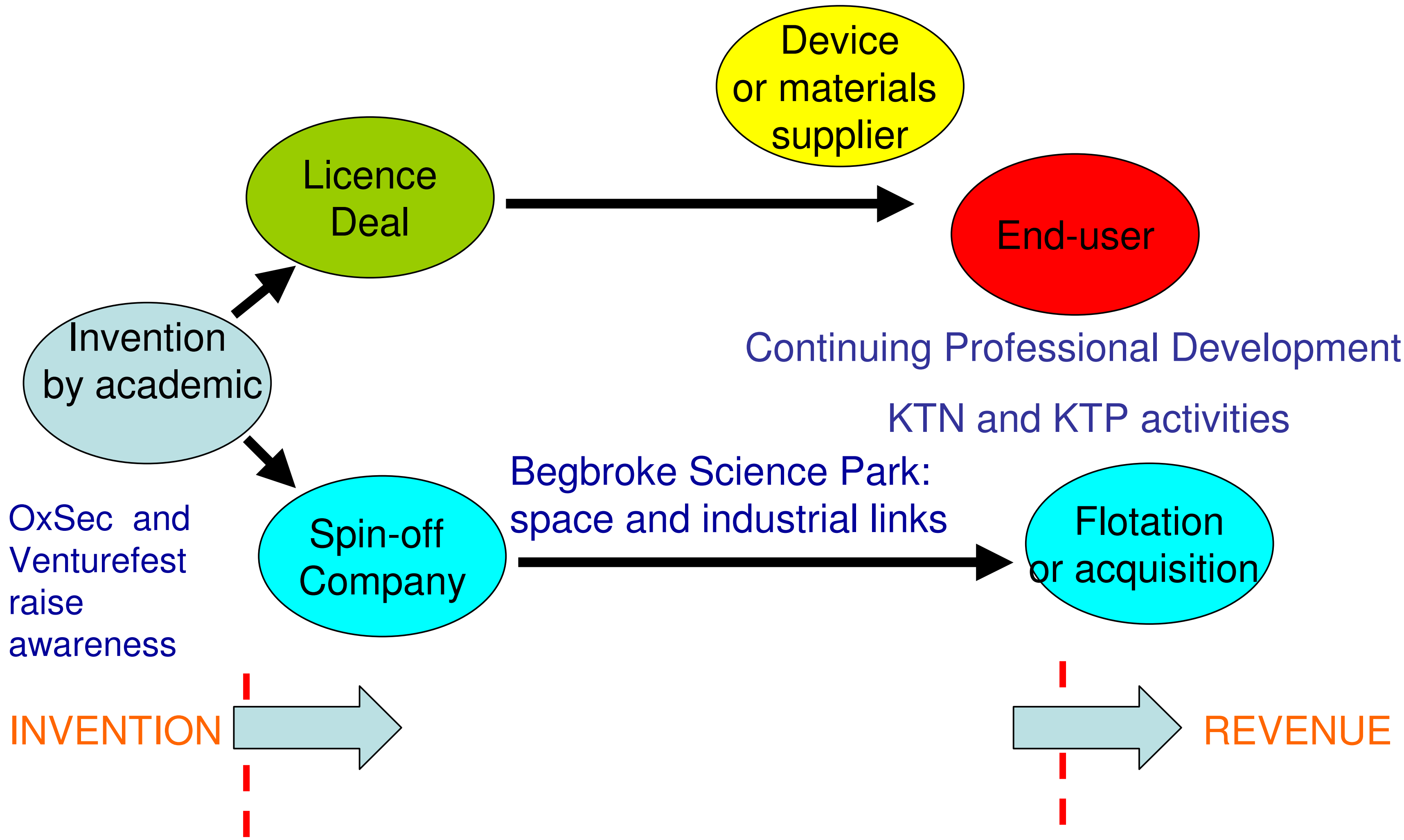
Initial Focus on Advanced Materials and Nanotechnology

Transfer of Intellectual Property in Oxford University



Innovation at Oxford

"Innovation is what happens between invention and revenue generation"



How Oxonica started: the original vision

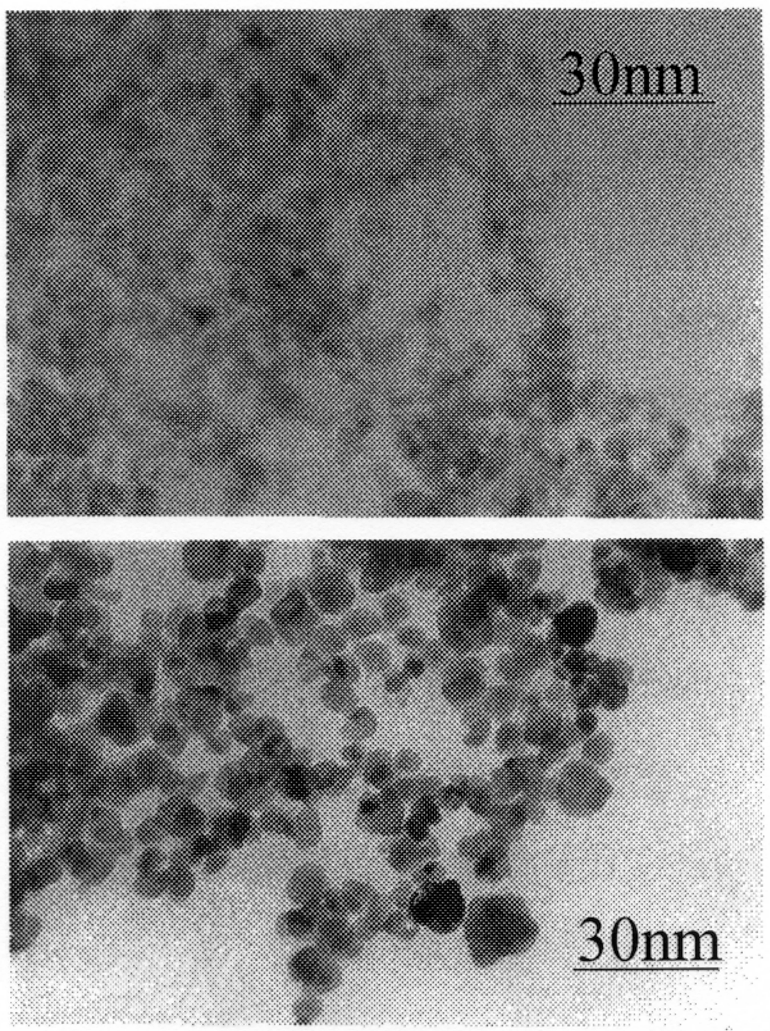
- Research on manufacture of luminescent nanoparticles in the late 1990s led to belief that we could offer low voltage nanoparticle phosphor materials to the field emission display industry.
- This idea was flawed, because industry wanted a complete solution and not a small part of the solution.

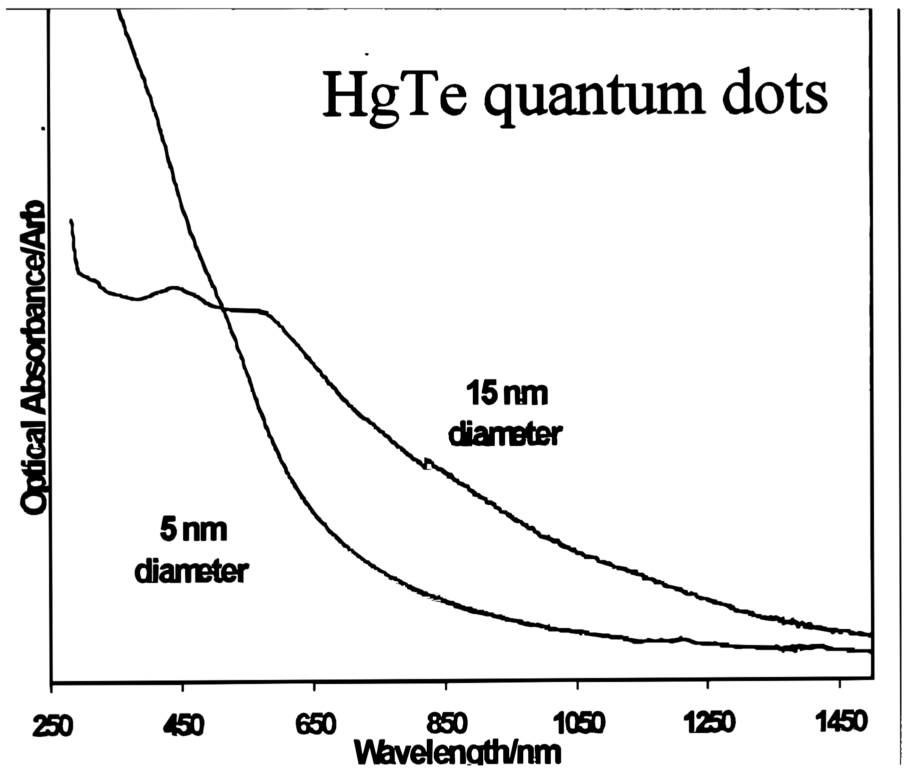
  Note a field emission display needs electron emitters, the phosphors, a screen, fully integrated into a product.
- Attention was then given to nanoparticle sunscreens and diesel fuel catalyst additives. The former had strong internal University IP, the latter did not.

Oxonica plc

- University of Oxford spin-out formed 1999 after 7 years background research
- Focus on Energy, Environment and Healthcare
- “Solution Provider” ethos
- £2.3M from Angels and DTI awards
- £8.2M from Institutional Funding
- 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
- Deal with a Turkish oil company broke down in 2007, reduced valuation.
- ~40 Employees, strong commercial and industrial experience.
- Current shares trade at ~25p

Early Oxonica products



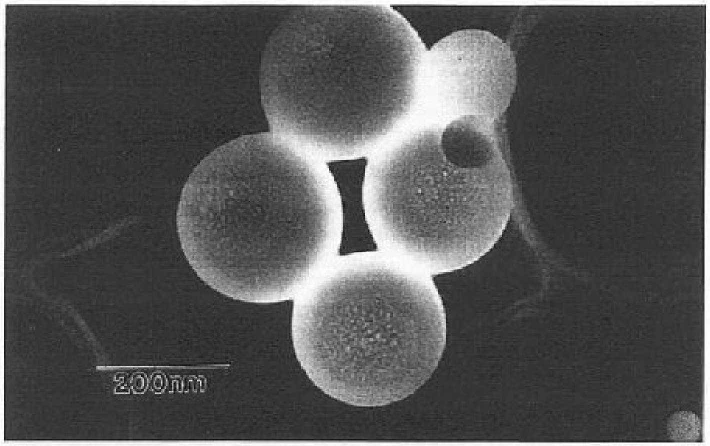


Grown by colloidal solution growth

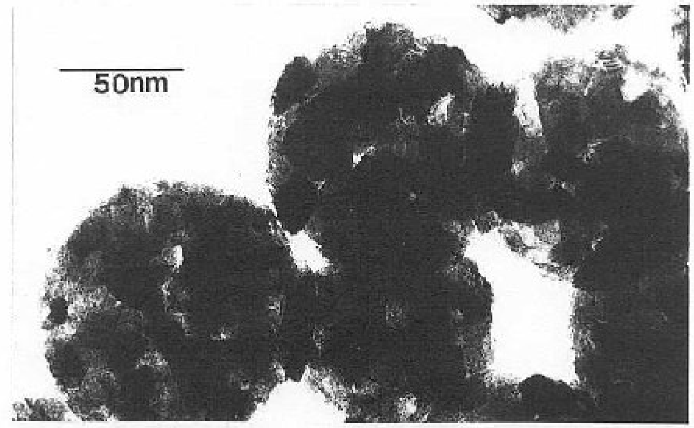
Size-tuning of optical properties

Quantum dots are still looking for a high value application!

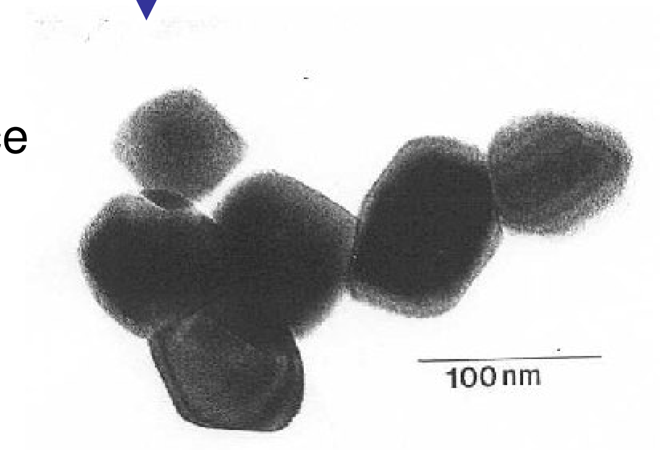
Nanophosphor particles Y_2O_3:Eu



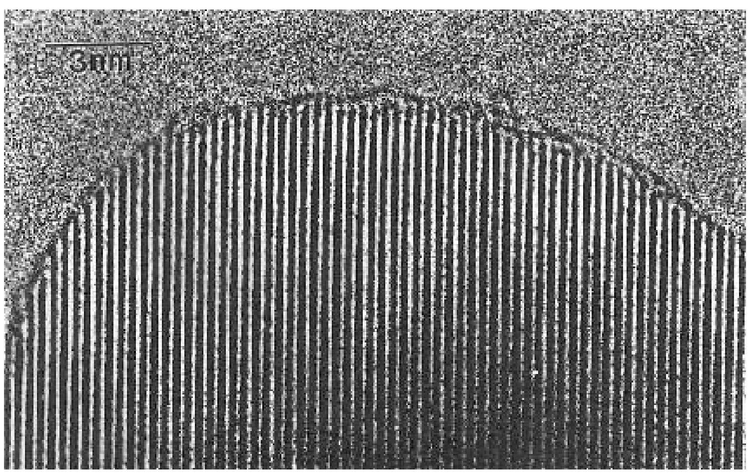
Mild anneal



High temperature heating



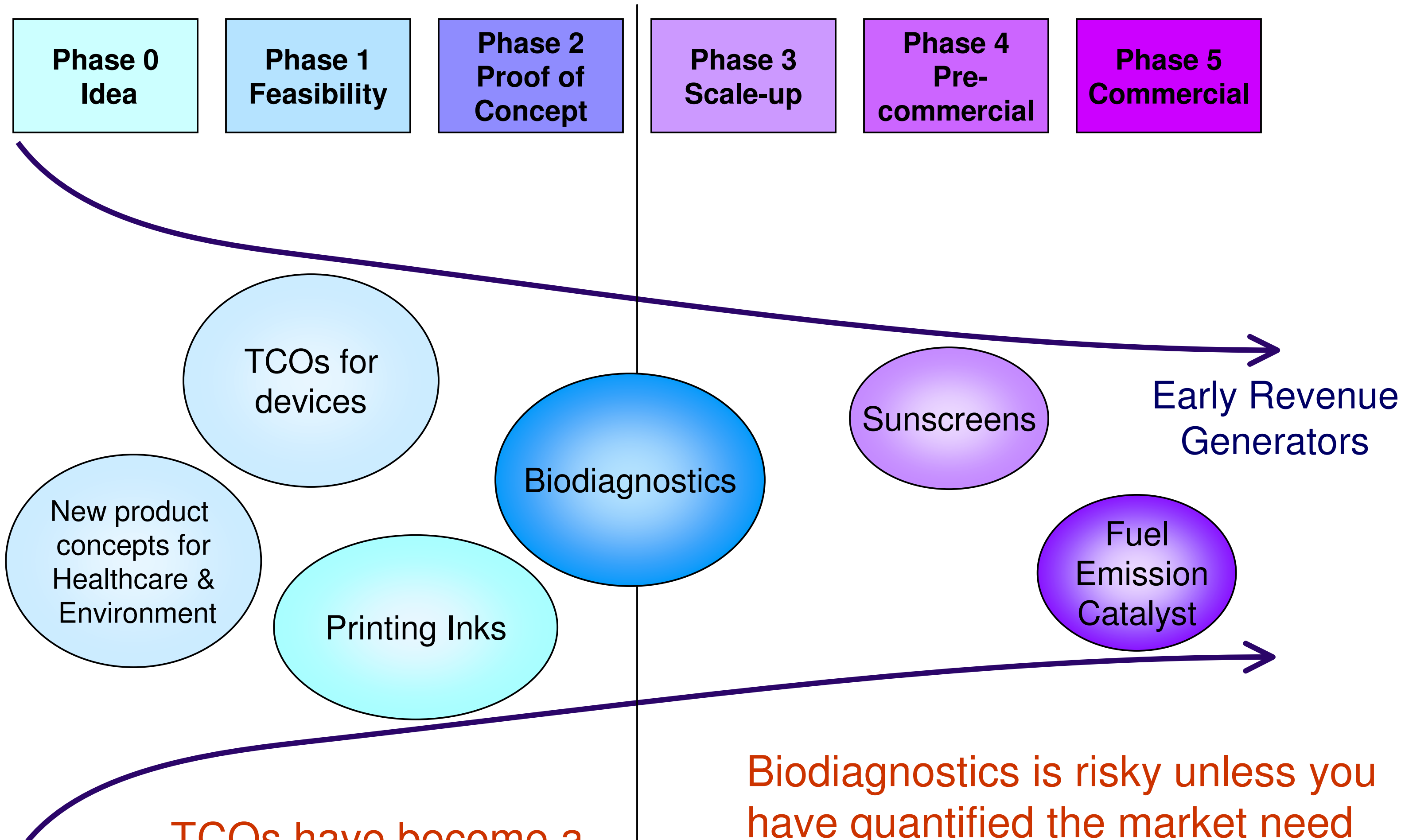
Detail of surface



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!)

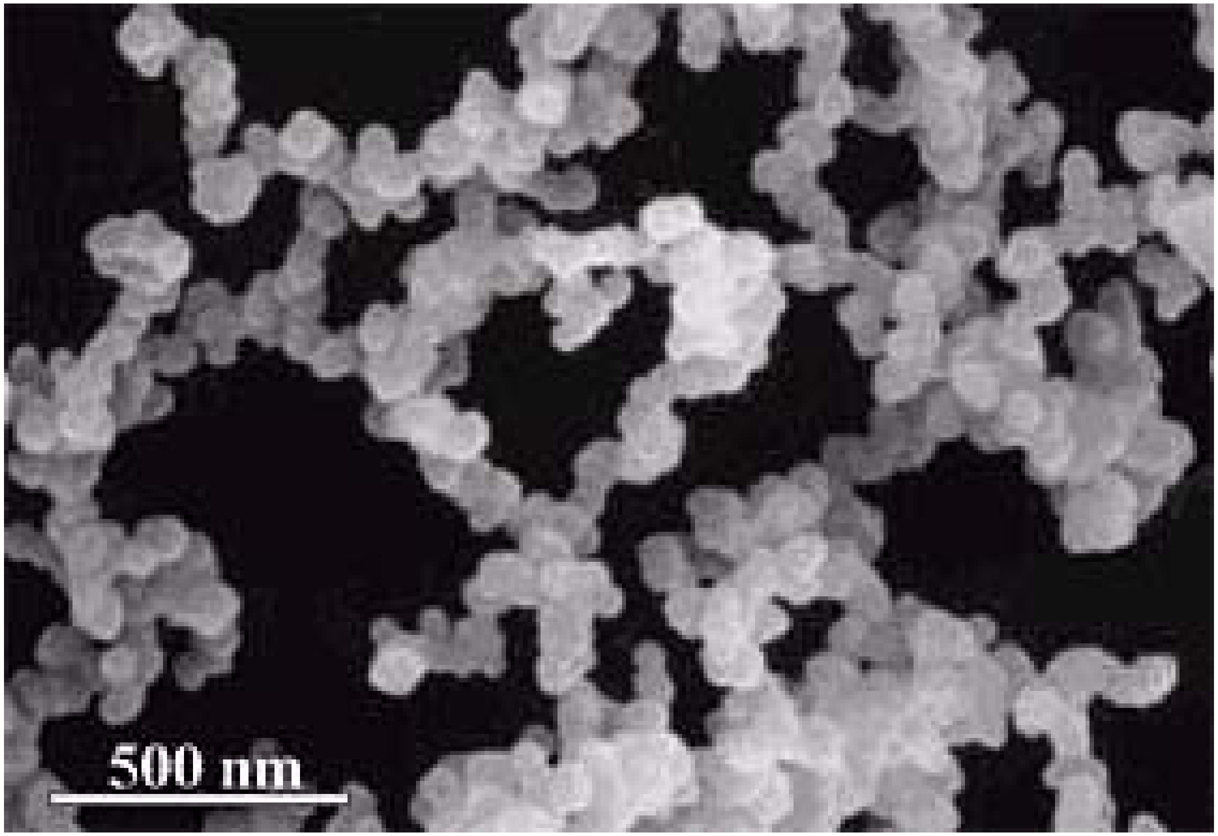
Oxonica product pipeline



TCOs have become a very important market need

Biodiagnostics is risky unless you have quantified the market need and supply chain

Cleaning up diesel exhaust



Examples of diesel exhaust particles

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
- Cerium Oxide has a long history in smoke reduction
  - used in paraffin light mantles
- Approx. 5ppm Cerium Oxide
  - Low application rate – only 1 litre of Envirox to 4000 litres of fuel
  - No engine modifications required

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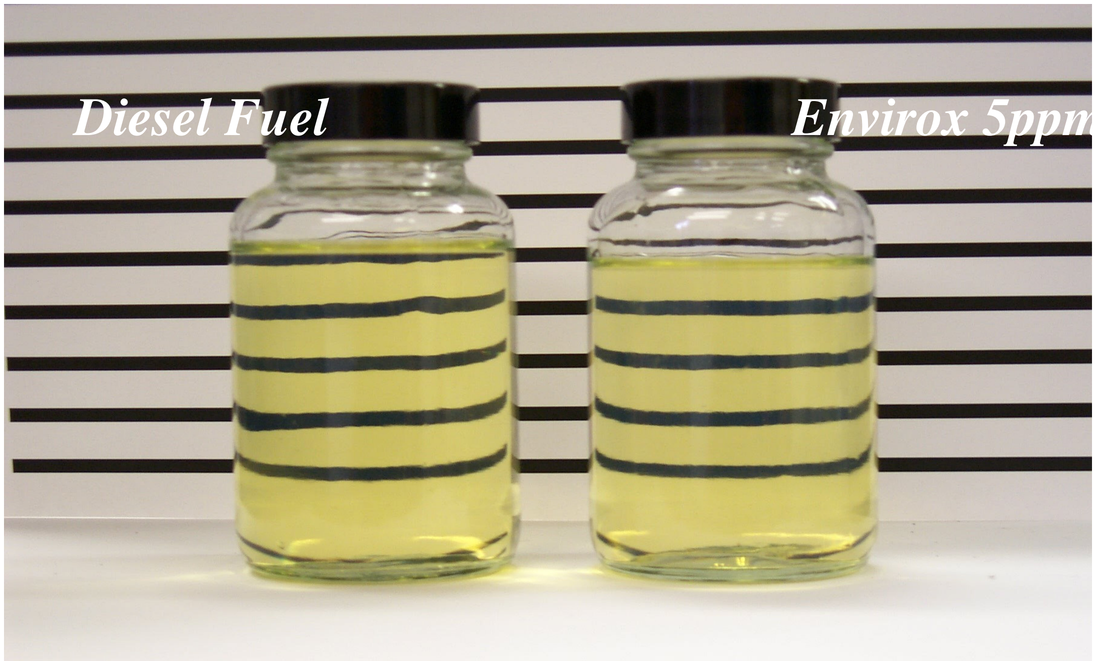
Envirox additive is a stable suspension



Diesel fuel with Envirox 5ppm 10nm particles added. Key point is that fuel must be stable and remain haze free.

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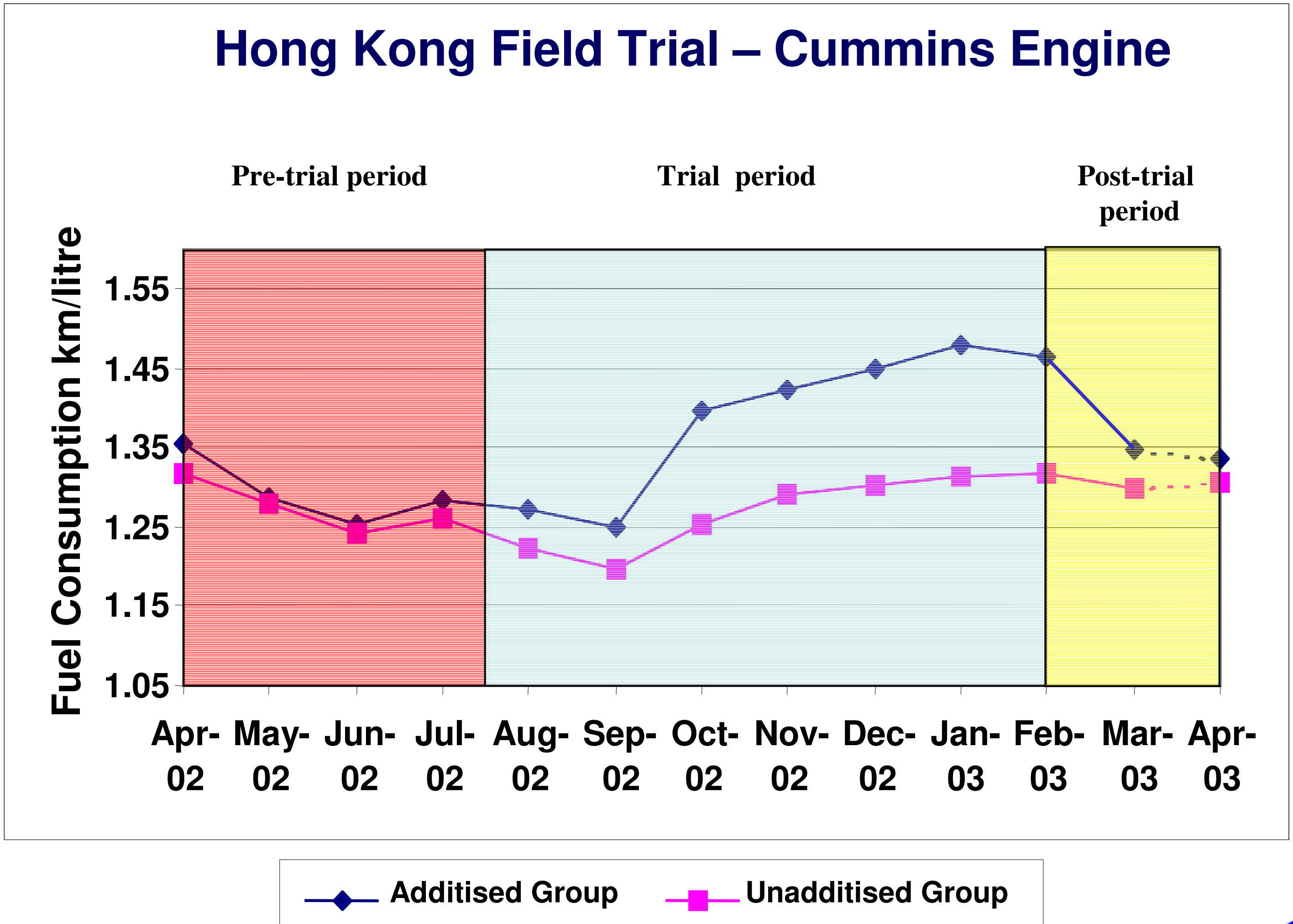
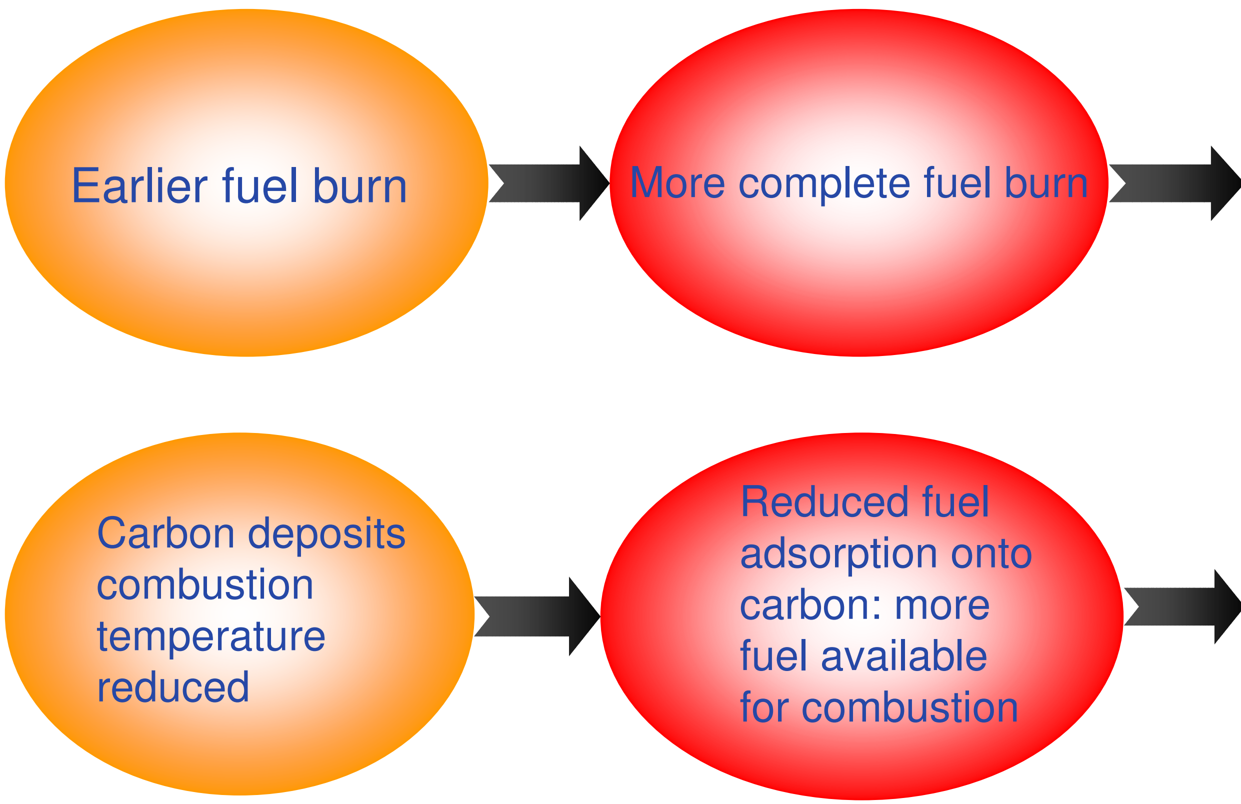
Envirox™ : Fuel Economy Performance



Envirox™: The Process



The Benefits:

1. Higher energy (power) output translates to fuel economy
2. More complete fuel burn reduces hydrocarbons and particulate emissions
3. Combustion of carbon deposits provides engine clean-up

Envirox™: Emissions Reduction

- Tests carried out at a range of independent laboratories

  Immediate reduction of up to 14% in particle and hydrocarbon emissions – may further improve over
  time

- No increase in ultra fine particles emitted

- Potential to enhance Diesel Particulate Filters performance – lower emissions and reduced regeneration temperature

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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?

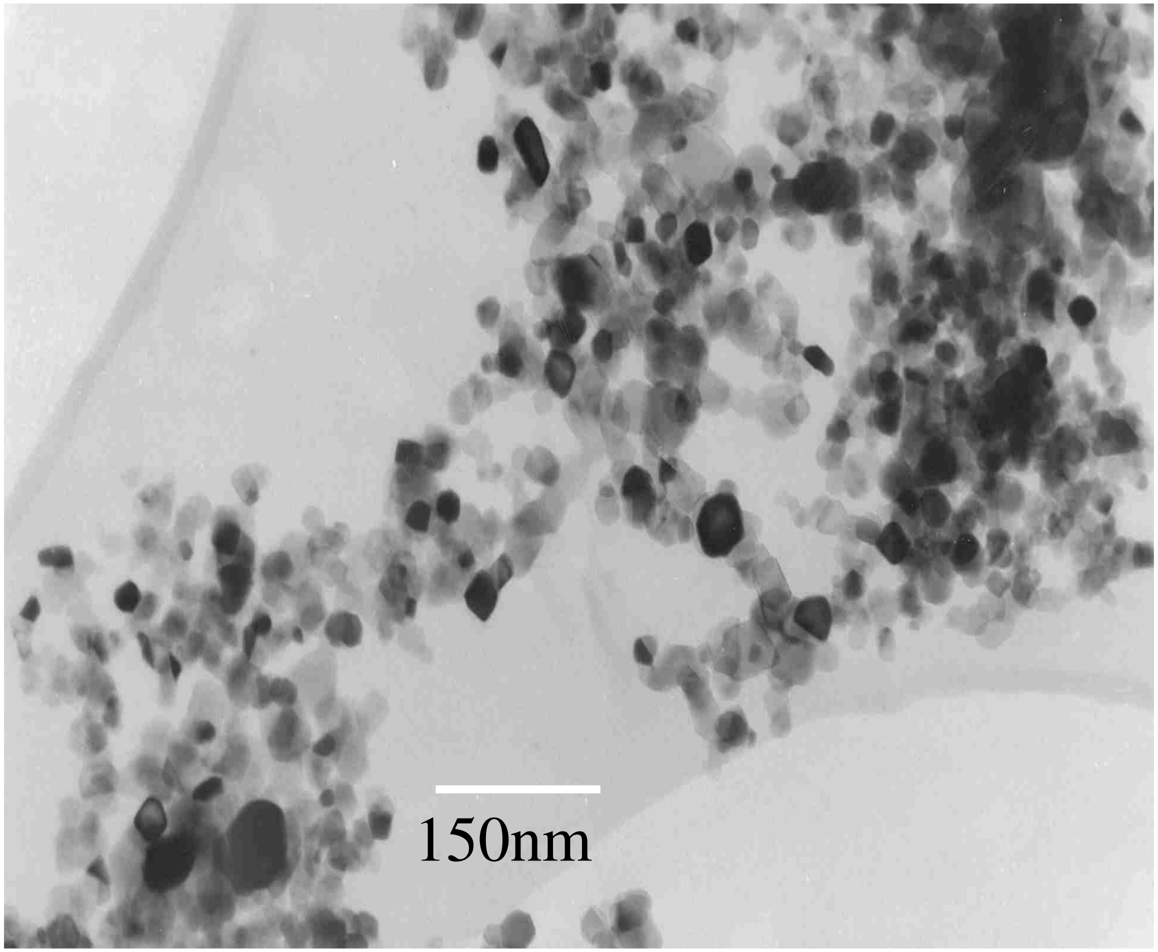
Optisol TM®

- The “driver” for this product was the evidence that most “transparent” sunscreens in the 1990s posed a health hazard.
- Nanoparticles of titania are used so that they appear transparent to visible light on the skin, but block UV
- The titania is doped in a special way so that it does not behave as a photocatalyst (that would cause skin damage)
- The new titania particles prevent the formation of “free radicals” and hence the formulation lasts much longer in sunlight and protects the skin.

Other thoughts to improve sunscreens (1999-2000)

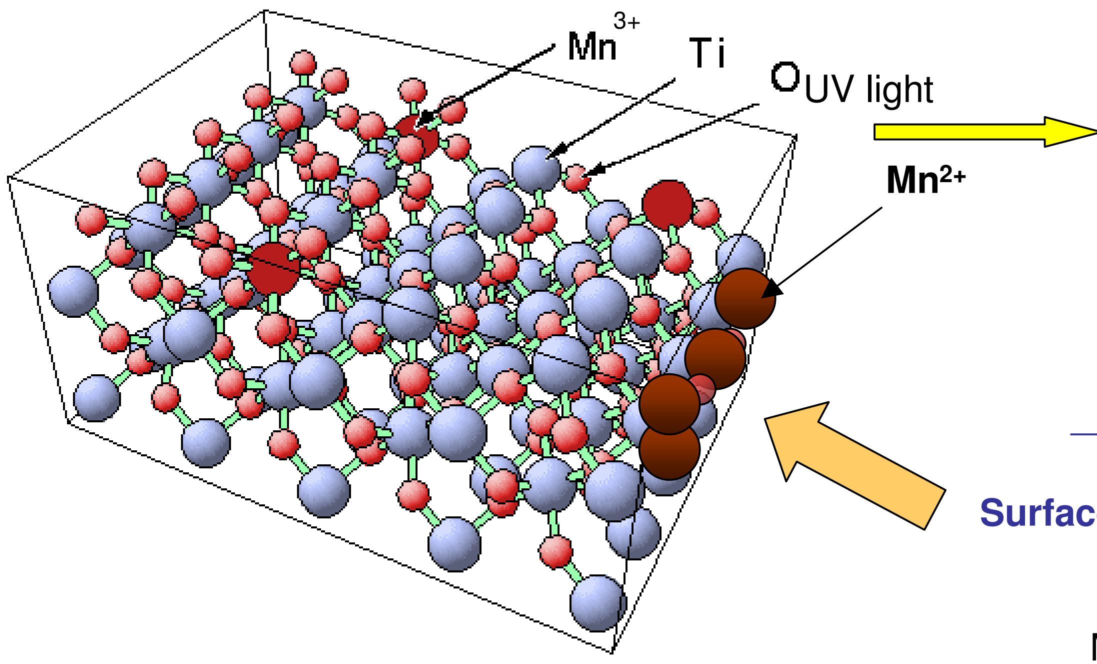
- Could we convert uv light to visible? ZnO could be used as a “convertor”
- Was the idea of using TiO_2 doped to make it p-type a general solution?
- Could this be used to make other uv protective layers in the paint and plastics industries?

Titania sunscreen nanoparticles



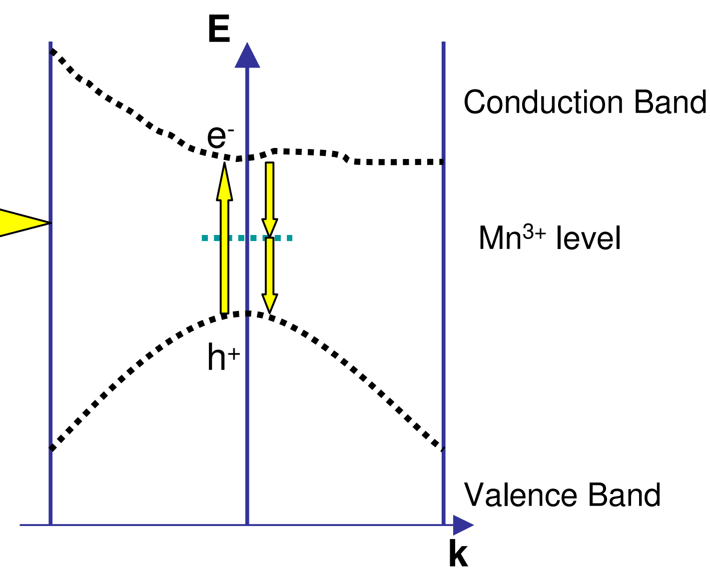
These are Mn-doped rutile particles, small enough not to scatter light, but still absorb the harmful UV rays.

OPTISOL: Mode of action



Rutile $P4_2/mnm$ Titanium Oxide lattice

Schematic band structure



Surface Mn^{2+} free radical scavenging

$$Mn^{2+} \Leftrightarrow Mn^{3+} + e^-$$

$$Mn^{2+} + OH^\bullet \Rightarrow Mn^{3+} + OH^-$$

$$Mn^{3+} + {}^\bullet O_2 \Rightarrow Mn^{2+} + O_2$$

Optisol TM based on nanoparticles of titania

Photostable UV absorption with enhanced UVA protection for skincare & materials applications

- Safer sunscreens and cosmetics
- Anti-ageing properties
- Skin-lightening applications
- Formulation enhancement
- Extended in-use product lifetime

OXONICA

New doped titania products

- Enhanced performance for many other cosmetic foundation formulations
- Possible use as a uv protective agent in coatings and polymers: “Solacor”®

Oxonica, new lessons!

- Make use of core technology to provide solutions
- Provide solutions where there is a market need
- Early revenue generation is essential
- Balance the team, remember sales/marketing, but keep a strong technical base
- Collaborate with many universities
- Form strategic alliances to speed time-to-market and reduce costs

Overall Conclusions
How can we speed up Innovation?

- Never "push technology" but look for market-led solution provision
- Develop a balanced team, especially help with sales/marketing, but do not neglect the technical team
- Try to shorten the time from invention to revenue generation by partnerships
- Treat investors' money as your own and respect their risk and confidence