

Nanotechnology for more efficient wind energy



Image supplied by Npower Renewables ©Anthony Upton 2003



MNT Network
Collaborating for the future



Nanotechnology for more efficient wind energy

Prepared by Patrick Eaton in
partnership with the UK MNT
Network

This presentation is intended
to encourage participation and
collaboration for the future
adoption of micro and
nanotechnology for UK plc.

Overview of presentation

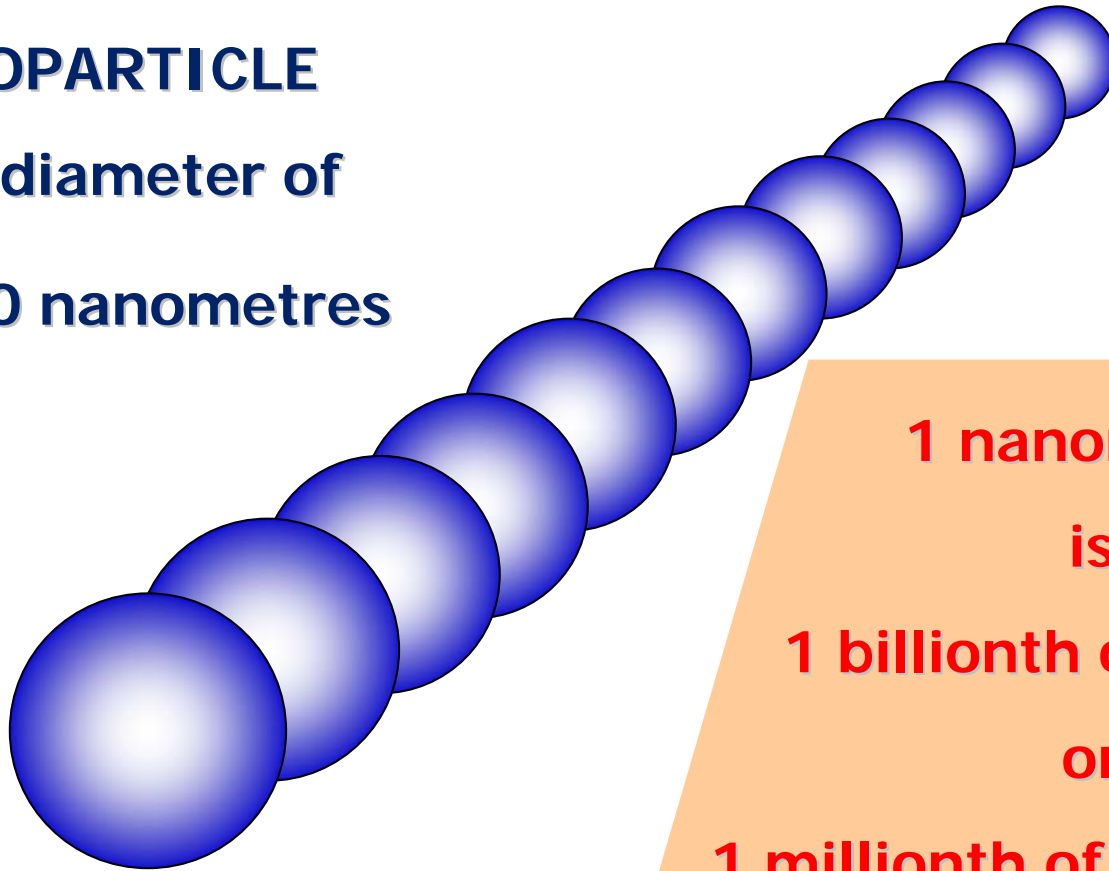
- Introduction to micro and nanotechnology
- Opportunities for innovation and market penetration for the UK manufacturing supply chain
- Micro and nanotechnology – resolving challenges in wind power component supply
- Broader examples of developments in MNT manufacturing and applications
- Support and taking things further

Introduction to Micro and Nanotechnology (MNT)



SIZE MATTERS !

NANOPARTICLE
has a diameter of
1 to 100 nanometres



1 nanometre
is
1 billionth of a metre
or
1 millionth of a millimetre

Putting things into perspective

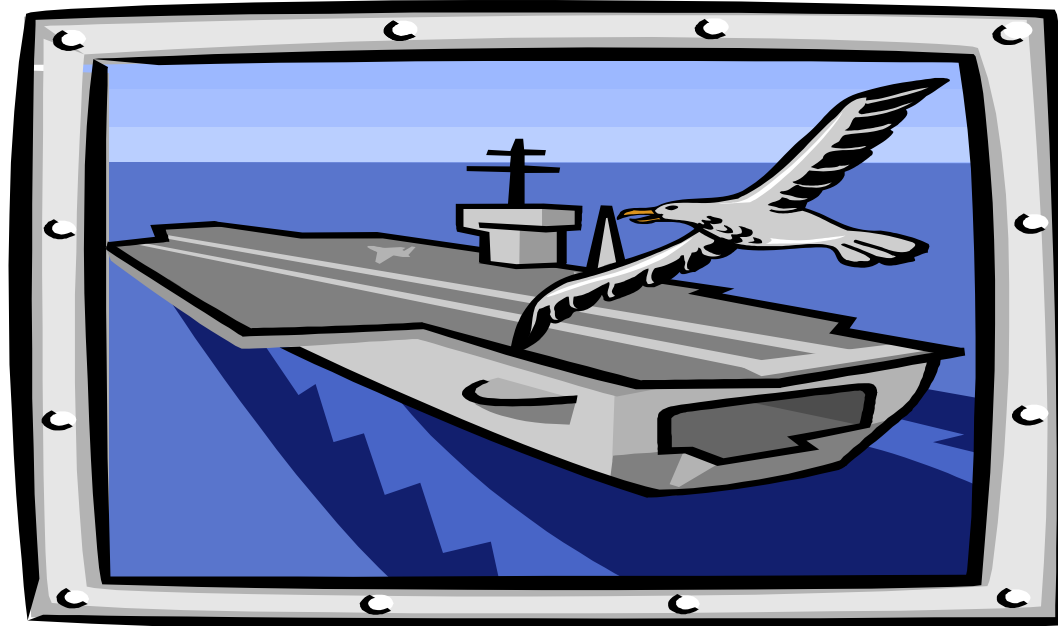


80,000 nanoparticles in a row are the diameter of a hair



Louse and it's excreta (>20,000 nm) on a human hair

Putting things into perspective



If a seagull landed on an aircraft carrier it would sink by 1 nm

Putting things into perspective

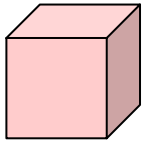


Converting a grain of salt into nanoparticles would increase the surface area by 100,000 times

Nanoparticle properties

Quartz

Dissolution time



1 mm³

34 million years



1 nm³

1.1 seconds

Conditions: 25°C, pH 7, in water

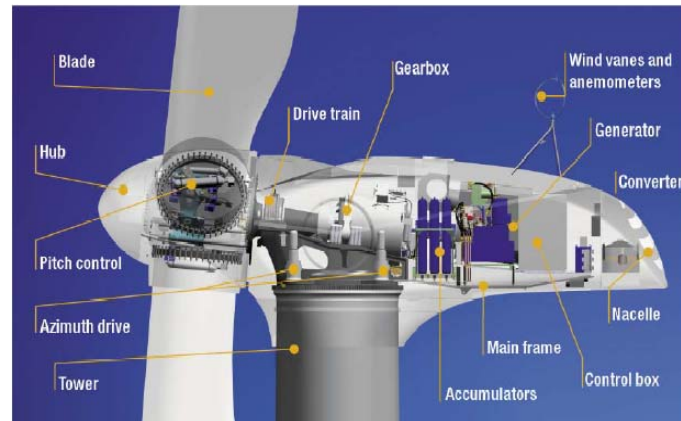
Unusual properties of nanoparticles

- The following physical properties are likely to change:
 - Thermal
 - Mechanical
 - Electronic
 - Magnetic
 - Optical
 - Surface
 - Interfacial

Why nanotechnology? - Business

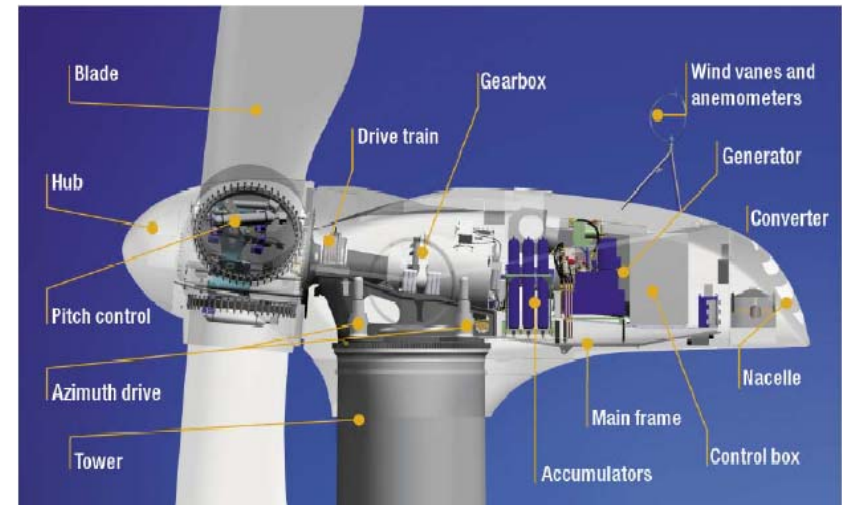
- Predicted \$1, 000 billion MNT global market in the next 10 years
- Predicted that MNT will be the next industrial revolution
 - UK expected to have 4 % i.e. £25 billion
 - Creating 30,000 new jobs
- Nanotechnology is 'disruptive'. Users will win!

Opportunities for innovation and market penetration for the UK manufacturing supply chain



Wind power generation – supplying components

- A market worth >£20 billion – worthy of some effort!
- UK Renewable Obligation which could lead to circa 10,000 MW in the next decade
- EU directive looking for 40,000 MW of large scale wind by 2010



Cost analysis - turbines

- **Typical cost breakdown**
 - Turbine 45%
 - Foundations 25%
 - Installation 7%
 - Connection 3%
 - Transmission 8%
 - Management 2%
- **Approximate cost– £1million per MW**



Failure analysis - turbines

- **Reasons for failure of wind turbines (45% of cost breakdown), mainly in the turbine nacelle**
 - Electrical control system 13%
 - Gearbox 12%
 - Yaw system 8%
 - Generator 5%
 - Hydraulics 5%
 - Grid connections 5%
- **Opportunities to improve**



Micro and nanotechnology – resolving challenges in wind power component supply



Opportunities for MNT in wind power turbines

De-icing coatings

Self-cleaning coatings

Weight saving

Lubricants

New sealants

Power pack improvements



www.windsupply.com

Opportunities for MNT

De-icing coatings

Wind power problem	Possible nano/ micro solutions	Example of nano/ micro solutions
Ice-build up on blades & sensors	Non-wettable surfaces	Degussa's Lotus Effect® treatment



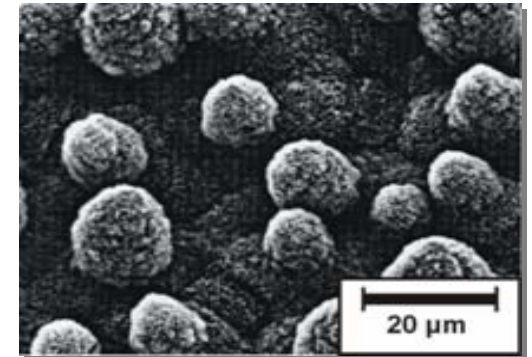
Surface treatments – de-icing

Surface treatment to repel water could prevent ice forming on the blades e.g. the Lotus Effect® by Degussa Germany

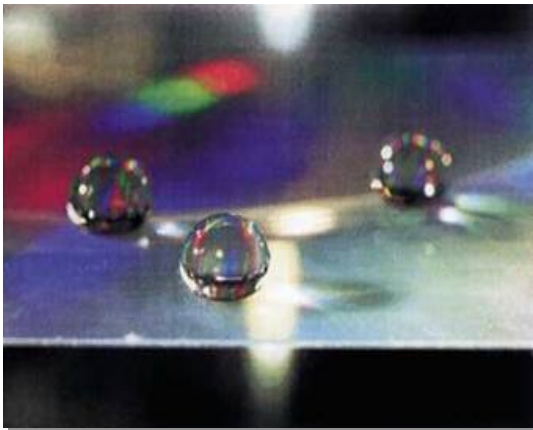


Lotus Plant

- non-wettable self-cleaning leaves due to:
- nanostructured rough surface with wax crystals

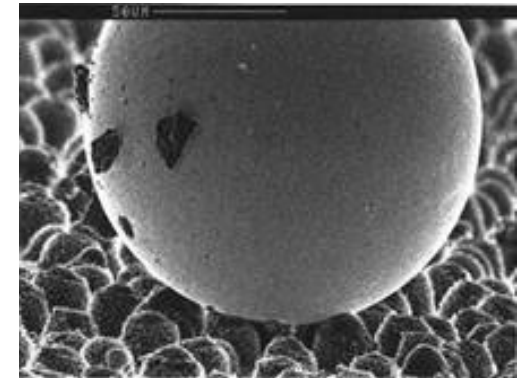


Lotus leaf - micro-structure



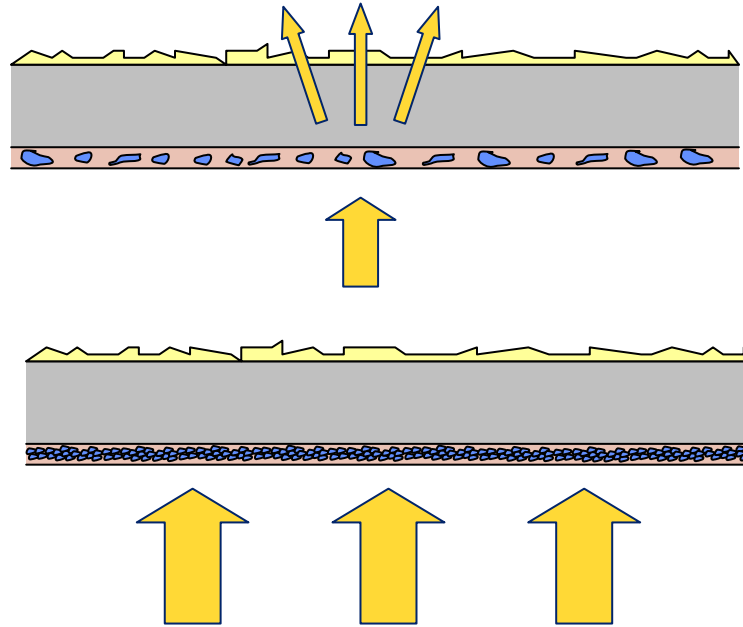
Degussa

- design of non-wettable surfaces for technical applications: Lotus® Effect
- wetting protection



Lotus leaf - water droplet repulsion

Reduced porosity and moisture absorbance



Micro-porosity of fibreglass can also be solved with nanotech manufacturing technology. Reduced porosity helps prevent ice build up

Reduced porosity – successful application of MNT



Reduced or eliminated need for 'new balls please'

Opportunities of MNT

Self-cleaning coatings

Wind power problem	Possible nano/ micro solutions	Example of nano/ micro solutions
Dirt build up on blades	Self-cleaning surfaces	Pilkington's self-cleaning glass
Damage to blades	Use protective coatings e.g. non-scratch surfaces	Automotive e.g. Mercedes



Self-cleaning surfaces

Self-cleaning surfaces are available for everyday applications...

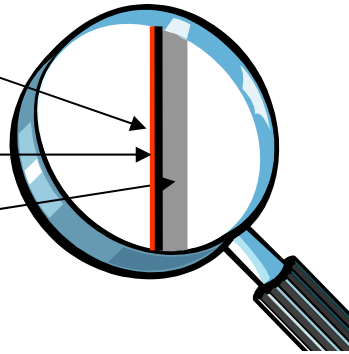


... this technology could have potential within the wind power sector

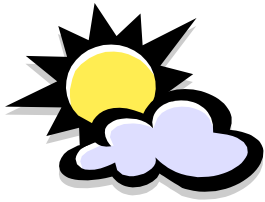
How it works...

1

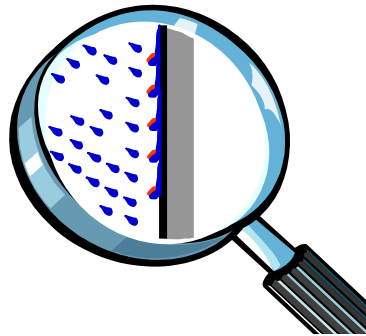
DIRT
TiO₂ NANO
COATING
GLASS



2

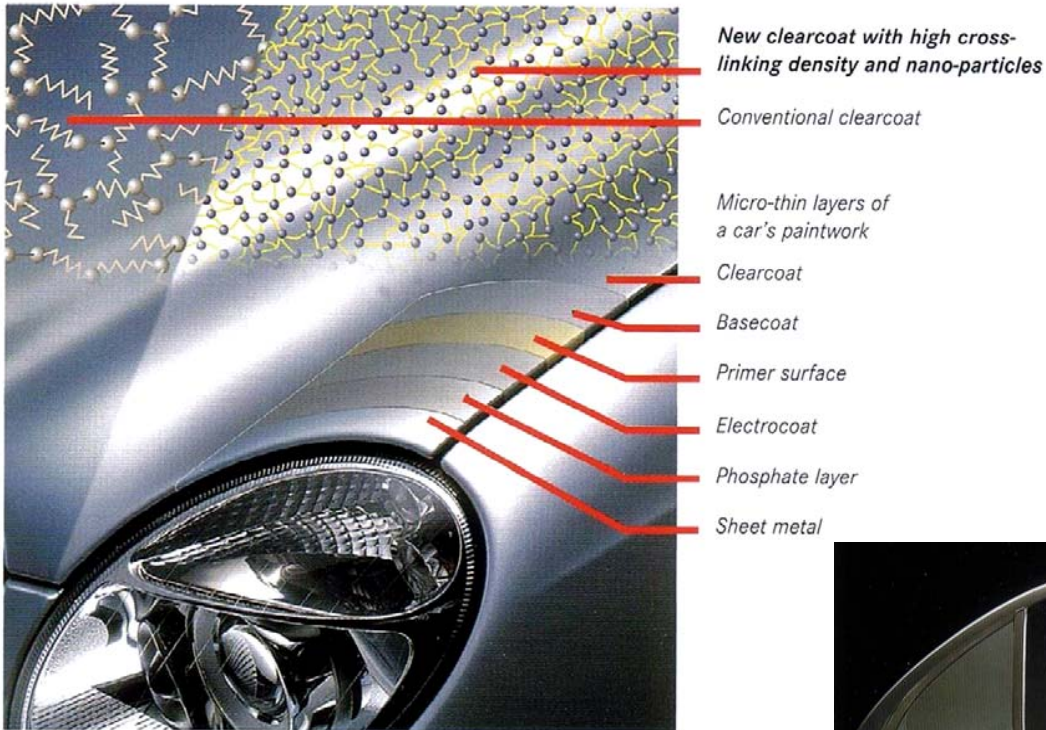


3



Self-cleaning
surfaces in blades

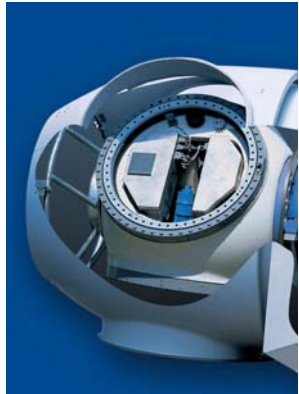
Non-scratch protective coatings used on 2005 Mercedes



Opportunities for MNT

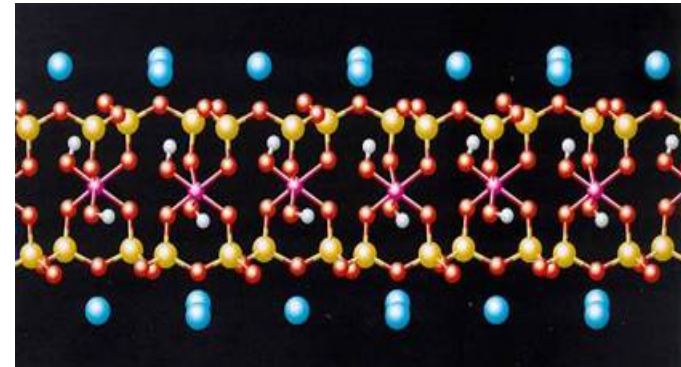
Weight saving

Wind power problem	Possible nano/ micro solutions	Example of nano/ micro solutions
Strength /weight of composites	Nanocomposites improve properties	Automotive use e.g. Toyota, Chevrolet



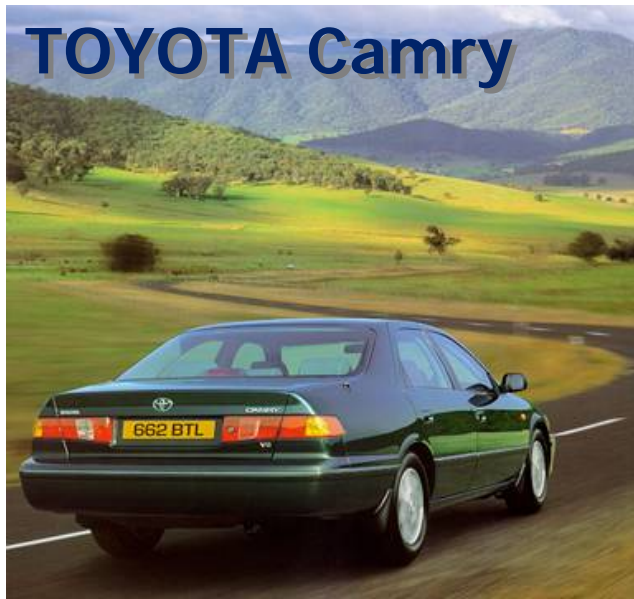
Nanoparticles in composites

- **Strength/ weight improvements**
 - Tensile strength up 40%
 - Tensile modulus (elasticity) up 68%
 - Flexural strength up 60 %
 - Flexural modulus (bending) up 126%
 - Distortion temperature up from 65% to 152%
 - Improved flame retardant properties



**COMPOSITE OF NYLON-6
/ MONTMORILLONITE
(CLAY)**

Examples of nanocomposites in use



Nylon/Clay Nanocomposite
for Air In-take Cover



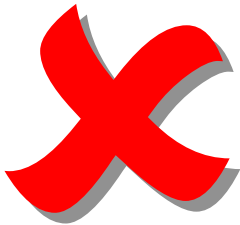
245 tonnes / year of
nanocomposites. Polypropylene side
body mouldings reinforced with
montmorillonite

20% weight saving over conventional materials



Advantages of nanofillers:

- Improved mechanical properties
- Better diffusion-barrier characteristics
- Better processability
- Better transparency
- Electrical conductivity
- Better burning behaviour
- Better surface properties

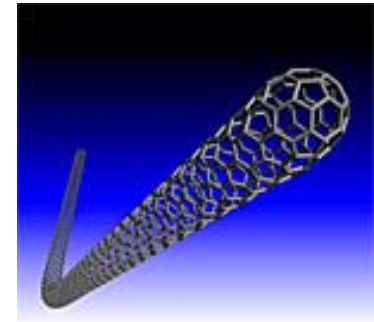
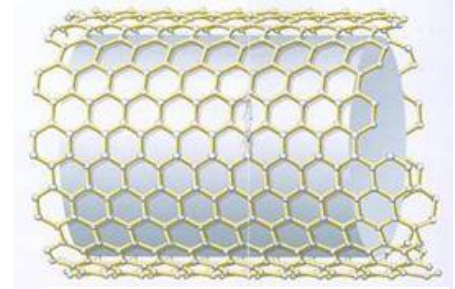


Disadvantages of nanofillers:

- Difficult compounding
- Brittleness
- Inadequate cost/performance ratio
- Recycle-ability

Carbon nanotubes

- 55 companies making carbon nanotubes
- Mitsubishi will make 1,500 tonnes by 2007
- Carbon nanotubes:
 - 50-110 times stronger than steel
 - 1/6th the weight
 - Used in body armour, yacht masts, tennis racquets and car body panels
 - The “best electrical and thermal conductors ever”
 - Result in plastics that conduct electricity and heat
 - Storage of hydrogen



Thomas Swan & Co Ltd & Cambridge University, high-purity single-wall carbon nanotubes

See case studies
www.mntforum.com

Strength /weight improvements – high strength steels



Welcome to
Sandvik Materials Technology



Examples of applications

Sandvik Nanoflex® - Sports
Designed for extremes

Sandvik Nanoflex® - Security & Safety
Designed for impact



www.smt.sandvik.com/nanoflex



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Opportunities for MNT

Lubricants

Wind power problem	Possible nano/ micro solutions	Example of nano/ micro solutions
Reliability of rotating machines and replacing worn out components	Nano lubricant for improved wear resistance at all temperatures and pressures	Nanolub contains particles which behave like mini ball bearings



New Sealants

Wind power problem	Possible nano/ micro solutions	Example of nano/ micro solutions
Hydraulic system leaks	Novel sealants based on nanocomposite elastomers	Nanocor

- Hydraulic systems
 - Brake systems, pitch & yaw controls
 - On-board cranes, locking systems.
 - Pumps, drives, oil tanks, filters, pressure valves and control systems



Opportunities for MNT

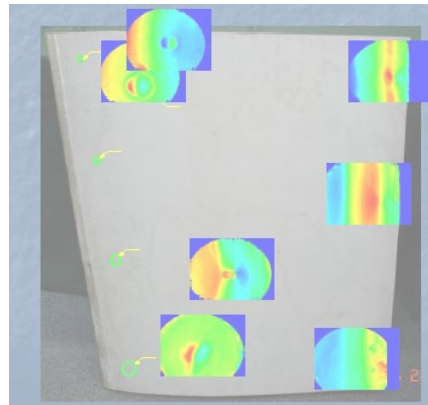
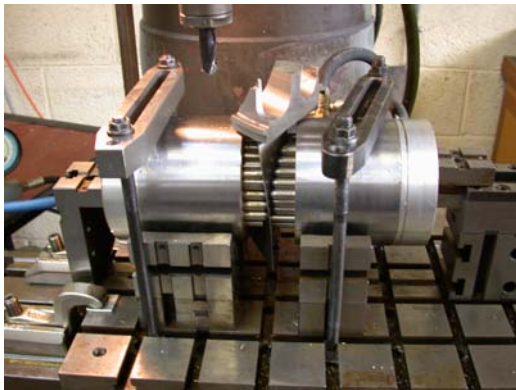
Power pack improvements

Wind power problem	Possible nano/ micro solutions	Example of nano/ micro solutions
Start up and orientation requires grid power	Carbon nanotubes as fuel storage	Hydrogen storage for fuel cells using nanotube fuel storage

- Control systems are increasingly important
 - SCADA for systems required by grid operators
 - Condition monitoring
 - Remote control and full monitoring
- Mini generators and energy storage for start-up and nil wind.



Broader examples of developments in MNT manufacturing and applications



Fixturing of complex components

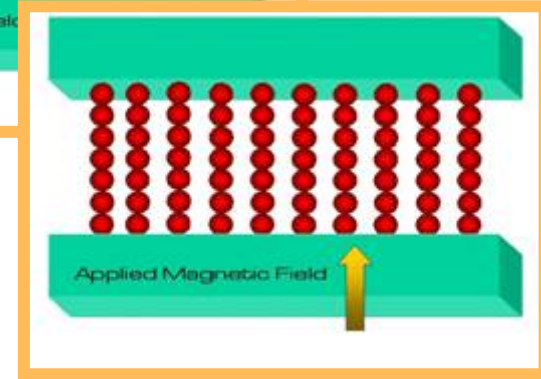
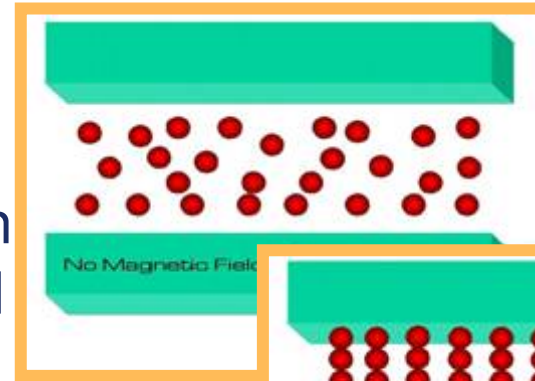
Magneto-rheological fluids (MR fluids)

Micro /nano sized particles magnetised in a state of change from fluid to semi solid



MR fluid holds brass screw at angle

NIMRC NOTTINGHAM INNOVATIVE MANUFACTURING RESEARCH CENTRE



Pin-Fixture



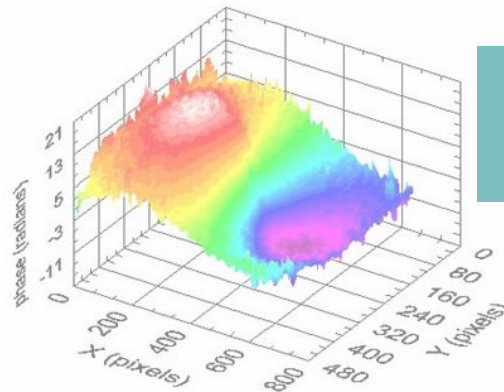
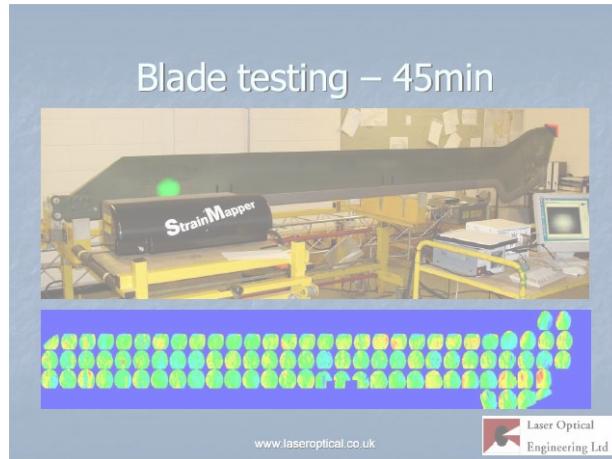
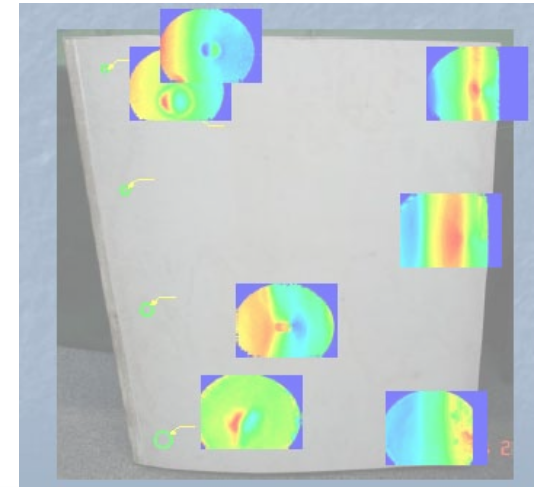
Modular fixture



Dedicated Fixture

Nanoscale non-destructive testing (NDT) composites

- Visualising damage by a nanoscale interferometric technique using lasers.
- Strain data can determine damage and residual life.
- Used for periodic inspection of helicopter blades, turbine blades.



Laser Wavelengths
532nm (green)



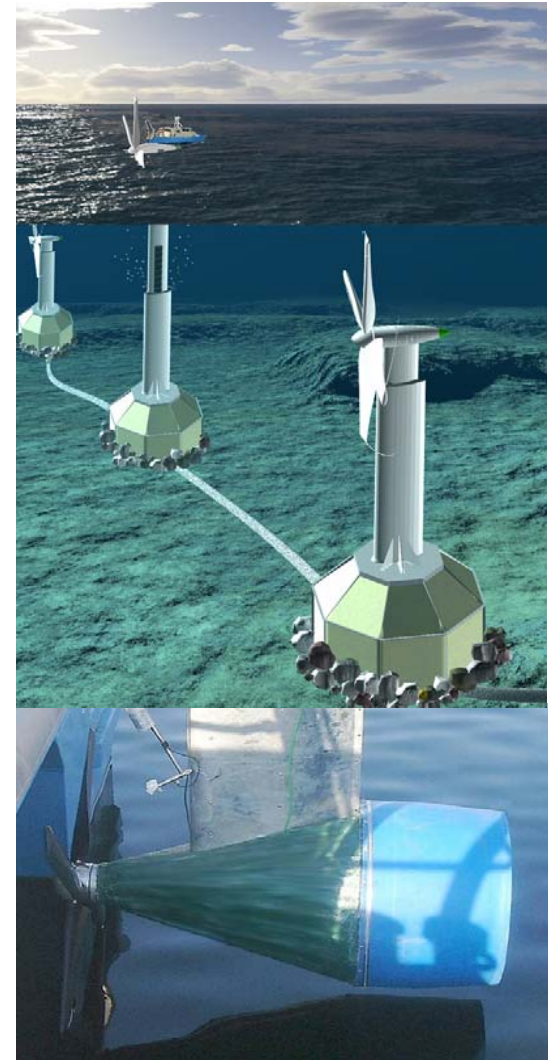
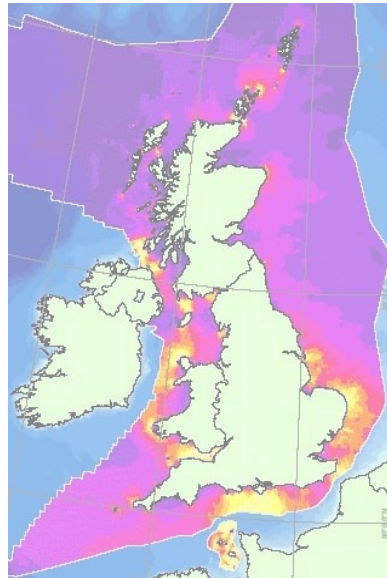
www.laseroptical.co.uk

Tidal flow – a long term opportunity

- 27% of UK domestic consumption?
- UK currently at the leading edge
- Need industrial collaborators



Swansea University
School of Engineering



www.swanturbines.co.uk

Support and taking matters further



MNT Network
Collaborating for the future

- **If you want to utilise MNT in your business, you should consider the following points:**
 - Technical opportunities
 - Funding opportunities
 - Technology providers
 - More information

Resources: funding opportunities

- **DTI Products – Innovation (www.dti.gov.uk/bss)**
 - Knowledge Transfer Networks
 - Grant to set up inclusive network in priority area
 - Collaborative Research and Development
 - Grants for Investigating an Innovative Idea (75% costs up to £12K)
 - SMEs reimbursed for consultancy to understand 'how'.
 - Grants for Research and Development
 - SME Grants for R&D
 - Knowledge Transfer Partnerships
 - Partial grant for technology transfer via strategic project, 1-3 yrs

Resources: funding opportunities

- **Best Practice and Investment (www.dti.gov.uk/bss)**
 - Access to Best Practice
 - Materials available, organised visits to leading organisations
 - Support to implement Best Business Practice
 - SMEs given free diagnostic run by business link adviser (+ consultancy)
 - Small Firms Loan Guarantee (£5 to 250k or 100k if <2yrs trading)
 - SMEs without security, 75% of loan (2-10 yrs, repay at 2% pa)
 - Selective Finance for Investment in England
 - Grant towards capital costs for productivity etc in assisted areas

Technology providers: centres of excellence

- **UK MNT Network is funding centres of excellence throughout the UK.**
- **Aims:**
 - Accelerate the commercialisation of MNT to benefit the UK economy
 - Develop a critical mass of capabilities
 - Provide an open access on equitable commercial terms to microsystems and nanotechnology platforms and associated knowledge

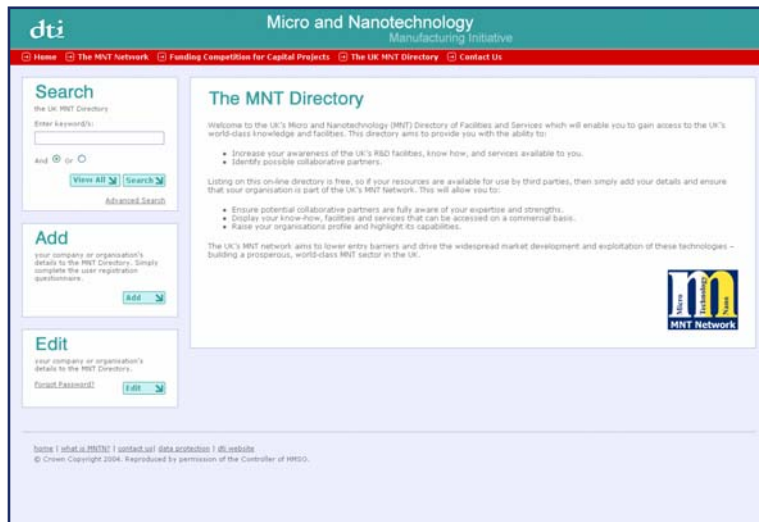
For more information go to www.mntforum.com

More information – MNT Network



www.mntforum.com

MNT information, news, communications, reports, roadmaps, this presentation and others



www.mntdirectory.com

For MNT suppliers and partners

For more information about UK wind turbine component supply and innovation www.windsupply.co.uk

Feedback

UK MNT Network would like to encourage the use of this presentation to promote MNT and its exploitation. If you wish to use it or suggest any changes and/or improvements please contact the MNT Network.

mntreports@mntnetwork.com

This presentation was produced by Patrick Eaton in collaboration with the MNT Network. For further information on MNT and it's suppliers:-

www.mntnetwork.com, www.mntforum.com, www.mntdirectory.com

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