Nanotechnology and PI

A real prospect for funding - honest!

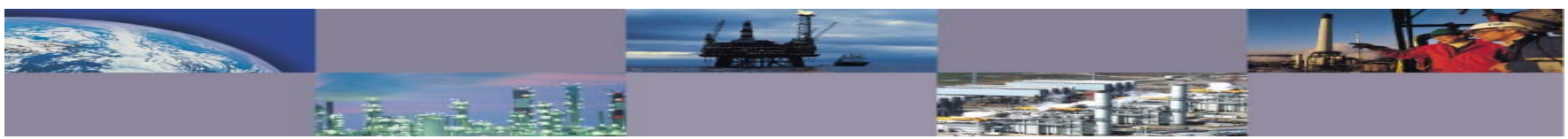
A review for DTI

Jeff Howarth, NEL

Some quotes from I.o.N / DTI

"In Germany micro-engineering and micro-systems technology are seen as providing enabling technologies for Nanotechnology.

"Because Germany has created a micro-technology infrastructure it is well positioned to exploit Nanotechnology"

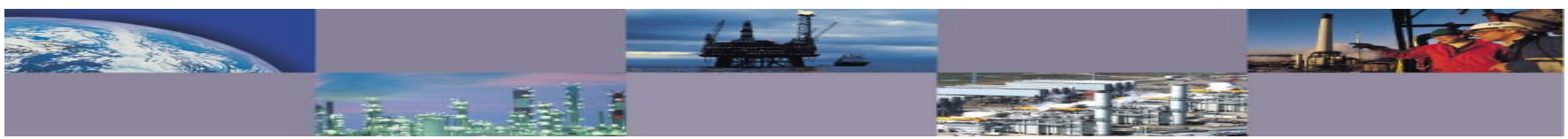


Some quotes from I.o.N / DTI (cont.)

The consequences of the UK not having a microsystems infrastructure is that we have a harder race to run if we intend to capitalise on the early applications of nanotechnology

Ref: International Technology Service Missions on nanotechnology to Germany and the USA.

March 2001. Institute of Nanotechnology

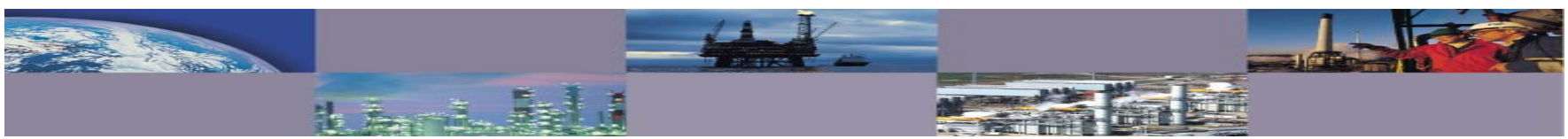


NEL review for DTI - project brief

Can P.I. be a type of enabling microtechnology for the increased application nanotechnology in the process industry?

On the other hand -

Can the incorporation of nanoscience and technology into P.I. microsystems help P.I. deliver what it has promised ?



Potential budget

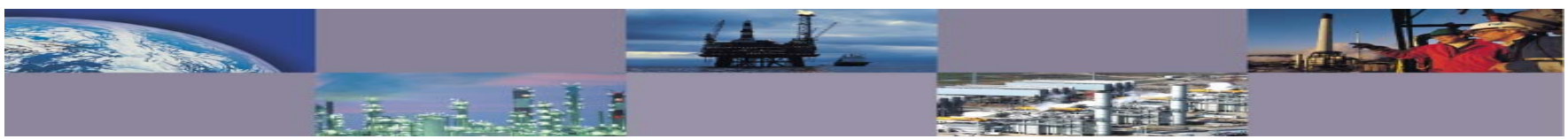
£600m over 10 years!!(Taylor report's recc'n)

Phase 1 Infrastructure - £60m R&D - £30m

However - this covers very wide field -

photonics, electronics, biochips, materials, genetics, Microsystems (MEMS, **P.I.?)**

?? 1% of budget, 50% funding - £12m PI funding ??



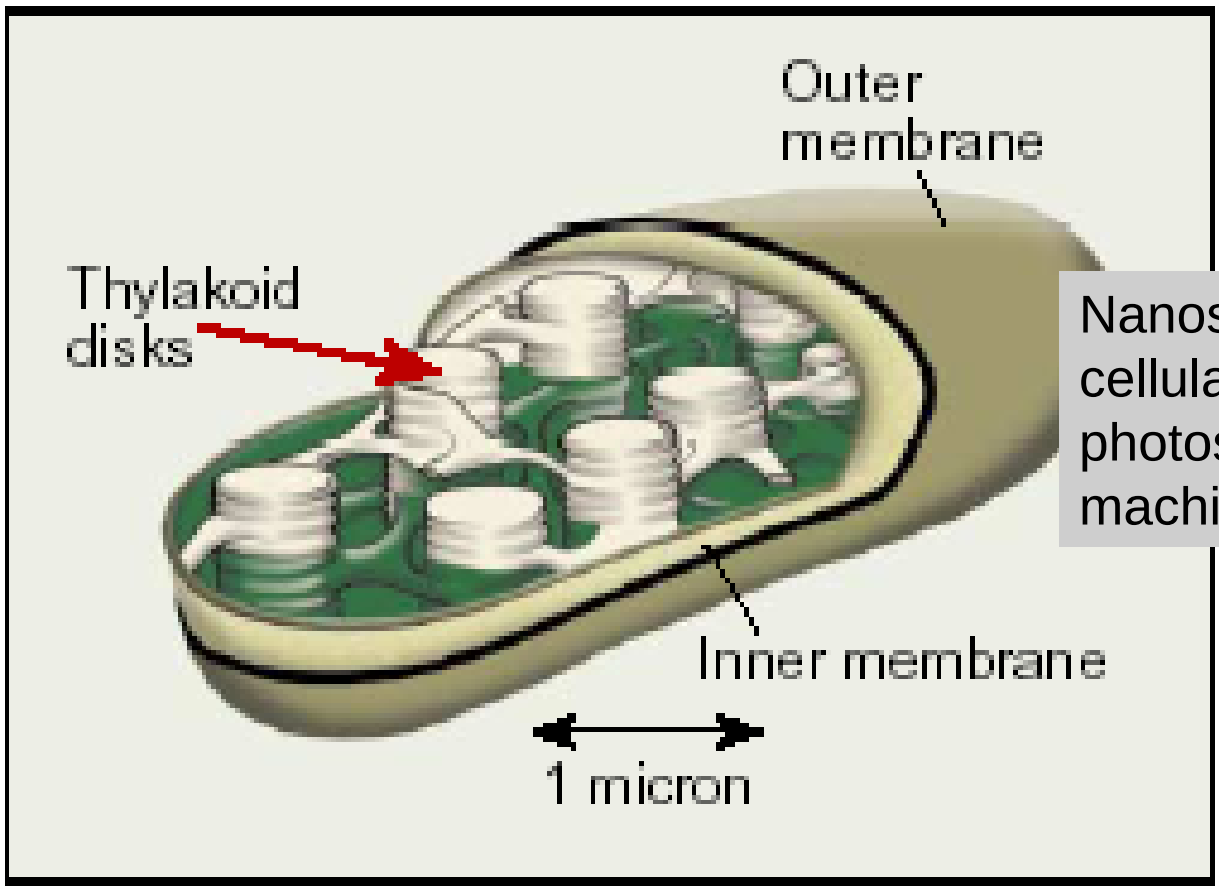
Work so far

David Reay Associates
Newcastle University
Protensive
Heatric
DTI Biotechnology
Nalco
PALL, Kvaerner Process
I.o.N Frankfurt
PIN

Work planned

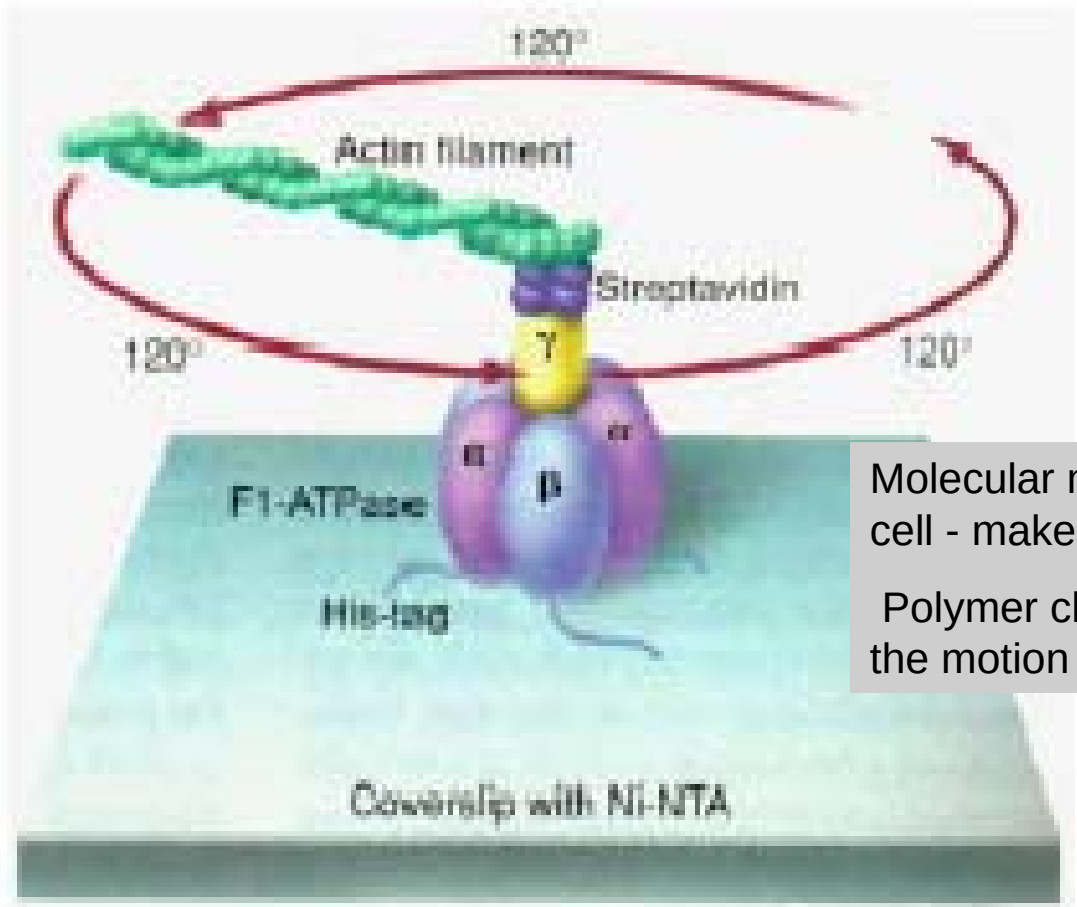
BHRg
UCL/Imperial/London Centre
FES
Heriot Watt - several
NPL / T2PAC
Synetix
Wilton Tech Centre
Dow Corning, BP
EPSRC/BBRC
INEX

Views from nature



Nanostructured cellular photosynthesis machines

Views from nature



Molecular motors inside every cell - make AT.

Polymer chain is to visualise the motion of the core.

Views from nature

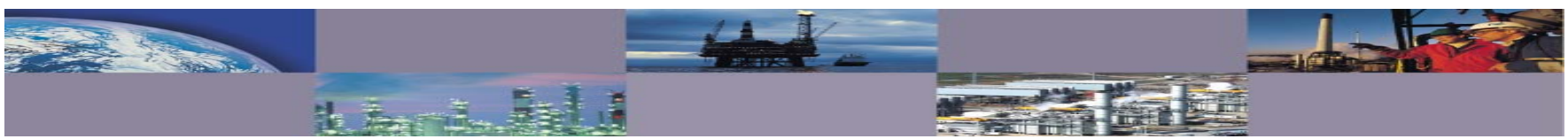
Nature's nanocomposite - Mother of pearl

Crystals embedded in organic polymer.

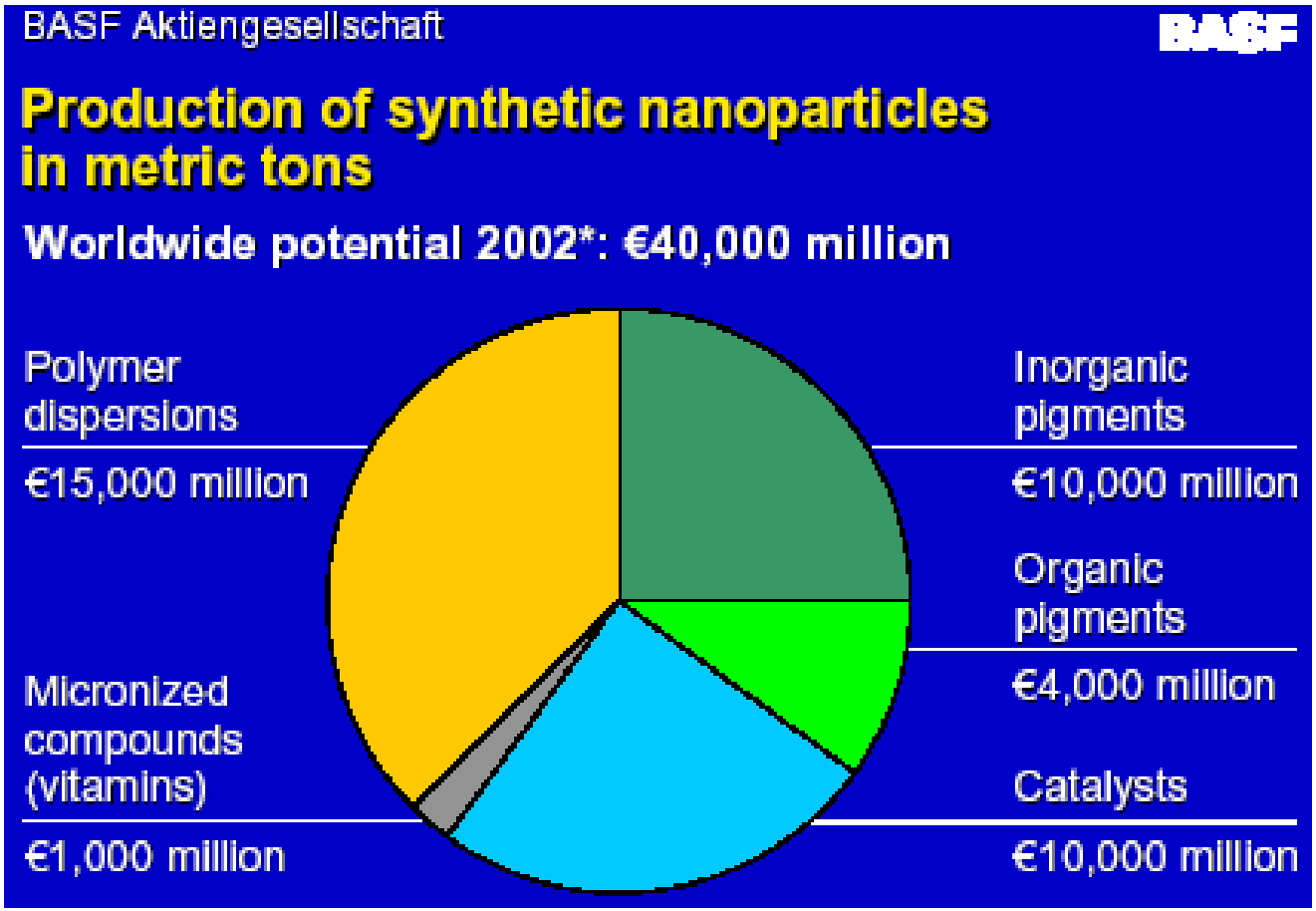
Very hard, self healing of cracks

Compare to chalk

Both are made of $CaC0_3$!!



A view from BASF



Taken form the BASF website

Nanotechnology now

Photographic film

Zeolite catalysts

Tioxide sunblock

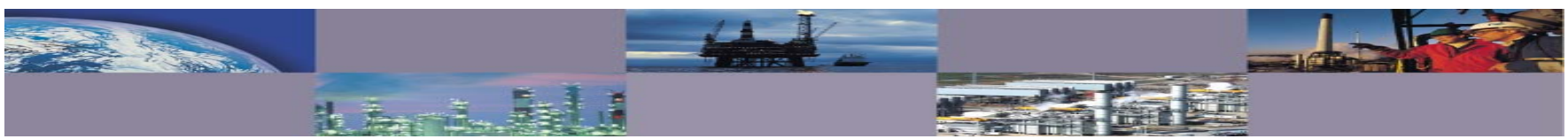
Nanoporous membrane separations

Clay particles for hard wearing tyres

Printing inks

GMR magnetic disk heads

etc.



Nanotechnology -The fundamentals

New axis in the Periodic table - N, (cluster size) - e.g.

Single Atom - Ionisation Potential

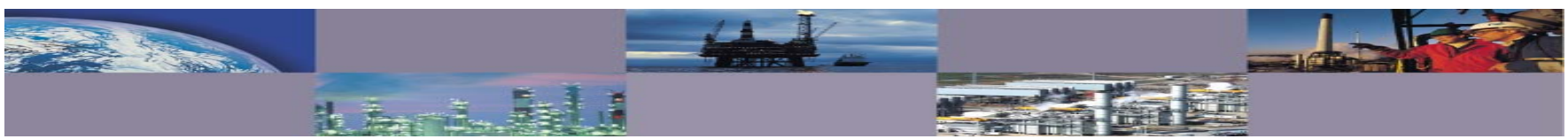
Variable cluster size

Bulk - Work function

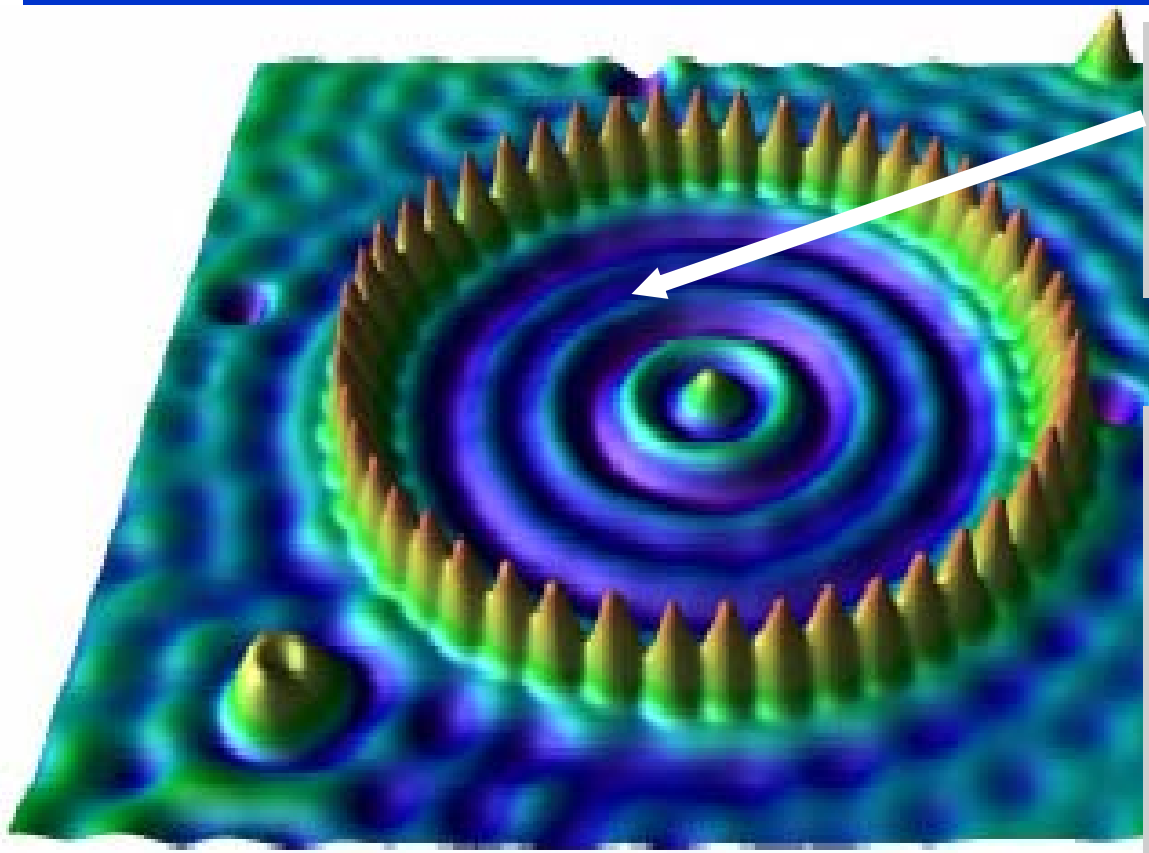
<u>FOR "N" metal atoms</u>
Ionisation potential and electron affinity varies dramatically, non-monotonically.

<u>Change properties without changing composition</u>

- **Hardness, colour, UV absorbance, melting, magnetic behaviour**
- **Catalytic behaviour, H_2 absorption capacity, etc.**
- **Mainly result of huge surface area and quantum effects**
- **Need control at all length scales and stages:**
  - **atoms/molecules-clusters-assemblies-bulk**



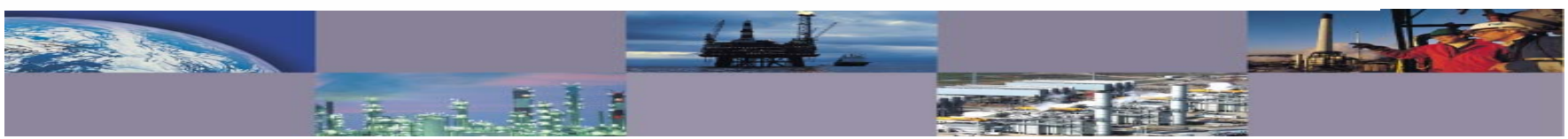
View from the frontier - The quantum corral



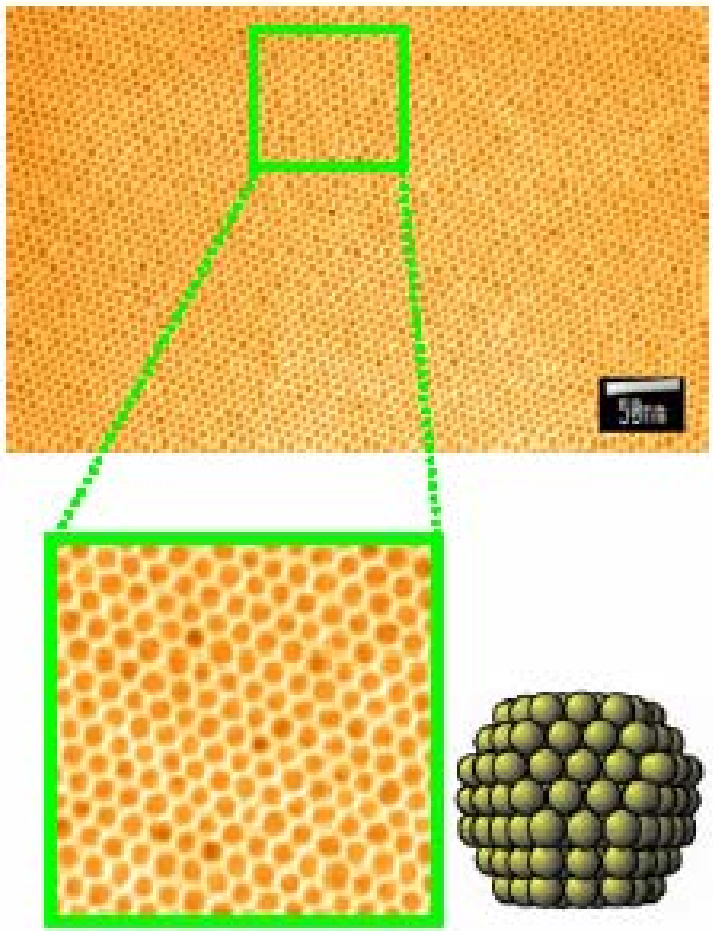
- **Electron gas - visualisation of the quantum states of trapped electrons**

- **Bottom up assembly**
- **Quantum effects**
- **Atom by atom control**
- **Simultaneous Imaging and manipulation techniques**

Figure 1.2. STM image of a "quantum corral" (courtesy IBM Research Division).



Ordered Monolayer of Gold nanocrystals



Hexagonal array of gold crystals on a thin carbon film

Separated electrically and mechanically by polymer

Spontaneous formation in water

Self assembled Germanium quantum dot

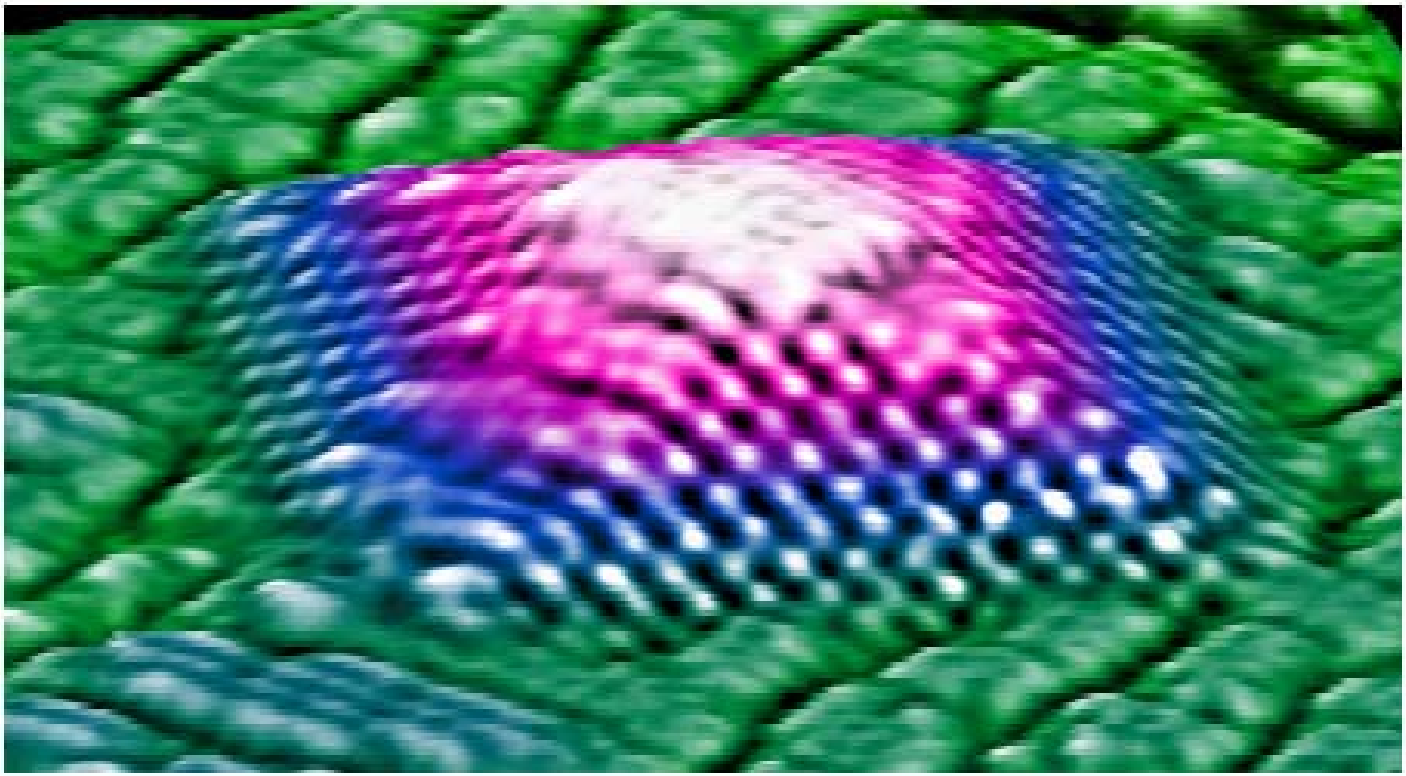
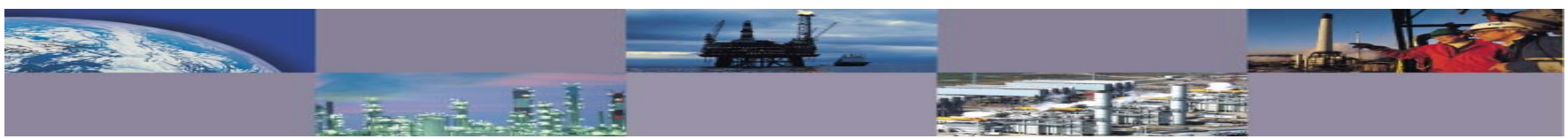


Figure 1.1. STM image of quantum dot formed by self-assembling (Ge "pyramid") (courtesy Hewlett-Packard; image acquired by G. Medeiros-Ribeiro, Hewlett-Packard Labs).



Nano-materials - some applications

Nanoparticles and nanolayers

Composites

Membranes

Energy storage and generation

- H_2 storage, Gratzl cells, photovoltaics, batteries.

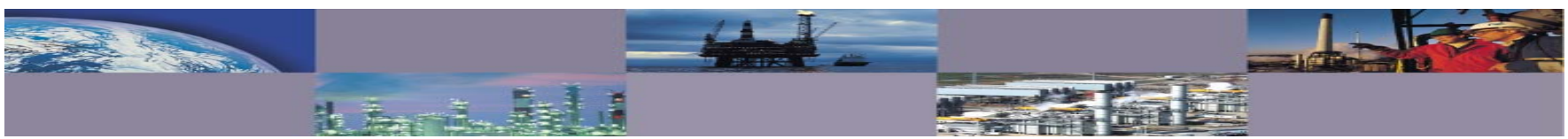
Electronic devices

- next generation chips
- quantum computing / SET

Drug delivery

Catalysis

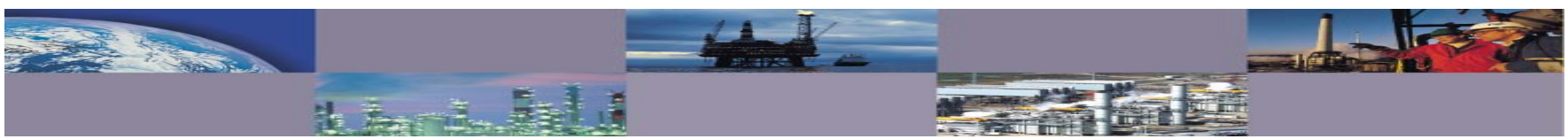
Photonics - lasers, fibre optics, etc



Developing a rationale for PI - ideas

For example - Nano- particle manufacture

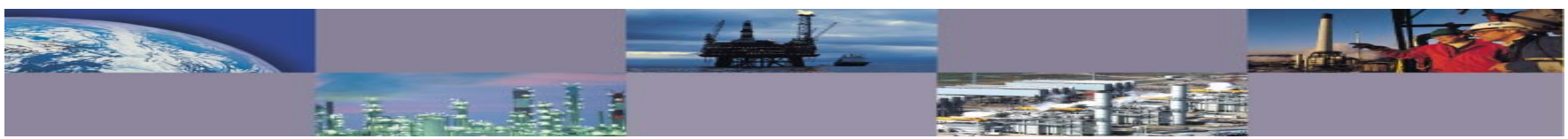
- Desktop production of small quantities for development
- Easy scale up to larger tonnages - continuous production or parallel units
- Overcome the problem of cluster/particle stability - SDR spreading flow field, or two phase microreactors.
- Simultaneous particle and polymer production - easy route to encapsulation in polymers for drugs, nano-composites, slow release.
- Encapsulation for good mixing before final processing



Developing a rationale for PI - ideas

- What do we have to do to succeed in this budget?
- What systems of particular value should we concentrate on for applications?
- Do we have the right connections with other groups?
- Do we understand how PI can applied?
- Do we understand how PI can be improved?
- What role can PIN play?

LET'S GET CONNECTED



Developing a rationale for PI - ideas

- Future of PI/PIN
- High value products is the way
- New management processes needed
- Maybe no other way to make these products
- PI not yet fully achieving poteniital?
- PI road map – coherent plans useful way ahead
- Links to Sustech
- IS NANO THE FUTURE FOR PI?