Please Note: some of our courses are run every year and some alternate years. This is the most recent brochure available. We are planning to run this course next in April 2008.

NANOMATERIALS

24 – 28 April 2006

Overview

This course will present a review of the state of the art of materials structured at the nanometric level. Characterisation at the nanoscale can be achieved by a variety of electron, ion beam and scanning probe methodologies and these, together with more specialist methods such as position sensitive atom probe and spectroscopic ellipsometry, will be introduced. Nanoscale structure in metals, polymers and ceramics may have a marked influence on structure-property relationships with the possibility of providing behaviour not seen in coarser scale structures. In addition certain new classes of materials may be produced at this size level, for example C_{60}, carbon nanotubes and a variety of colloidal structures. The processing and applications of nanofluidics will also be dealt with in some detail. Finally, the commercial perspective on the larger scale production of nanomaterials will be given to illustrate the move of this class of materials from laboratory to plant.

Aim

The aim of this course is to introduce the various classes of nanomaterials: both bulk materials with a well defined and controlled nanostructure and discrete materials produced by nanotechnology such as carbon nanotubes and self-assembled monolayers. Further, the techniques required to analyse structures at the nanoscale will be reviewed

Learning Outcomes

On successful completion of the module, all participants should be able to

- Appreciate the range and breadth of application of nanomaterials
- Discuss the potential impact, in all classes of materials, of the control of nanostructure
- Describe the methods for the chemical and nanostructural characterisation of such materials
- Outline the nanotechnology production routes currently available
- Identify possible opportunities for nanomaterials in product development and enhancement

WHO SHOULD ATTEND?

The course is directed at engineers and scientists who require a thorough grounding in the benefits of nanomaterials technology described above. These are applicable to a wide range of industrial scenarios. As the field of nanomaterials is developing very rapidly, the course provides an ideal opportunity to review the scope and applicability of the currently available and emerging nano-structured materials. While the course is open to all, a scientific or engineering education to degree level, or a higher education qualification in physics or chemistry is desirable.

COURSE FORMAT

The course will commence at 10.00 on Monday 24 April 2006 and continue until lunchtime on Friday 28 April. Each day there will be a number of lectures, together with exercise classes and tutorials to reinforce the various lecture topics. Lecture notes will be distributed at registration and will include much of the detailed visual material presented by each lecturer. This will relieve the student of some note-taking and will permit greater concentration on the topic. However, these handouts are merely notes,

and are intended to **supplement** lectured material. Copies will only be made available to registered attendees.

ACCOMMODATION
There is no University accommodation available for this course so when you register you will be sent a list of local accommodation. A range of hotels is available and also guest houses and the YMCA offering good accommodation at reasonable rates. Early reservations are recommended as Guildford accommodation is at a premium.

ENROLMENT
Each applicant should complete the Registration Form at the back of this prospectus and return it with the appropriate remittance. Additional forms may be photocopied as required. The basic Course Fee will be £1020 and includes tuition and one set of lecture notes. The cost of coffees, lunches and teas from morning coffee on Monday 24 April 2006 until lunch on Friday 28 April will be £50.00.

The closing date for applications is Friday, 7 April 2006. Cheques should be made payable to the "University of Surrey" in £ sterling. **Companies sending two delegates may send a third delegate for the price of their meals only.**

If there are a number of people in your company who would benefit from a course in this field, please contact us to discuss the possibility of an in-house, customised, course to meet your requirements.

DISCLAIMER
The organisers reserve the right to amend the sequence of lecture topics and to cancel lectures or substitute lecturers if necessitated by circumstances beyond their control.

LECTURE TOPICS

1 The Nanoscene — **Professor John Watts**

This lecture will aim to put the furore regarding nanotechnology into context. Are we really in danger of being overtaken by *grey goo* or Drexler's nanorobots as some authorities have suggested. This speaker thinks not and will discuss why not! Certain aspects of nanotechnology are well established and have simply been renamed to meet the current vogue for all things nano, other areas are truly innovative and have only emerged very recently. As far as nanomaterials is concerned this will be presented as a subset of nanotechnology and its relationship to other sectors such as nanobiotechnology, functional nanotechnology and chemical and environmental nanotechnolgy will be outlined.

2 SPM: The full range of nanotechniques and relationship to SEM

Professor Jim Castle

Historically, the scanning probe family started with the invention of the STM. It was extended by the AFM but since these pioneering developments the principle of a scanning probe has been exploited in numerous different ways. The relationship between characterisation at the nanometre scale by AFM will also be contrasted with the data available by scanning electron microscopy.

3 Surface Analysis — **Professor John Watts**

If we are to carry out elemental and/or chemical analyses of sub micrometer features the conventional analytical approaches are, by and large, no longer valid. This lecture will outline those methods that can be used for the analysis of solid materials at this size range. Most widely used are analytical transmission electron microscopy, with analysis of characteristic X-rays or by electron energy loss methods and the surface analysis methods based on ion and electron spectroscopies. A brief

introduction to these methods will be given and examples of use in nanomaterials provided.

4 3D atom probe **Professor George Smith**

Developing and understanding nanomaterials requires the ability to characterise the nanostructures present with high spatial resolution, and link the observed structures with both the processing and the properties of the materials. The technique with the highest spatial resolution for chemical analysis is the 3D atom probe, which is able to reconstruct in 3 dimensions the elemental distribution of the majority of the atoms from a volume typically 20nm $\times$ 20nm $\times$ 100nm of a conducting material. The basic principles of the 3D atom probe will be described, including the techniques of time-of-flight mass spectrometry and position-sensitive detection that form the basis of the instrument. Recent developments in specimen preparation that have extended the applicability of the technique to thin film materials will also be reviewed.

5 Nanometallics **Professor George Smith**

For centuries, Man has unwittingly made use of metallic alloys with microstructures on a range of scales down to a few nanometres. Only in recent history has the development of microscopy allowed an understanding of the structure of alloys that produce the useful properties. More recently, a range of advanced processing techniques have permitted a range of more complex materials to be formed, and led to the creation of nanostructured materials. The basic techniques for the creation of a range of nanostructured metals will be briefly reviewed, from conventional metallurgical methods to more recent non-equilibrium techniques. Typical microstructures obtained and their influence on useful properties, whether structural or functional, will be described.

6 Nanoceramic Materials **Dr Julie Yeomans**

The processing- microstructure-property relationships in ceramics with nanoscale grain sizes and/or nanoscale second phases will be reviewed. Possible application areas will be outlined.

7 Nanotubes: Production to Application **Professor Ravi Silva**

Carbon nanotubes are nearly ideal 1-dimensional nanostructures with many unique properties and can extend to many tens of microns, but their diameters are in the nano-metre range. These properties range from ballistic transport of carriers, very high thermal conductivity, high mechanical strength and robustness to name a few. This lecture will discuss growth, structure, properties and potential electronic uses of this fascinating form of carbon.

8 Nanostructured Coatings for Wear Resistant Applications **Dr Mark Baker**

In general, the most influential mechanical property affecting wear resistance is hardness. As the Hall-Petch relationship dictates that hardness is inversely proportional to grain size, reduction of the grain size to nano-dimensions has a beneficial effect on wear resistance. Different nanoscale coating architectures being developed to enhance mechanical properties will be described.

9 Nanocomposites Review **Professor John Hay**

Nanocomposites consisting of intercalated or exfoliated clay-polymer systems are attracting considerable interest because of their attractive properties such as good barrier properties and good fire performance. In this lecture, the synthesis, characterisation, properties and applications of these exciting materials will be reviewed.

10 Sol-gel hybrids **Professor John Hay**

The low temperature sol-gel route provides a method of making hybrids of inorganic oxides and glasses with organic species such as polymers and small molecules. Many of these products are nanophase materials. In this lecture, the synthesis, characterisation, properties and applications of these hybrids will be reviewed.

11 Nanotubes and Nanocomposites **Dr Alan Dalton**

There are a variety of experimental approaches that can be used in the synthesis of conducting polymer-silica nanocomposite particles, dating back over a decade in the author's laboratory. The first class of materials produced was by the oxidative polymerisation of aniline or pyrrole in the presence of commercially available colloidal silica in aqueous solution. The resulting nanocomposite structures were dense black in colour which suggested a variety of uses where such a property would be of value. This lecture will also review more recent work in the colloidal nanocomposites area and describe characterisation methods used to establish morphology and chemistry of these particles. The lecture will also review possible applications of such structures.

12 Structure/Property Relationships in NanoPolymers **Dr Tina Lekakou**

Nanopolymers incorporate various types of materials including polymer nanoparticles or various types of nanophases, nanodomains and nanofeatures in polymeric materials. The lecture will cover different classes of nanopolymers, applications, manufacturing and structure/properties relationships.

13a Field-Ion Emission and Liquid Metal Ion Sources **Dr Richard Forbes**

The Position Sensitive Atom Probe (PoSAP) and the Focused Ion Beam (FIB) machine use the same physical mechanism (field-induced ion evaporation) to generate ions. Background theoretical understanding of how scientific instruments work can sometimes help in the interpretation of results or the development of new technologies. This part presentation aims to explain in basic terms our current understandings of how the ions are generated (for both techniques), and how the liquid-metal ion source used in FIB machines works.

13b Applications of FIB Machines **Dr Richard Forbes**

FIB machines are one of the potential "top-down" techniques of nanotechnology. This part presentation provides an introductory survey of some of the past and potential applications of FIB machines.

14 Self Assembled Monolayers **Professor Graham Leggett**

This lecture will describe the formations, properties and potential uses of self assembled monolayers. SAMs are formed by the adsorption of alkanethiols on noble metal surfaces and are attractive for many applications including fundamental studies of adhesion, biological interactions at surfaces and other phenomena , and the fabrication of novel molecular architectures for use in molecular electronics novel sensors and other analytical devices. SAMs can be patterned down to the nanometre level and ways of achieving this will also be described.

15 Polymer Nanoparticles for Coatings and Adhesives **Dr Joe Keddie**

Colloidal (i.e. sub-micrometer) polymer particles in water have been used for decades to make waterborne coatings and adhesives. This lecture will review recent developments in the use of even smaller particles (< 100 nm) to tailor the mechanical and optical properties of materials. The mechanisms of film formation and new techniques for characterisation will be reviewed.

16 Nanoribbon synthesises in molecular mangles: Exploring the world of neglected dimensions **Professor Paul Sermon**

Nanoengineering of materials is one of the new *nano*businesses. Here we describe a molecular *nano*mangle that delivers continuous ribbons of selected materials with nm thickness.

17 Nanomaterials – the new commercialisation challenge Dr Mike Pitkethly

Nanoparticles have been used in a variety of applications for many years without the fanfare currently associated with nanotechnologies. However, over the last few years the research into the production of nanoscale particles that have been designed to give specific properties has begun to be exploited with the commercialisation by a number of companies. This talk look at the nanomaterials arena from the viewpoint a new start-up company and will discuss the current market situation, production techniques, the applications being targeted, some of the issues surrounding nanoparticles and take a look at why the future could be very rosy for these companies.

18 The future of nanoscience in the UK Professor Roland Clift

This lecture will review the progress made by the current Royal Society/Royal Academy of Engineering Working Group on nanoscience of which the speaker is a member.

THE LECTURERS

COURSE DIRECTOR

Professor John F Watts: Professor of Materials Science at the University of Surrey, within the School of Engineering he is Head of Materials, Surfaces and Structural Systems and is also Director of the cross School UniS Materials Institute. He has extensive experience in the application of surface analysis (XPS, AES, ToF-SIMS and SPM) to applied problems in materials science. His research fields include adhesion between inorganic and organic phases and their subsequent failure, and surface characterisation of polymeric materials, he was awarded a DSc in 1997 for this work (following a PhD in 1981). He has over 270 publications in adhesion and applied electron spectroscopy and has lectured widely in the UK, Europe, the USA and the Far East. He is Editor-in-Chief of the journal *Surface and Interface Analysis.* He is on the organising committee of SIMSXV and a member of the International Steering Committee of the biennial ECASIA conference series.

LECTURERS

Dr Mark Baker - Advanced Materials MSc Director: Dr Baker is a Senior Lecturer in Interface Engineering at the University of Surrey. After obtaining his PhD from the University of Surrey he worked in the electronics industry and spent 6 years running the electron spectroscopy laboratory in the Surface Engineering Unit at the EU Institute of Advanced Materials, Ispra, Italy. His current main research interest is the use of advanced analytical techniques to characterise nanostructured coatings for wear resistant applications. He has over 15 years experience in the application of electron spectroscopic and microscopic techniques to the study of thin films, coatings and corrosion and has published over 60 refereed papers. He is Director of the MicroStructural Studies Unit at Surrey and is a Chartered Scientist.

Professor James E Castle: Emeritus Professor in the School of Engineering at the University of Surrey. He has published well over 200 papers in the fields of thin film and interface analysis, using all forms of surface analysis, including the scanning probe microscopies. He has served on the Editorial Boards of several major journals in the field. His current interests include studies of electrochromic thin films and the supra-molecular structures of bio-molecules adsorbed on surfaces and the manner in which surface bonding influences their conformation. He is currently co-ordinator of an EU project on intercalation of lithium ions into thin films of vanadium oxide in the context of

electrochromic devices. Recent interests, still coming into publication, deal with transport of copper with the working fluids of electrical generation equipment used in the power industry.

Professor Roland Clift CBE: Distinguished Professor of Environmental Technology and formerly Director of the Centre for Environmental Strategy at the University of Surrey; previously Head of the Department of Chemical and Process Engineering. Professor Clift is Visiting Professor in Environmental System Analysis at Chalmers University, Sweden. He is a member of the Science Advisory Council of the Department of the Environment, Food and Rural Affairs (Defra) and of the International Expert Group on application of Life Cycle Assessment to waste management, and a past member of the Royal Commission on Environmental Pollution, of the UK Ecolabelling Board and of the Royal Society/Royal Academy Working Group set up at the instigation of a UK Government Department (DTI) to advise on the risk and regulatory issues raised by nanotechnology. He has also served as Expert Adviser to a House of Lords enquiry into energy efficiency. In 2003 Professor Clift was awarded the Sir Frank Whittle Medal of the Royal Academy of Engineering "for outstanding and sustained engineering achievement contributing to the well-being of the nation".

Dr Alan Dalton: Alan received his PhD in polymer physics from Trinity College Dublin in 1999. Since then Alan spent periods of time at the Dublin Institute of Technology, Honeywell Technologies NJ and the University of Texas. Alan joined the physics department at the University of Surrey as a lecturer in soft condensed matter in the summer of 2004. With over 60 publications (and over 600 citations) in internationally recognised journals relating to this topic, Alan and his group are at the forefront of research in the area of nanocomposites and in particular nanocomposites based on carbon nanotubes.

Dr Richard Forbes: Reader in Applied Electrophysics in the Advanced Technology Institute at the University of Surrey. His interests are theoretical and lie in the general area of Nanoscale Electrical Science (including aspects of field electron and ion emission). He has published extensively in these areas, and is the current President of the International Field Emission Society. Current interests include emission aspects of the underlying theory of Atom-Probe Field-Ion Microscopy and of Focused Ion Beam (FIB) machines. He has recently been part of the FP5 "NANOFIB" consortium, which has been developing a new higher-resolution FIB machine; this project was selected by the European Commission as one of its showcase FP5 projects in Nanotechnology.

Professor John Hay followed a BSc and PhD at Edinburgh University with postdoctoral studies at ETH, Zurich. He then spent 14 years working in industrial research before joining the Chemistry Department at the University of Surrey as Reader in 1994. He was promoted to Professor of Materials Chemistry in 1999 and was the first QinetiQ Professor of Materials Chemistry from 2000 to 2003. He is now Head of the School of Biomedical & Molecular Sciences. His research activities encompass the synthesis and characterisation of polymers and polymer composites, studies of organic-inorganic hybrids and nanocomposites, and use of clean polymer technologies. Professor Hay is a member of the EPSRC Peer Review College and is on the editorial boards of 'International Materials Reviews' and 'High Performance Polymers'.

Dr Joe Keddie: Reader in Physics at the University of Surrey. Although currently working in the Department of Physics, he has degrees in ceramic engineering and in materials science. His research interests are reflected in his 65 research papers and book chapters on ceramic thin films, colloidal processing, polymer thin films and coatings, and techniques of characterisation, especially ellipsometry and scanning probe microscopy. In recent years he has been awarded two international prizes for his work on organic coatings.

Professor Graham Leggett: Professor of Nanoscale Analytical Science in the Department of Chemistry at the University of Sheffield. The biological interactions of SAMs are a key inertest, and current work focuses on understanding the role played by adsorbed proteins in regulating cell attachment to SAMs. He has published over 90 papers and given over 60 invited lectures in this, and other, research fields. He plays an important role in various committees of the American Vacuum Society and is on the editorial board of *Surface and Interface Analysis.*

Dr Tina Lekakou: Senior Lecturer in the School of Engineering at the University of Surrey. She gained her PhD at Imperial College working on reaction injection moulding. After a further period of research on multi-phase systems in the Mechanical Engineering Department at Imperial College, she took up her present appointment in 1989. Her current research focuses on the study of polymer and composite processing and specifically on Resin Transfer Moulding.

Dr Michael Pitkethly graduated from Imperial College, London and has a Ph.D. in composite materials from the University of Surrey. He worked at Plessey Microwave Materials, Towcester before joining DERA (RAE) in 1988 to work on radar absorbing materials and composites. During his time with DERA and then QinetiQ, Michael held a number of technical and managerial positions including establishing the DERA Brussels office, Head of Department for Multifunctional and Composites Materials, Commercial Director for Mechanical Sciences Sector, and Associate Director for Technology Exploitation for FST Division. He was a founding director of QinetiQ Nanomaterials Ltd, a wholly owned subsidiary of the QinetiQ Group that was established in October 2001. In September 2005 he took up the position of CEO of Cenamps, the Centre of Excellence for Nanotechnology, Micro and Photonics Systems in Newcastle. He is a Chartered Engineer and a Fellow of the Institute of Materials.

Professor Paul Sermon: Professor in Chemistry in the School of Biomedical and Molecular Sciences, where he has an active group studying nano-engineered solids. He has been studying colloid chemistry for over 30 years.

Professor Ravi Silva: Director of the Advanced Technology Institute, which houses the solid-state electronics and physics activities within the University of Surrey. It is part of the 5*A research rated Department of Electronic Engineering within the School of Electronics and Physical Sciences. He also heads the Nano-Electronics Centre, which is an integral part of the Advanced Technology Institute (ATI). He joined Surrey in 1995. Ravi's secondary education was in Sri Lanka, after which he joined the Engineering Department at Cambridge University for his undergraduate and postgraduate work. His research interests encompass a wide range of activities. Nano-Electronics and renewables are two themes that are very important to the research. Much has been achieved in the areas of Carbon based electronics that includes carbon nanotube and diamond-like carbon research. His research has resulted in over 200 presentations at international conferences, and over 150 journal papers.

Professor George Smith: Professor of Materials at the University of Oxford.

Dr Julie Yeomans: Director of the EngD Programme in Micro- and NanoMaterials and Technologies (MiNMaT) and Reader in Ceramics in the School of Engineering at the University of Surrey. She joined the University in 1988 from the BP Research Centre. This followed a first degree in Materials Science and Metallurgy and a PhD on microstructure-property relationships in ceramic tool materials, both at the University of Cambridge. Her current research is concerned principally with toughening mechanisms in ceramics and ceramic matrix composites and their effect on wear and thermal shock resistance. She is an Editor of the *Journal of Materials Science,* a member of the

Ceramic Science Committee of the Institute of Materials, Minerals and Mining and Chair of the EPSRC Structural Ceramics Network (SCerN).

UNIVERSITY OF SURREY

The University of Surrey is one of the UK's leading professional, scientific and technological universities with approximately 12,500 students and a world class reputation for excellence in teaching and research. Guildford is a thriving business and shopping centre for the surrounding area, easily accessible from London, 35 minutes by fast train and 30 miles by car on a fast road. Both London airports, Heathrow and Gatwick, are just 40 minutes by car; there is a direct rail service from Gatwick and a bus-rail service from Heathrow.

A large Research Park has been established on University land the other side of the A3 from the main campus. This provides facilities for industrial companies to conduct research, and operates in conjunction with the research schools already established at Surrey. Several major research establishments are also within a few miles, and many collaborative research projects with the University have resulted from this proximity.

THE SURFACE ANALYSIS LABORATORY

Research within this Group, which numbers some 30 academics and researchers, is concerned with the understanding of the manner in which materials surfaces interact with their environments and with each other. Such interactions may be deleterious as in the case of corrosion of metals or environmental degradation of polymers, or they may be beneficial, as we see in the pre-treatment of polymers to enhance their performance and the adhesion phenomena that occur between polymeric materials and metal oxides.
Sponsorship for this work is obtained from both government and industrial sources and the current portfolio of research projects is split fairly evenly between fundamental scientific investigations and the study, and hopefully the solution, of problems directly relevant to industry and the community.

The focal point of the research group is The Surface Analysis Laboratory which contains the most complete cluster of surface analysis instrumentation (X-ray photoelectron spectroscopy, time-of-flight secondary ion mass spectrometry. scanning Auger microscopy and scanning probe microscopy) certainly in Europe, and perhaps in the world. The installed capital value of this instrumentation is of the order of £3M and recently we have installed new state-of-the-art instruments for scanning probe microscopy and X-ray photoelectron spectroscopy. The ethos within the research group is that all student members have virtually unlimited access to this equipment, as required for their research projects. Industrial consultancy work is regularly undertaken using all of the techniques described above. For further details please contact Professor Watts.

Permanent Academic Staff: Professor J F Watts, Dr M A Baker. Professor Emeritus Professor J E Castle

MODULAR MSc PROGRAMME

This short course is offered as a module in our part-time or full-time Modular MSc Programme 'Advanced Materials'.

The **Advanced Materials Programme** aims to study the structure, processing and properties of a range of advanced materials and associated analytical techniques.

The principal objective of the programme is that science and engineering graduates will be equipped with a thorough understanding of several classes of advanced materials and of means by which they can be characterised.

It also aims to provide a coverage of aspects of the properties, manufacture, selection, design and economics relating to the use of materials in engineering applications.

The modules available are set out below. Each module may be taken as an individual short course.

SE3M11	Introduction to Materials Science
SE3M12	Introduction to Physical Metallurgy
SE3M41	Ceramics and Ceramic Matrix Composites
SE3M14	Polymers for Advanced Applications
SE3M15	Introduction to Composite Materials Science
SE3M16	Characterisation of Advanced Materials
SE3M56	Nanomaterials
SE3M18	Surface Analysis: XPS, Auger and SIMS
SE3M19	Scanning Probe Microscopy
SE0M20	Research Methods
SE3M26	Materials under Stress: An Introduction to Fracture Mechanics and Fatigue
SE3M27	Adhesive Bonding Technology
SE3M28	Managing Materials Cycles
SE3M29	Materials for Biomedical Engineering Applications
SE3M31	Surface Engineering
SE3M32	Numerical Modelling in Materials Engineering
SE3M37	Composite Materials Technology
SE3M38	Corrosion Engineering
SE3M40	The Science of Adhesion

Modules may also be taken from a similar programme 'Advanced Manufacturing Management and Technology'.

Candidates normally complete seven taught modules and a project.

Further details of our programme can be found on our web pages

http://www.surrey.ac.uk/eng/pg/mse/

REGISTRATION FORM

NANOMATERIALS
UNIVERSITY OF SURREY, GUILDFORD, UK
24 – 28 APRIL 2006

Name ..... Title .....

Company/Affiliation: .....

Address: .....

.....

Tel. No: .....email address .....

Name of Approving Manager: .....

			£
1.	**STANDARD COURSE FEE** each delegate will receive one set of Lecture Notes		1020.00
	Reduced fee for <u>registered</u> MSc students		995.00
2.	**MEALS - Coffee, Lunch and Tea** from Coffee 24 April – Lunch 28 April	5 days	50.00
3.	**PARKING** @ £2 per day (if required)		10.00

Please complete the following as applicable:
Please charge to the following credit card No .....

Expiry Date.....

3 digit security no. .....

Name of Cardholder.....

Type of Card: Visa/ Mastercard / American Express / Other:.....

I enclose a cheque for £ .....

Please invoice myself/my company for £ .....

Order No or Reference/Invoice Address .....

Company VAT registration number .....

Special dietary requirements, if any .....

I AM/AM NOT registered for the MSc in Advanced Materials

This form should be returned to:

Rebecca Jones
School of Engineering (D3)
University of Surrey, Guildford, Surrey, GU2 7XH, U.K.
Tel: 01483 689378 Fax: 01483 686671 Email: RF.Jones@surrey.ac.uk

PLEASE REGISTER BY 7 APRIL 2006 ALTHOUGH LATER REGISTRATIONS WILL BE ACCEPTED IF PLACES ARE AVAILABLE