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 June 2008.

COMPOSITE TECHNOLOGY AND SMART SYSTEMS

12 - 16 June 2006

THE COURSE

This is an intensive short course on Composite Technology and Smart Systems consisting of lectures, tutorials/exercise classes, demonstrations and discussion.

WHO SHOULD ATTEND?

The programme has been designed for engineers and scientists with some exposure to composite materials, and/or some working experience with composites, who wish to expand their understanding to include composite design issues and the science and technology of many important smart composite materials systems. The course is also appropriate for new graduates in engineering or materials disciplines wishing to expand their knowledge base to include the area of composite technology and smart composite materials. The aim when discussing any area will be to introduce the concepts involved, and hence the mathematical demands of the course are kept to a minimum (an ability to be able to deal with mathematics at A-level/BTEC equivalent is desirable). All practicing engineers and scientists in industry should therefore find the material readily accessible.

COURSE OBJECTIVES

Delegates completing this course will have been presented with an overview of many important manufacturing, design, joining and repair issues of concern in current applications of composite materials technology. They will also develop an awareness (based on a fundamental understanding of the science and technology involved) of the goals and limitations of structural health monitoring of composite structures, together with an understanding of the considerations involved in implementing many optical and non-optical smart composite applications, including process monitoring, structural/damage monitoring and damage limitation and self-healing.

COURSE FORMAT

The course will start on Monday 12 June and end early afternoon on Friday 16 June 2006. In the first two days, the aim is to highlight developments and trends in the processing and application of advanced composites in a number of sectors, and specifically aerospace, general engineering and land transport. There will be an intensive review of basic composite science followed by more specialist presentations on design issues and joining and repair of composites. In the following three days, the course focuses on smart composite systems, beginning with an overview of structural health monitoring. Optical systems for process and damage monitoring are introduced, preceded by lectures on the relevant background science, together with presentations on the practicalities of implementing such optical systems, including fabrication issues and commercial realities. Other important smart composite systems introduced include self-healing and self-sensing systems, dielectric cure monitoring, shape-memory alloy composites, and piezo-electric systems for a wide range of applications. Tutorials (delegates are asked to bring their own scientific calculator) and demonstrations will provide additional insights, and delegates will have ample opportunity to interact with the lecturers. We have found these informal contacts to be a most valuable and enjoyable aspect of such short courses.

ENROLMENT

Each intending registrant should complete the registration form at the back of this brochure and return it with the appropriate remittance. Additional forms may be photocopied as required. The **basic course fee** is **£1020**. **Companies sending two delegates paying full fees may send a third delegate for the price of the accommodation and meals only.** The closing date for applications is Friday 26 May. Cheques should be made payable to the "University of Surrey" in £ sterling.

ACCOMMODATION

Accommodation may be available on campus in single study bedrooms with full en suite facilities. The cost of accommodation is £40 per night, including breakfast. Details of other local accommodation are available.

LECTURE NOTES

Each delegate will be provided with a comprehensive set of lecture notes. These extend to several hundred pages and include all the principal visual material presented during the course. This relieves the student of the need to take extensive notes during the lectures and ensures that accurate information is taken away. It must be emphasised, however, that they are merely notes intended to supplement the oral presentations, and not intended as a substitute for text books. Copies are therefore made available only to attendees

INTRODUCTORY COURSE

Please note: A separate course, for which no prior knowledge is assumed, entitled **AN INTRODUCTION TO COMPOSITE MATERIALS SCIENCE** will be given at Surrey from 6 – 10 November 2006. Delegates should note that material from some of the lectures near the beginning of this course is also presented in the introductory course. The purpose of this is to introduce certain materials with which it is necessary to be familiar prior to both the design principles and smart systems sections of the programme. Most of the delegates on this course will not have attended the introductory course; it is hoped that those who have will find these introductory lectures to be useful revision. Delegates should also note that if they intend to take both this course and the introductory course, they are strongly advised to take the introductory course first. Students registered for the MSc who wish to gain credits from both courses **must** take the introductory course first. For full details, please contact Rebecca Jones at the address shown on the Registration Form.

DISCLAIMER

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

LECTURE TOPICS AND PROVISIONAL PROGRAMME

The course will follow the general order of the lectures outlined below. A detailed programme will be despatched to all registrants three weeks before the start of the course and any further changes will be advised at registration.

INTRODUCTION **S L OGIN**

1. PROPERTIES OF LAMINATES **P A SMITH**

The characteristic behaviour of laminates under in-plane loading will be reviewed. This will include discussion of the application of laminated plate theory to predict the elastic response as well as reviewing typical sequences of damage development under tensile and compressive loading.

2. PRINCIPLES OF PROCESSING POLYMER MATRIX COMPOSITES **C LEKAKOU**

A very wide range of processing possibilities is now available for composites. The basic principles and requirements for lamination and moulding processes are analysed and a rationale proposed for classification of processes. Technical and economic limitations are discussed.

3. PROCESSING THERMOSETS **M G BADER**

Thermosetting matrices are used in more than 50% of composites' applications and are the matrix of choice when mechanical efficiency and elevated temperatures are a major consideration. The technology has evolved dramatically over the past 10 years in response to the need to optimise performance, productivity and costs. This has resulted in the development of several hybrid processes that utilise aspects of more traditional processes, so that both the material and the process may be tailored to the product.

4. MECHANICAL DESIGN CRITERIA **P A SMITH**

The main criteria (maximum stress/strain, Tsai-Hill, Tsai-Wu) enabling progressive failure of laminates under in-plane loading to be predicted will be reviewed critically. In particular, the limitations of these approaches will be explored. The usefulness of fracture mechanics in modelling intra- and interlaminar matrix cracking processes will be discussed.

5. PROCESSING THERMOPLASTIC COMPOSITES **C LEKAKOU**

The large volume market of thermoplastics, the wide range of thermoplastic polymer products and their low cost and ease of recycling seem to attract a lot of interest in the use of thermoplastics in composites products. However, their high viscosity seems to be a major disadvantage in the development of high volume processing techniques. This lecture will focus on the issues involved in the processing of thermoplastic composites, will review the most important processing options and associated materials and outline challenges and opportunities for economic processing.

6. COMPOSITE DESIGN **K T KEDWARD**

To illustrate the evolution of a composite design from the conceptual stage, through to the detailed design state, examples of recent design experiences will be used. Specific topics including joints and attachments, curved and tapered geometrical features will be treated. The contemporary approach to design, based on an integrated product development philosophy, will be described. Through the lecture, both the advantages and the limitations inherent to composites will be featured. Also, the fundamental differences between design with composites vis-à-vis design with metallic alloys is incorporated in the presentation.

7. JOINING & REPAIR **K T KEDWARD**

For composites to be accepted as a competitive material system in the manner evidenced by recent major shifts from aluminium alloys (for applications in aircraft wing and fuselage structures), it is essential that the principles of joining introduced in the previous lecture can be extended to major structural attachments between composite components and between composite and metallic components. Both mechanical and adhesively-bonded joints will be discussed, and applications of repair concepts are included to emphasis the inevitable critical nature of such connections.

8. APPLICATIONS IN AEROSPACE **K T KEDWARD**

A selection of aircraft, aero-engine, and spacecraft applications are utilized for the purpose of demonstrating the potential opportunities together with the hazards arising from environmental factors including fatigue/durability and safety/damage tolerance issues. This lecture will supplement and stimulate activities in the tutorial/exercise class, which will include considerations of helicopter drive shafts, large engine fan blades, the space shuttle remote manipulator system and pressure vessel examples.

9. APPLICATIONS: GENERAL ENGINEERING AND LAND TRANSPORT M G BADER
The concept that composites are expensive specialised materials viable only in "High-Tech" applications no longer holds. The general engineering, land transportation and infrastructure sectors are now growing a greater rate than are aerospace, military and sports, which have traditionally sustained the composites market. Applications are driven by the need to reduce component mass, increase durability, and improve manufacturing efficiency, always at an economic cost. These factors will be emphasised by consideration of a number of recent applications.

10. OVERVIEW OF STRUCTURAL HEALTH MONITORING P LLOYD
Structural monitoring systems have existed for a long time in some specific applications. However recently there has been a considerable upsurge in interest in the technologies for monitoring a wide range of high value structures. This lecture will outline the drivers for implementing structural monitoring systems and the benefits that their use can bring. A number of limitations remain and these will be discussed together with some possible solutions.

11. INTRODUCTION TO SMART SYSTEMS FOR COMPOSITES G FERNANDO
The lecture will present a brief overview of past and current directions of Smart Sensor systems and materials of specific relevance to composites. Elements of this lecture will be developed in detail by subsequent speakers over the remainder of the module.

12. BASIC PRINCIPLES OF GUIDED WAVES AND OPTICAL FIBRES G T REED
This lecture will introduce the concept of guided waves via a simple planar waveguide model. This will allow the development of the concepts of guided modes, propagation constants and propagating fields in a simple way. These concepts will then be translated to the more complex circular waveguide, the optical fibre, to develop an understanding of modes in optical fibres. The differences between traditional types of single mode and multimode fibre will be discussed, as well as the differences between step index and graded index fibres, and the concept of dispersion in optical fibres. Mode profiles, acceptance angle and polarisation issues will also be discussed.

13. OPTICAL MEASUREMENT SYSTEMS (DISTRIBUTED AND POINT) A ROGERS
Optical fibres offer many advantages for measurement sensing: they are thin (and thus unobtrusive), flexible, dielectric, insulating, chemically inert and easily installed, retrospectively if necessary, on to a wide variety of civil-engineering and industrial structures. The optical properties of fibres are influenced by a large range of external parameters, allowing many measurand fields to be accessed. Point, quasi-distributed and fully-distributed systems all are possible. In distributed sensing the value of the measurand field is determined also as a function of position, thus providing measurement information in both space and time.

14. OPTICAL SENSORS FOR PROCESS MONITORING G FERNANDO
The focus of this lecture is to review the general cure or cross-linking reactions and to explore optical fibre-based sensor system that can be used for real-time process monitoring. The advantages and disadvantages of such sensor systems are discussed.

15. OPTICAL SENSORS FOR STRAIN AND DAMAGE MONITORING S L OGIN
Optical sensors of many types are readily incorporated in a wide range of composite materials and structures to monitor strain changes and damage development in service (such as matrix cracking and delamination). A wide range of optical sensors for composite

applications will be discussed including sensors based on intensity techniques, interferometric and polarimetric techniques, fibre Bragg gratings and optical time domain reflectometry.

16. PRACTICALITIES OF SENSOR FABRICATION R CHEN

Whilst a range of fibre optic-sensor systems can be purchased from commercial sources, in-house fabrication of optical fibre sensors can offer cost savings. This module will review the fabrication processes associated with optical fibre sensors.

17. OPTICAL SELF-SENSING CONCEPTS AND DEPLOYMENT G FERNANDO

This is a two-part lecture where the first part will review developments in the so-called self-sensing composites. The second part of the lecture will consider practical planning issues associated with the deployment of sensors in service.

18. COMMERCIAL PERSPECTIVES ON IMPLEMENTING OPTICAL SYSTEMS C DOYLE

Optical fibre sensors are making the transition from being the subjects of research and development to objects of real commercial use. So far, the most successful applications have been in areas where alternative sensors are either unsuitable or simply not cost effective. Case studies from the fields of civil engineering, oil and gas extraction and renewable energy generation will be used to illustrate particular advantages of optical sensors. Likely future market areas and sizes will be discussed.

19. DIELECTRIC MONITORING OF CURE IN THERMOSET POLYMER SYSTEMS. R A PETHRICK

Many of the systems which are interesting for composite manufacture contain polar entities. The mobility of the system can be observed through the observation of the changes in the mobility of these dipoles. As a system is cured so the mobility of the dipolar species decreases and this allows changes in the local viscosity of the matrix to be inferred.

20. SHAPE-MEMORY ALLOY COMPOSITES S L OGIN

The unusual mechanical characteristics of shape-memory alloys such as NiTi (i.e. the shape-memory effect and superelasticity) make such alloys ideal candidates for incorporation into composite materials to produce a wide range of novel effects related to vibration, impact damage limitation and composite actuators. In this lecture, the relevant properties of shape-memory alloys will be introduced and the principles underlying the behaviour of shape-memory alloy composites will be explained.

21. SELF-SENSING AND SELF-HEALING SYSTEMS S A HAYES

This lecture will cover two related, but independent topics, those being self-sensing and self-healing of composites. Repair of composites is inevitably an invasive process as the damage is generally located deep within the structure. Consequently, several healing systems have been implemented, based on liquid-resin encapsulation techniques or modified resin chemistry, that allow the composite to repair the damage with minimal intervention. Each of the approaches will be reviewed and the pros and cons of each considered. Self-sensing is a process by which the material itself is induced to give information upon its damage-state without the need for additional sensing elements such as optical fibres. Methods for this will be introduced, and the state-of-the-art presented. Ways of combining self-sensing and self-healing to give a truly smart material will be discussed.

22. PIEZOELECTRIC SENSOR SYSTEMS T W BUTTON

Piezoelectric ceramic materials have become an integral part of modern technological life. In particular, their properties have been exploited in diverse applications from gas igniters, medical ultrasound imaging, sonar, advanced sports equipment, camera focusing systems, and car reversing sensors to accelerometers (airbags), thermal imaging, surface acoustic wave devices (high frequency telecommunication filtering), and embedded Smart Systems for active vibration control. This lecture will introduce some of the important scientific concepts in order to understand how the materials are used in some of the applications. A series of demonstrations linked to the lecture will be used to illustrate fabrication routes for this important group of ceramic materials and show how, with using novel processing techniques, new and novel devices can be realised.

SESSION FOR MSc CANDIDATES **S L OGIN/ M A BAKER/ D A SAUNDERS**

THE LECTURERS

JOINT COURSE DIRECTORS AND LECTURERS

Dr STEPHEN OGIN: Reader in Composite Materials and Smart Systems in the School of Engineering at the University of Surrey. Dr Ogin began work on composite materials as a postdoctoral researcher in the Engineering Department of Cambridge University in 1982, before joining the University of Surrey in 1985. Currently, his research interests lie in the areas of damage mechanisms and design allowables in composite design, and in the development of smart composite materials using optical sensing technology or shape-memory alloys. He has worked on optical fibre systems for damage monitoring for the past 10 years.

Professor GERARD FERNANDO: Professor Fernando, who is based in the Department of Metallurgy and Materials at the University of Birmingham, has research interests in the design and development of optical fibre-based sensor systems for chemical process modelling and structural health monitoring of fibre reinforced composites.

LECTURERS

Professor MICHAEL BADER: Emeritus Professor in the School of Engineering at the University of Surrey. He has been engaged on research into several aspects of composite materials for more than 30 years. These include the processing and properties of short-fibre reinforced thermoplastics, damage development in laminates, statistical aspects of strength of fibres and composites, metal matrix composites and process modelling for both polymer and metal based systems. He has published extensively and lectured in four continents.

Dr TIMOTHY BUTTON: Reader in Functional Materials at the University of Birmingham, and Managing Director of Applied Functional Materials Ltd, a spin out company from the University. He leads research within the Functional Materials Group at the University with interests in a wide range of functional ceramics particularly ferroelectric thick films, micro-wave dielectrics, high temperature superconductors (HTS), net shape fabrication techniques and 3-D piezoelectric sensor and actuator devices. He is author of over 160 publications.

Dr RONGSHENG CHEN: Dr Chen is a research fellow in the Department of Metallurgy and Materials at the University of Birmingham. He has designed and developed a number of fibre optic sensors and devices over the past decade.

Dr CRISPIN DOYLE: Chief Engineer, Smart Fibres Ltd. Dr Doyle gained a PhD from Brunel University, working on optical fibre vibration sensors for damage detection in composites. He took up a lecturing post in the Sensors and Composites Group at the Royal Military College of Science, researching the use of fibre-optic sensors for processing and health monitoring of fibre-reinforced polymer composites. Dr Doyle joined Smart Fibres in 2003 and is currently responsible for R&D and applications engineering.

Dr SIMON HAYES: Lecturer in the Department of Engineering Materials at the University of Sheffield. He gained his PhD at Brunel University working on Self-Sensing of Damage Using a Novel Optical Sensor System. After a period of further research work examining fibre-matrix adhesion in model composites, he took up his current position in 2000. His research interests lie within the field of smart composites, and nanomechanical testing of polymeric materials. He has filed patents on both self-sensing and self-healing within composite structures.

Professor KEITH KEDWARD: Professor of Design Engineering in the Department of Mechanical and Environmental Engineering at the University of California, Santa Barbara. Previously Vice-President of McDonnell Douglas Technologies Inc, San Diego; Director, Materials Sciences Corporation, California; Engineering Chief, General Dynamics, San Diego and Head, Compressor Research Dept, Rolls Royce Ltd, Derby. He has participated in many composites courses given within the USA, Australia, South Africa, Switzerland and England (Universities of Surrey and Cambridge). Most recently, he has contributed to industry-based composites courses at Boeing, Goodrich, United Technologies, and at NASA. He is a widely-regarded expert on structural design and analysis for composites and adhesively bonded joining, having published numerous articles and presented many invited keynote lectures in international venues.

Dr TINA LEKAKOU: Senior Lecturer in the School of Engineering at the University of Surrey. She gained her PhD at Imperial College in reaction injection moulding. After a further period of research on multi-phase systems in the Mechanical Engineering Dept., she took up her present appointment in 1989. Her current research focuses on the study of polymer and composite processing and the molecular modelling of polymeric materials.

Dr PETER LLOYD: Specialist advisor within the Defence Science & Technology Laboratory in the areas of smart and multifunctional materials and aircraft airworthiness. He has been involved for many years in research in non-destructive testing, military aircraft airworthiness and smart materials. He has contributed to a number of national and international projects on structural monitoring.

Professor RICHARD PETHRICK: Professor Pethrick is Professor of Chemistry at the University of Strathclyde. He has been using dielectric techniques for over twenty years to study mobility in polymer systems. He is a Fellow of the Royal Society of Edinburgh, the Royal Society of Chemistry and of the Institute of Materials, Minerals and Mining. He has published over 450 papers on many aspects of polymers and in particular the relationship between their chemical structure and physical properties.

Professor GRAHAM REED: Graham Reed is Professor of Optoelectronics at the University of Surrey. He obtained a PhD in Integrated Optics in 1987. After a brief period as leader of the Electro-Optics Systems Group at ERA Technology Ltd, he joined the University in 1989, where he established the Silicon Photonics Group. Professor Reed has published extensively in the international scientific literature, has presented at numerous international conferences and has served on a variety of international committees. Recently he has co-authored the first textbook on silicon photonics, entitled Silicon Photonics: An Introduction.

Professor ALAN ROGERS: After a PhD in Radio Astronomy and Space Physics, he subsequently became Professor of Electronics at King's College London in 1985, leading a group working on optical sensors, non-linear optics and optical signal processing. From 1991 to 1996, Alan was Head of the Department of Electronic and Electrical Engineering at King's College London, and in 2001 he moved to the Department of Electronic Engineering at the University of Surrey. He has published 197 papers in learned journals, initiated 14 patents, and ‘Polarmetrix’, a spin-off company from the University of Surrey, was launched in 2003 to exploit the commercial potential of distributed optical-fibre sensors.

Professor PAUL SMITH: Professor of Composite Materials in the School of Engineering at the University of Surrey. Professor Smith graduated from the Engineering Department at the University of Cambridge where he subsequently gained his PhD working on joints in composite materials. He joined the University of Surrey in 1986 and his current research interests are concerned with experimental characterisation and analytical modelling of failure processes in a range of materials, in particular composites, with a major aim being to develop mechanism-based models for use in engineering design. He has published extensively and lectured in the UK and overseas. He is Editor-in-Chief of the journal Composites Part A.

MODULAR MSc PROGRAMME

This short course is offered as a module in our part-time or full-time Modular MSc Programme 'Advanced Materials'. Further details of our programme can be found on our web pages: http://www.surrey.ac.uk/eng/pg/mse/

COMPOSITES RESEARCH AT SURREY

The Composite Materials Research Group has been established for more than 20 yearsl. Research is pursued on a wide range of topics, covering virtually the whole spectrum of composites. These include composites with polymeric, metallic and ceramic matrices and systems reinforced with continuous fibres, short-fibres, whiskers and particulates. The main emphasis has been on mechanical properties and damage mechanics but now encompasses probabilistic studies of strength, process modelling and 'smart' measurement techniques. Most of our research is sponsored by industry or research establishments and we contribute to a number of continuing education programmes both at Surrey and in other universities.

Research Facilities

The Group has always emphasised high-quality experimental studies on well characterised materials. Facilities have been developed for the manufacture of both metal and polymer matrix composites. A pilot scale pre-pregger is used for making small quantities of pre-preg with special fibres and matrices. These may then be consolidated by press or press-clave moulding. Metal-matrix composites may be made by powder metallurgy or liquid-metal infiltration techniques. These fabrication facilities are complemented by a full range of quasi-static and fatigue testing machines, capable of testing anything from single fibres to full thickness laminates at loads from 1 N to 250 kN. These are backed up with characterisation techniques including acoustic-emission, X-radiography, ultrasonics and a full range of optical and electron microscopy.

The School is very well equipped for the study of composite materials. In addition to a comprehensive range of equipment for mechanical testing, including fatigue, creep and environmental testing, facilities are available for a wide range of structural studies and non-destructive testing. The Microstructural Studies Unit (MSSU) has one of the most comprehensive ranges of electron microscopes and associated instrumentation to be found in any research institution. Likewise, the Surface Analysis Laboratory directed by Professor J F Watts is recognised as one of the leading groups in the world.

COMPOSITE MATERIALS TECHNOLOGY
University of Surrey, Guildford, UK
12 - 16 JUNE 2006

Name ....Title………………………..

Company/Affiliation:...

Address:...

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Name of Approving Manager: ....

			£
1.	**STANDARD COURSE FEE**		1020.00
	each delegate will receive one set of Lecture Notes		
	Reduced fee for <u>registered</u> MSc students		995.00
2.	**MEALS - Coffee, Lunch, Tea**		
	from Coffee 12 June – Lunch 16 June	5 days	50.00
3	**PARKING** @ £2 per day (if required)		10.00

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Special dietary requirements, if any ....

Cheques should be made payable to the "University of Surrey" in £ sterling.

<u>This form should be returned to:</u>

Rebecca Jones
School of Engineering (D3) , University of Surrey, Guildford Surrey GU2 7XH

Tel: 01483 689612 - FAX: 01483 686671 - E-mail: RF.Jones@surrey.ac.uk

PLEASE REGISTER BY **FRIDAY 26 MAY 2006** ALTHOUGH LATER REGISTRATIONS WILL BE ACCEPTED IF PLACES ARE AVAILABLE