micro&nano NEWSLETTER

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Editor Jon Newey (e-mail: mnt.news@pera.com)
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Dirac House, Temple Back, Bristol BS1 6BE, UK. Tel: +44 (0)117 929 7481.
E-mail: kerry.hopkins@iop.org. Fax: +44 (0)117 930 0733. Web: iop.org.
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Editorial

Europe is waiting for your proposal

There's a decidedly European theme to this issue of the newsletter, with a two-page article about European funding and a couple of news items concerning the start of new collaborative projects. The timing's no coincidence, with the timetable for proposals for funding from European Framework Programme 7 (FP7) probably having been released by the time you read this. Now is the time to give the subject of European funding some serious consideration.

Funding from Europe is a rather dry subject and it's difficult to make it sound any other way. The article on pp6–7 is an introduction. Much of the detail for FP7 has yet to be released at the time of writing, so the article is necessarily rather generic. However, it's a good guide as to how it all works and what to expect. As you will see from some of the numbers quoted in it, it's worth persevering with, especially if you work in micro- and nanotechnology. FP7 contains a significant increase in funding over FP6, with €32 billion over the next seven years, including €12.5 billion to be spent on the two themes that are directly relevant to MNT.

The proportion of FP funding devoted to nanotechnology has risen sharply in the last few years. Given that UK organisations benefited to the tune of about €50 million per year, representing about 11% of the spend, during FP6, and that the FP7 pool of funds will be larger than FP6's, the UK MNT community should be primed for action. We'll be keeping tabs on how FP7 is developing and bringing you updates from the UK's National Contact Points for FP7 in future issues.

Jon Newey *is editor of* micro&nano newsletter.

Medicine

UK scientists will lead DVT- and PE-detection project

The European Commission Information Society and Media Directorate General has awarded £3.3 million to a consortium of 11 leading European research and technology firms to develop a prototype hand-held medical, negative diagnostic prototype device for patients suspected of suffering from deep vein thrombosis (DVT) and pulmonary embolism (PE). These conditions claim more than a million lives each year in Europe. In addition to the £3.3 million from FP6 the consortium partners will contribute £2.2 million.

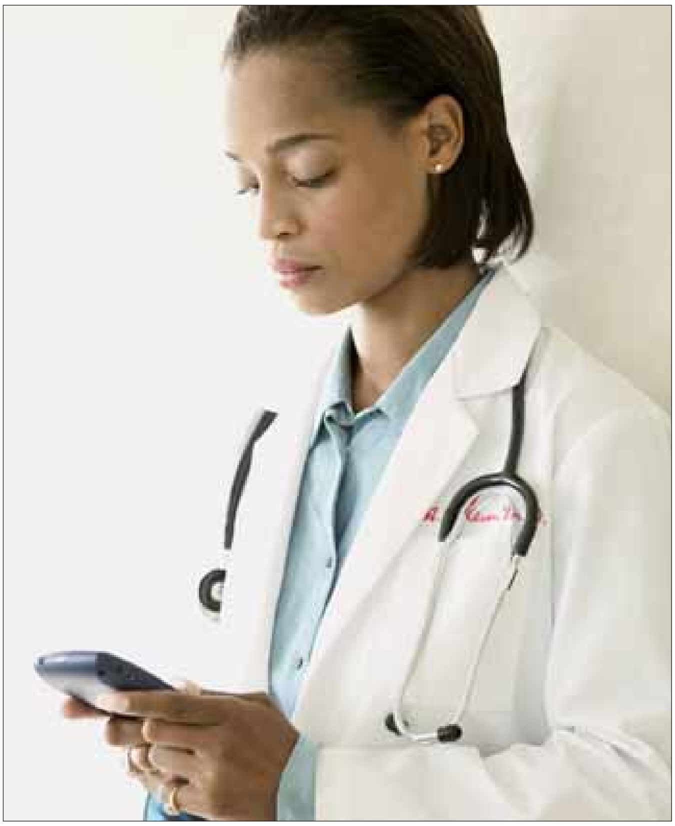
The DVT/PE diagnosis effort will be led by Cenamps, a UK national centre for emerging small-scale technologies; Helena Biosciences, a medical devices firm; and the University of Teesside. Other members of the project team include Haptogen, a leading biopharmaceutical spin-out from the University of Aberdeen; the Fraunhofer Institute; the Parc Cientific de Barcelona; Claude-Bernard University-Lyon; Comenius University; Budapest University of Technology & Economics; and Universite Paris-Sud.

Staff from AntiCoagulation Europe (ACE), a charity that offers information and advice to people on oral anticoagulation therapy, will work closely with the consortium as both advisors and observers.

Cenamps' involvement is in keeping with its remit to bring forward new technologies – something that it's already demonstrated through the establishment of a national Polymer Electronic Technology Centre in north-east England.

The DVT-IMP consortium is working to improve both the reliability and the accuracy of the early-stage detection of DVT/PE through the use of conducting polymers for the low-cost and rapid production of printable biosensors.

"Our consortium approach is to combine the latest developments in biotechnology with advances in materials science and computing," said Prof. Andy Porter, chief scientific officer at Haptogen. "Our science facilitates this fusion of biology with technology to allow the rapid diagnosis of DVT at a patient's bedside or possibly, in later versions, in their own home."



Taking diagnosis in hand: portable, hand-held diagnostic instruments have the potential to identify DVT and PE and thus prevent thousands of deaths.

DVT: the silent killer

Around 80% of all deep vein thromboses have no clinical signs. PE is also often silent, it is life threatening and it largely originates from DVT. Failure to diagnose and treat DVT/PE has made it the most common cause of unexpected death in hospitalised patients in most developed nations. In these countries it is estimated that health-care systems invest up to £6.6 billion annually in the DVT diagnosis of suspected patients who then turn out not to be suffering from a thromboembolic event.

The current medical devices used to test for DVT yield a large number of false positives. Many accident and emergency units are referring increasing numbers of patients who are suspected of acute venous thromboembolism for diagnostic imaging. This has major cost and workload implications and only 20–30% of patients presented with suspected DVT actually have a demonstrable thrombosis.

Contrast venography for DVT and pulmonary angiography for PE remain the diagnostic gold standards, but these are expensive and invasive. Doppler ultrasound (DUS) is non-invasive and thus usually preferred, but it is much less sensitive. Patients may have to wait days for DUS examination and in the meantime are administrated the drug heparin. This not only carries the risk of side-effects but can also reduce the size of the thrombosis such that the DUS examination fails to detect the forming thrombosis, leading to an incorrect diagnosis and subsequent withdrawal of the appropriate treatment.

Micro- and nano-solutions

The shared aim of the consortium is to develop a mobile and hand-held medical diagnostic prototype device that can be used by medical practitioners for DVT/PE prognosis in any primary point-of-care situation, including the patient's home, through creation and integration of new bio-nano-micro-informatic technologies. The device will have significant predictive capabilities across the entire range of both positive and negative tests.

The scientific goal of DVT-IMP is to advance and integrate four key bio-nano-informatics technology areas further:

- bioengineered D-dimer antibodies for high-specificity immunoassay diagnostics, using technology owned by Haptogen, a consortium member of DVT-IMP;
- nano-/microengineered impedimetric analysis electrodes incorporating biocompatible conducting polymer substrate for enhanced D-dimer detection capabilities;
- development and packaging of a disposable, robust, sterile, microfluidic manifold specifically enabling diagnostics at the point of first contact;
- development of e-Health medical diagnostic software for high positive and negative predictivity for D-dimer tests.

The resulting technologies will be deployed to develop a whole-blood, low-cost D-dimer medical diagnostic device that can be used at primary point-of-care locations, including hospitals, local clinics, accident and emergency units, doctors' surgeries, paramedics, outpatients, home visits and self-testing to individually prescribed patients.

Training

MapTech initiative strengthens skills

Cenamps has been working successfully with European partners to establish and secure a European FP6 Marie Curie project called Training for Micro-Analytical Platform Technology (MapTech).

Marie Curie fellowships are a funding vehicle aimed at helping the mobility of researchers across Europe. MapTech is an integrated training programme that will provide talented early-stage researchers with the opportunity to gain specialist experience that blends scientific research, commercialisation, economic development andtechnology development, focusing specifically on emerging microanalytical systems, biosensors and nanotechnologies.

The project brings together host institutions that have established research laboratories in this area of technology and it will facilitate the flow of researchers, expertise and technology between the institutions using a multihost training site.

Specifically, the MapTech consortium and training partners aim to strengthen individuals' skills, know-how and capabilities in plastic electronics and nano-/ microanalytical systems on polymers, metals, silicon and other substrates.

A key element of MapTech is that researchers will be expected to spend a significant period of training at institutions other than their primary host, thereby strengthening cross-border collaborations. Training and mentoring incorporating a number of exchange periods will be available to PhD students enrolled on programmes at the host institutions of Cenamps, the University of Teesside, Parc Cientific de Barcelona, Fraunhofer and VTT Technical Research Centre.

Specifically included in MapTech are aspects outside the normal remit of academic scientific research to expose students to the commercial and economic aspects of their work, including project management, new product development, innovation and enterprise, intellectual property, technology and ethics, economic development and business start-up.

Nanomaterials

Oxonica wins major customer

Nanomaterials specialist Oxonica has entered into an agreement with a Turkish company to supply its Envirox fuel-borne nanocatalyst. Petrol Ofisi, the leading national oil company in Turkey with 2005 sales of $8.8 billion, will use Envirox across its nationwide diesel distribution network.

The agreement provides for an initial supply of Envirox, which will be used by Petrol Ofisi to evaluate market acceptance of the new enhanced fuel within its national market.

The deal is expected to generate sales for Oxonica of $12.7 million this year. Following the marketing evaluation, the company expects to be in a position to indicate likely levels of ongoing demand in early 2007.

Oxonica, Petrol Ofisi and Oxford University will also jointly develop new catalysts for the petrochemical industry.

Envirox has been shown in field trials to reduce fuel consumption in diesel engines with savings of 5–10% with commensurate reductions in CO_2. It also reduces particulate emissions by up to 15%.

Although this is the first agreement of its kind for Envirox, Oxonica has a good record in finding major customers in large markets for its nanomaterial products. This latest customer could add significantly to the company's sales in future.

Facilities

Welsh minister opens the MicroBridge facility

Welsh Assembly Minister for Enterprise, Innovation and Networks, Andrew Davies, officially opened the £7.5 million MicroBridge facility at Cardiff University's Manufacturing Engineering Centre (MEC) on 12 October.

The MEC won funding for MicroBridge through the DTI's MNT Capital Facilities programme, the Welsh Assembly and industry. MicroBridge's work is aimed at the miniaturisation of components for industry, enabling precision engineers in manufacturing to work to the same microscales as those in electronics. Facilities include focused ion beam milling and laser ablation tools. Engineers using MicroBridge are able to work with any materials, leading to even greater reductions in the size of products and associated benefits.

In control: Andrew Davies and one of MicroBridge's laser ablation systems.

Instrumentation

Malvern and FEI join forces

FEI Company (Oregon, USA) and Malvern Instruments Ltd (Malvern, UK) have entered into a joint development and marketing programme for advanced nanoparticle analysis using Malvern's particle image analysis software on FEI's line of Quanta SEMs. The combination delivers a powerful particle analysis tool that extends current analysis technologies for nanoparticles.

Malvern's particle image analysis software will be optimised for FEI's Quanta SEMs. The deal extends the utility of the software, which is already used on Malvern's systems of traditional optical microscopes, such as the Morphologi G2. These systems provide rapid data on particle size and morphology, and they yield distribution profiles for quality control and manufacturing applications.

Rationalising batch-to-batch variation of materials, and identifying crystal polymorphisms and foreign bodies are just some of the current applications. However, the software will now be used on FEI's systems, which image significantly beyond the limits of optical microscopy.

Communication

Internet offers meeting rooms

Members of the UK MNT Network should be aware by now that Interwise, the online communication tool available on the MNT Forum, was recently upgraded. A new feature is the "My Meeting Room" capability.

All registered members can obtain a unique ID number for their own meeting space. This provides a means of holding online discussions in complete privacy at the touch of a button.

Just send the unique link to your "meeting space" to colleagues/ associates around the world and hold online conferences with the same ease as using the telephone. A limited number of free PC headsets are still available (e-mail: mntevents@ mntnetwork.com).

Facilities

Plastic electronics centre to start construction in 2007

County Durham is to be home to a new Plastic Electronics Technology Centre (PETeC), thanks to £10 million in funding. The centre will make clean-room facilities and expertise available to companies and universities involved in the research and development of plastic electronics.

Such work will include the development of inkjet and screen-printing technologies to enable electronics to be printed directly onto thin plastic sheets, which are manufactured close to PETeC's Sedgefield site by DuPont Teijin Films.

The funding has come from ERDF, One NorthEast and County Durham Economic Partnership and the project will be managed by Cenamps. Key partners will be the Centre for Process Industries, the universities of Durham and Newcastle and Thorn Lighting.

The first phase of the project, beginning in early 2007, will involve the construction of a 3000 sq. m facility equipped with class 10 and 100 clean rooms, laboratories, offices and seminar rooms.

An artist's impression of the new plastic electronics centre.

Medical devices

Akubio wins grant for disease-detection device

Cambridge nanotechnology firm Akubio, has received an £826 000 government grant to support the development of a portable and low-cost, rapid-response disease-diagnosis device, which could help doctors to make instant and accurate diagnoses for diseases such as malaria and meningitis.

The three-year £1.65 million development programme is part-funded by a collaborative R&D grant under the Department of Trade and Industry's Technology Programme. Akubio's partners in the project are the University of Cambridge and Melton Mowbray-based magnetic particle firm Reagent Mine Ltd.

Akubio, which was founded in 2001 as a spin-out from the University of Cambridge, develops acoustic biosensor instrumentation using resonant acoustic profiling (RAP), which enables the real-time detection of molecular interactions and can be applied in many fields

Using RAP means that the new device will be substantially different from other diagnostic devices currently on the market because these require the addition of expensive chemicals to a sample to enable disease detection. The device uses the quartz crystal element from a simple wristwatch and can be powered by standard batteries. It could enable doctors to make at-the-bedside or in-the-field medical diagnoses from blood or other samples.

Equipment

Radical moves from AML

AML has further strengthened the flexibility of its wafer-bonding tools with the release of its new radical activation technology. This means that users can perform surface activation, wafer alignment and bonding in a single chamber. QinetiQ's Malvern site will be the first customer for the new bonding tool.

The ability to bond wafers at lower temperatures has been a key requirement for many in the MEMS, IC, III-V and optical device industries. Lower process temperatures open up more design possibilities. The introduction of the only single machine process that can activate, align and bond in one chamber brings lower process temperatures and therefore greater process flexibility.

The use of radicals to activate a surface to enable low-temperature bonding offers many advantages over the use of plasmas. Surface activation by plasma has been the main activation route to date but this can roughen the surface, making bonding more difficult and resulting in a very small process window. Radicals are less damaging to any structures present on the wafers and they offer a more stable, reliable, and high-strength bond.

Business

Oxonica is tops for corporate partnership

Nanomaterials specialist Oxonica has been named in a study by industry research company Lux Research as one of four nanotechnology start-ups offering the greatest value for potential corporate partners.

The study analysed 36 venture-capital backed nanotechnology companies using a comprehensive, quantitative methodology for determining suitability for partnership. Oxonica received a score of 85, tied with two other nanotech leaders and was one point behind the highest scorer.

The corporate partnership rankings were developed by Lux with 20 objective criteria spanning four success factors:
- scientific pipeline;
- commercial viability;
- legal and regulatory position;
- operational and financial performance.

The methodology also incorporated qualitative criteria, such as the strength of the companies' management teams.

Medicine

ESF launches nanomedicine conferences

The European Science Foundation (ESF) has produced a major scoping paper that addresses nanomedicine and makes essential background reading for anyone involved in the field. ESF's "Forward Look" on nanomedicine is available on its website (www.esf.org). The complementary EC paper, the "European technology platform on nanomedicine", is available at Cordis (http://cordis.europa.eu/nanotechnology).

To support the drive to develop the European consensus obtained through these documents, the ESF has begun a biennial series of nanomedicine conferences, the first of which was held at Sant Feliu de Guixols, Catalonia, on 15–20 September. This attracted scientists from a range of disciplines from the academic, industrial, ethical and regulatory sectors, in an enriching and cross-fertilising atmosphere. The event focused on discussion of up-to-the-minute research presentations.

The UK was well represented by about 25% of participants, indicating the strength and importance of UK nanomedicine globally. As a result of its prominent involvement and representation, the UK has been chosen to host the ESF Nanomedicine Summer School in Wales in 2007. The next ESF conference on nanomedicine will be held on 19–24 September 2008 in Barcelona. Contact Julie Deacon (e-mail: julie.deacon@mntnetwork.com), who continues as co-chair for the next meeting, if you would like to get involved.

For a full conference report, see MNT EU publications at www.mntforum.com.

Overseas collaboration

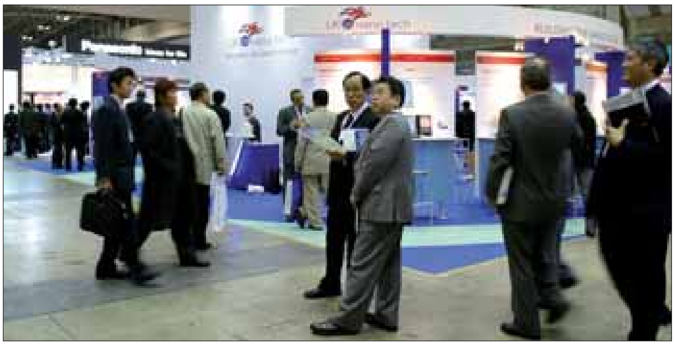
Nano network goes global

Through close collaboration with UKTI, DTI and the Regional Development Agencies the UK MNT Network continues to ensure that the UK's world-class commercial and academic MNT expertise is on show at major international events. As a result, UK nanotechnology R&D and companies featured strongly at Tokyo Nanotech in 2005 and 2006, resulting in new international business for participating UK nanotech firms.

As this issue went to press, a major inward mission, UK NanoForum, was taking place in London. This exhibition and partnering event was organised by UKTI and the UK MNT Network to introduce major overseas companies to the UK's growing commercial nanotechnology sector and the research and manufacturing infrastructure that has been established through the activity of the UK MNT Network.

The network has also been at the forefront of international strategy development in the nanotechnology sector, especially in the area of nanomedicine. It has contributed to the development of the "European technology platform on nanomedicine and innovative medicine", which was launched in September 2005. This key document influenced the scope of the subsequent EC Strategic Research Agenda. As a result a strong platform has been established for UK participation in the EC FP7 R&D programme.

The UK MNT Network is now building on this important platform and engaging with potential European R&D partners to ensure that the UK makes optimum use of the excellent opportunities under FP7 in nanomedicine.



Going Japanese: The UK Nanotechnology Pavilion at Tokyo Nanotech.

This activity resulted in the initiation of a Franco-British Nanomedicine Summit in early November in Paris. This was a key partnering meeting, organised to provide the opportunity for British and French R&D organisations and nanomedicine companies to discover the background to FP7's nanomedicine programme funding and to engage in the important activity of identifying potential partners for collaborative research. The summit will be the template for further partnering events across Europe, which will follow in the first quarter of 2007.

For more details, contact Julie Deacon (e-mail: julie.deacon@mntnetwork.com) or Steve Dennison (e-mail: stevedennison@mntnetwork.com).

Events

Network launches new nanomedicine seminars

The UK MNT Network has extended its meetings schedule to launch a series of nanomedicine seminars to promote the integration of the UK's exceptional nanomedical research base with industry and to enhance the commercial exploitation of nanomedicine. Already the field is bringing revolutionary advances to health care in, for example, medical diagnosis, nanosensors and targeted therapies.

The series of one-day seminars will bring together experts from academia and industry to present the latest developments and key commercial issues that impact on a specific sector of nanomedicine. The emphasis will be on addressing the technical requirements to enable effective commercial exploitation by bridging the technology gap between exciting scientific developments in academia and the realities of the commercial world; and identifying engineering solutions that will enable new products to be realised.

Dates and themes for the next three seminars are:

Micro and Nanotechnology in the Development of Smart Implants 7 December 2006

Nanotechnology in Diagnostics 25 January 2007

Nanotechnology in Drug Delivery 15 March 2007

All seminiars will take place at IMechE, 1 Birdcage Walk, London SW1H 9JJ. For further information, contact Stephen Dennison (e-mail: stephen.dennison@mntnetwork).

Publication

Online success

MNT Bulletin has been launched online to provide an archive of all of the news from the MNT *e-News Bulletin*. The response to it has been astounding with more than 3500 views in its first two weeks. The bimonthly publication is expected to become the main resource for trade news for the UK, so make use of the free service and e-mail promotional press releases to mntnetwork@mntnetwork.com. Download the *MNT Bulletin* free of charge from www.mntnetwork.com.

How to secure EU funds for

The UK is a major beneficiary of European research money despite the challenges that participating in Europe can often present. With the new Framework Programme 7 promising many opportunities for MNT, **James Johnstone** outlines the basics on how to gain access to European funding.

Participation in collaborative research within the European Framework Programme (FP) with the best researchers in Europe can help a company to develop more competitive products and services and can also facilitate access to European and global markets. However, participating in EU research programmes presents a whole new language that can take some time to understand, but once mastered the opportunities revealed can turn into long-lasting benefits.

UK organisations already participate strongly in Europe and have gained an approximately 11% share of the available funding, which amounts to around €50 million per annum in the FP6 nanotechnology, materials and production (NMP) theme alone. Although NMP also covers materials research and production technologies, the pervasive effect of nanotechnology has meant that its influence is seen in the majority of the funded projects. In the information society and technologies (IST) theme there was also substantial funding available for microsystems and nanoelectronics.

The level of investment in nanotechnology research has been growing sharply in recent years. A recent report highlighting how the funding is currently being spent has shown that the majority is taken by nanoelectronics with large rises in spending in the IST thematic area. The rationale for the interest in nanotechnology can be traced to the Commission's Nanoscience and Nanotechnology Action plan (see http://cordis.europa.eu/nanotechnology/actionplan.htm).

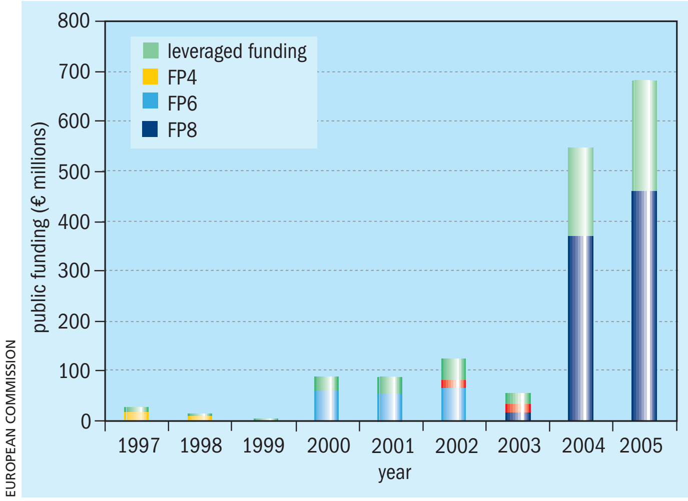
Framework Programme 7

The four areas of Framework 7, known as specific programmes, comprise "co-operation", "ideas", "people" and "capacities". The area on "co-operation" where most of the opportunities for collaborative research can be found is the largest, while "people" continues support for the Marie Curie fellowships to fund mobility of researchers across Europe.

The area on "ideas" is completely new and will support a European Research Council to fund research groups at the frontiers of knowledge, while "capacities" will provide support for European research infrastructure. It is expected that MNT will be one of the key technologies to benefit in both of these programmes. Alongside the FP the new Competitiveness and Innovation programme will support downstream activities to stimulate further the Lisbon agenda for the development of a knowledge-based European economy, in three areas:

- entrepreneurship and innovation;
- ICT;
- intelligent energy.

In developing individual work programmes, the commission has taken into consideration the Strategic Research Agendas of the European Technology Platforms (ETPs) developed during FP6. Several of these are in key technologies relevant to MNT (e.g. the European Nanoelectronics Initiative Advisory Council (ENIAC) and the platforms for nanomedicine, photonics, photovoltaics, hydrogen and fuel cells, and robotics. These platforms comprise a variety of stakeholders and have received strong encouragement from the European Commission to define the research needs of the sectors or the technologies concerned in the medium to long term.



Evolution of FP funding for nanotechnology R&D, including known funding leveraged by full-cost participants. (2005 data are an up-to-date estimate.)

For more information, see http://cordis.europa.eu/technology-platforms/home_en.html.

Funding schemes

The main methods of participation in the area on "co-operation" have been simplified and now consist of Collaborative Projects and Coordination and Support Actions, although there will be options for large and small/medium collaborative projects. Networks of Excellence used as a structuring tool to integrate leading-edge research groups to create world-class research teams will continue in FP7. The Co-ordination and Support Actions (CSAs) will combine the previous Co-ordination Actions and Specific Support Actions in FP6 into one instrument, which will include all of the types of activity previously covered by the individual instruments (e.g. studies for future research needs, stimulation actions and coordination actions). A further change is that the ERA-Net scheme to foster closer ties and eventual joint programming activities between national research funding providers has been brought within the relevant technological areas in the "co-operation" programme.

Joint Technology Initiatives (JTIs), designed to support large-scale public/private partnerships for nearer market activities where existing instruments are unable to achieve the objectives, are another new feature identified mainly in areas covered by the ETPs. Funding will be provided from the FP, national funding sources and the European Investment Bank, but they will be implemented by means other than periodic calls for proposals. Areas currently under consideration related to MNT are nanoelectronics, embedded systems, innovative medicines, and hydrogen and fuel cells, but so far there is little detailed information available about the means of implementation proposed for JTIs.

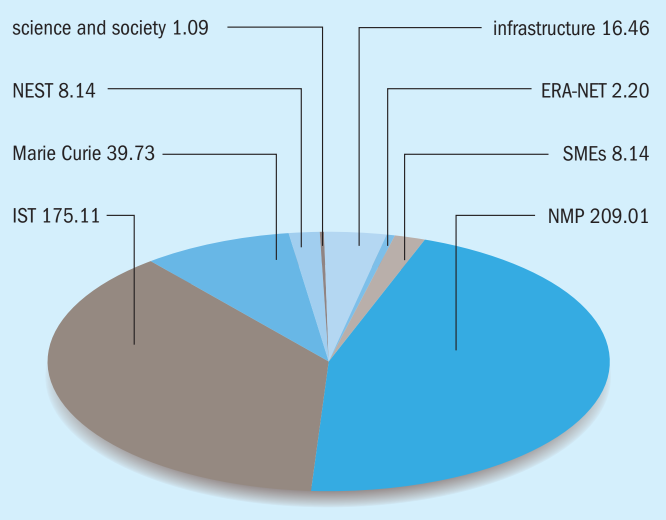
Financing and contracts

A significant increase in funding is proposed for FP7. The 10 thematic areas in "co-operation" will share ~€32 billion over the next seven years with €3.5 billion for NMP and €9 billion for ICT.

Funding for individual projects is subject to strict financial guidelines and procedures emanating from the Rules of Participation, agreed at the beginning of each new programme. The rules proposed by the commission have not yet been formally agreed so it is difficult to give a precise explanation of the details of funding. Three forms of financing have been proposed:

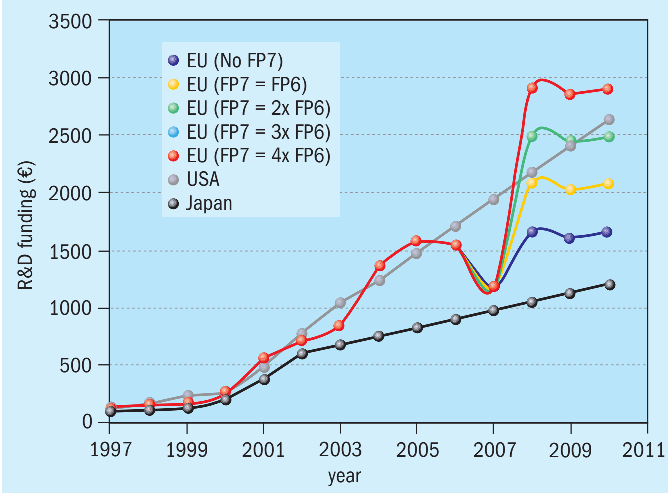
- reimbursement of eligible costs;
- lump-sum payments;
- flat-rate financing.

micro- and nanotechnology



EUROPEAN COMMISSION

FP6 support for nanotechnology R&D in 2005 (in millions of Euros).



EUROPEAN COMMISSION

Projection of absolute EU public expenditure compared with the USA and Japan under different possible FP7 scenarios of funding.

At the beginning of FP7, at least, reimbursement of eligible costs is likely to be the preferred method.

Generally it might be expected that the commission will reimburse 50% of eligible costs for research activities with an additional 25% allowed for SMEs, public bodies, secondary- and higher-education establishments, and not-for-profit organisations, although much will depend on the exact definition of eligible costs. It is also proposed that 100% reimbursement will be possible for frontier research, coordination activities, support actions and training activities for all entities.

The cost models used previously will be abandoned and participants will be able to charge all of their direct and indirect costs with the option of a flat rate for indirect costs. For most actions interim payments are made in advance to the coordinator for distribution to the participants, which means that maintaining a positive cash flow during most of the project lifetime is not an issue.

The system for all partners to accede to a grant agreement similar to that used in FP6 will be continued, which will establish the rights and obligations of participants between themselves and the commission. Normally all participants will be required to sign a consortium agreement that will define, for example, the treatment of IPR issues. The commission maintains that new provisions for IPR should make this process easier than in the past.

Gaining experience

Obtaining funding from Europe can be a daunting experience for beginners and the general advice is to get your feet wet initially, either by partnering in a research proposal or by joining a networking activity where potential partners often discuss and formulate ideas for future proposals. Another way of gaining useful experience is to apply to be an evaluator of the proposals. This gives potential participants an inside view of what a good proposal looks like. The coordination of EU projects is not to be taken lightly because it requires a good understanding of many relatively complex rules and regulations, and the technical and financial reporting requirements are significant.

It is always a good idea to speak to someone who has done it before, perhaps at one of the meetings held in the UK to explain a particular call, where there is often an experienced participant on hand to pass on their own knowledge. There is also a large database of current and completed projects on the Cordis website (http://cordis.europa.eu/fp6/projects.htm), where details of projects and contacts are published, because it is important to know the state of the art, particularly where funding for a related activity has already been provided from the FP. Many of the larger projects also have their own websites. The Cordis site is also the portal where the calls for proposals can be accessed and there is a facility to obtain automatic notification when a new call for a specified theme is issued.

If you haven't taken part in collaborative research previously and feel that Europe is a bridge too far in the short term at least, a good stepping-stone is through participation in the UK Technology Programme because this has some similarities with European programmes and covers related topics.

Formulating the proposal

The crucial documents to read are the Work Programmes issued for each call for proposals, because it is imperative that applications fall within their scope. Once you have identified a suitable call and have all of the supporting documents, you must study them carefully and follow the instructions without exception. Preparing a proposal can take a lot of time and money, so it's worth checking at the outset that your project stands a reasonable chance of success. The best way to do this is to check against the evaluation criteria, which are likely to be similar to those used in previous programmes (i.e. the relevance of the proposal to the call, the quality of the objectives and scientific approach, the potential impact, the quality of the consortium, the quality of management and whether the resources are in place and integrated to form a coherent project).

It's worth bearing in mind that scientific excellence alone will not be sufficient in most cases because there must be partners included in the consortium who are well positioned to exploit the results of the research. Any potential barriers to eventual exploitation should also be considered. At this stage it is also worth consulting with the National Contact Point for the relevant theme. They may also be able to put you in touch with a commission officer for an opinion, although they are not generally obliged to give advice.

Need more help?

As you can see from the above, there's plenty of funding available from the EU for MNT activities. If you're still confused or lack key information, the UK provides a National Contact Point service to help participants through the process. See the FP6UK website (http://fp6uk.ost.gov.uk) for contact details and a summary of FP7.

James Johnstone is with the National Contact Point for Industrial Technologies (NMP) and Peter Walters is with the National Contact Point for Information Society Technologies (IST). Both are based at the National Physical Laboratory. E-mail: nmp@fp6uk.co.uk or is@fp6uk.co.uk.

DPI will streamline your beam time

Beam time for neutron studies is limited by cost and accessibility. **Simon Carrington** and **Maggi Blakebrough** describe an instrument and technique that's finding favour with neutron reflection users.

The future success of the nanotechnology revolution depends on being able to measure nanostructures and their behaviour at ultra-high resolution. Over the last 20 years, neutron reflection has become a powerful technique for studies of surface chemistry (surfactants, polymers, lipids, proteins and mixtures adsorbed at the solid–liquid interface), providing quantitative data about the thickness, mass (surface excess concentration) and density (scattering length density) of interfacial structures.

Many nanotechnology processes occur at interfaces, so the possibility of using neutron reflection to study structural and behavioural aspects of both model and real systems is of considerable interest. Neutron reflection provides subnanometre resolution so information is gained at the molecular level. However, the number of such nanotechnology experiments reported to date is small, primarily because neutron reflection often involves extensive deuterium substitution of samples, and this is not usually an available option in complex molecular systems used in nanotechnology. On top of this, while the number of reflectometers in the neutron facilities around the world are increasing, the technique is not yet common because the availability of beam time is restricted by cost and accessibility.[1]

Farfield Scientific has developed dual polarisation interferometry (DPI), a non-invasive, optical technique offering equivalent measurements of thickness, mass (surface excess concentration) and density (refractive index) at subatomic resolution.[2] The company's AnaLight NanoFlex device is generating interest among nanotechnologists and the wider neutron-reflection community, many of whom number among Farfield's customers. The NanoFlex is used to measure and characterise molecular thin films and nanostructures at the solid–liquid interface on a range of AnaChip surfaces relevant to nanotechnology, biophysics and consumer goods product development.

While neutron reflection will continue to provide the "gold standard" for interfacial measurement for the foreseeable future, DPI is an invaluable complementary support technique, even offering advantages over neutron reflection for some applications. NanoFlex is an automated, benchtop instrument that allows users to perform all of their experiments in their own laboratory in their own time, rather than having to wait for access to beam time at core neutron facilities. DPI is a real-time technique that reveals structural and behavioural information about complex interfacial molecular processes as they happen.

DPI data are quantitative so they can be directly compared with data from neutron-reflection experiments. The data are also of equivalent resolution to those of neutron reflection for all parameters measured: thickness, density and mass. A key advantage of DPI over neutron reflection is that DPI produces absolute data at the point of measurement, with full data analysis available in minutes and no need for the complex data-fitting algorithms common in neutron-reflection studies.

NanoFlex DPI users have completed benchmarking experiments on surfactant, polymer, lipid and protein systems that have been well characterised by neutron reflection, two of which are summarised below.

Adsorption studies of BSA

Many nanotechnology processes involve proteins changing conformation as they function. As will be demonstrated, DPI provides a unique combination of high-resolution data in real time on protein dimensions, density, surface coverage and orientation.

The adsorption behaviour of the protein bovine serum albumin (BSA) onto a hydrophilic, negatively charged AnaChip was studied at pH 3, 5 and 7. BSA reversibly forms pH-dependent conformational isomers in solution: the N (normal) isoform at pH 5–8, F (fast) isoform at pH 3–4 and E (expanded) isoform below pH 3. Figure 1 shows real-time data on the thickness, mass and density (RI) of the adsorbed BSA layer during the pH cycle 3–5–3. At pH 3 a thin, dense layer formed as the predominantly positively charged and unfolded BSA attracted electrostatically to the chip surface. Adsorption increased as BSA was added at pH 5. With minimal net charge at pH 5, globular BSA molecules can pack closely without repelling each other, resulting in large surface mass. When the system is returned to BSA at pH 3 the thickness, mass and density return to approaching their original values, indicating that the protein did not denature on the surface.

Proteins retaining their globular framework tend to adsorb reversibly with respect to pH cycling, while denatured proteins show irreversible adsorption. These results demonstrate how the adsorption behaviour of different folded states of BSA can be distinguished using DPI measurements. Table 1 shows the excellent correlation between DPI mass data at equilibrium and analogous neutron reflection data.[3]

Analysing the DPI data on the surface-adsorbed structures, in combination with the measured adsorption rates and the known bulk solution structures, makes it possible to gain an understanding of the mechanisms involved in the surface adsorption of BSA. At pH 3 the adsorption process for the unfolded protein is predominantly driven by electrostatic interactions between the positively charged protein and the negatively charged AnaChip surface and it occurs rapidly.

The DPI thickness and density data imply that the protein orientates prone on the surface. At pH 5, adsorption is still rapid but slower than at pH 3. Having no net charge at pH 5, the globular BSA molecules can pack closely together without repelling each other, resulting in large surface mass. At pH 7 the molecules are negatively charged and the rate at which they interact with the chip is reduced because electrostatic repulsion must be overcome before adsorption can proceed. Again they adopt a prone attitude on the surface.

Surfactant adsorption behaviour

Tetraethylene glycol monododecyl ether ($C_{12}E_4$) is a well characterised, non-ionic surfactant commonly used in industrial formulations. NanoFlex was used to understand the time-dependent adsorption behaviour and the concentration-dependent structural behaviour of $C_{12}E_4$ at the trimethylsilane (TMS)–water interface. Six concentrations of $C_{12}E_4$ (0.05 × CMC to 2.0 × CMC)

Method	BSA (mgml^{-1})	Mass (ngmm^{-2}) adsorbed at pH 3	pH 5	pH 7
Neutron reflection	0.15	0.50	2.50	0.50
NanoFlex DPI	0.10	0.48	2.11	0.42

Table 1: Comparison of adsorption of BSA at equilibrium and at different pH values using neutron reflection and NanoFlex DPI

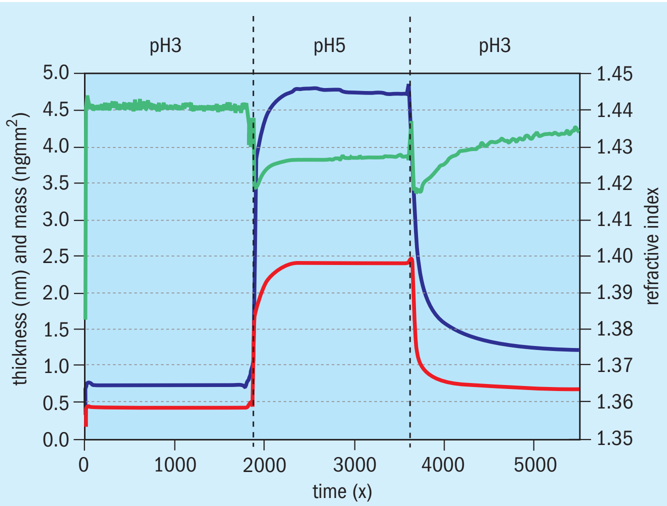


Fig. 1: NanoFlex measurements of reversible conformational change and adsorption behaviour displayed by BSA during pH cycling.

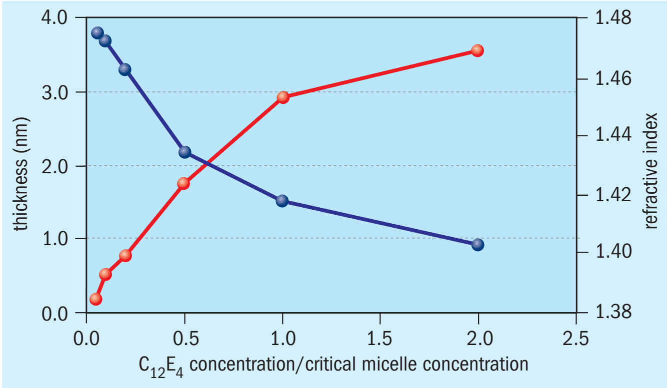


Fig. 2: DPI measurements of adsorbed layer thickness and density (refractive index) for $C_{12}E_4$ adsorption at the TMS–water interface as a function of CMC.

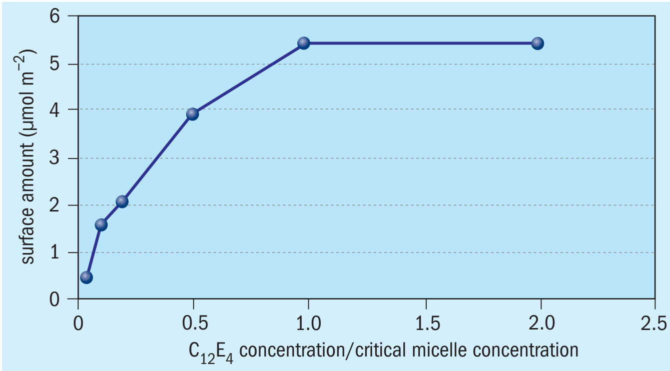


Fig. 3. Measurements of surface excess concentration of $C_{12}E_4$ at the TMS–water interface as a function of CMC.

were passed over a hydrophobic TMS AnaChip. The solution with the lowest concentration of surfactant was allowed to incubate over the chip surface until no further changes were observed in the DPI measurements. The flow was then returned to water to allow the bulk solution to exchange. This procedure was repeated for all six surfactant solutions in order of increasing concentration.

Figure 2 shows the thickness and density (RI) of the adsorbed $C_{12}E_4$ layer versus the surfactant concentration normalised to the surfactant CMC. As the surfactant concentration increases, the adsorbed layer thickness increases and the density (RI) decreases. This suggests that the surfactant molecules adopt a prone attitude to the surface at low concentrations, resulting in a thin and relatively dense layer. As the surfactant concentration approaches the CMC, the layer coverage becomes less dense and thicker, suggesting that the molecules adopt a more upright stance. This behaviour has been reported for studies of similar molecular systems.[5]

Given that the RI and density are well characterised for the $C_{12}E_4$ molecule at 1.453 and 0.946 gcm^{-3} respectively, the results can easily be expressed as adsorbed mass and surface concentration. The area per molecule, or molecular footprint, can then be calculated to aid data interpretation. Figure 3 shows how the surface concentration of $C_{12}E_4$ increases up to and levels off at the CMC. This behaviour conforms to the standard Langmuir isotherm characteristics. The calculated area per molecule at this concentration was 31 ± 1 Å^2 and the thickness of the adsorbed surfactant layer was 29.3 ± 0.4 Å.

For a surfactant molecule such as $C_{12}E_4$, a monolayer would be expected on a hydrophobic surface whereas a bilayer would be expected on a hydrophilic surface. In the case of monolayer formation, a surface area per molecule of 50 Å^2 and a layer thickness of 20 Å have been reported from neutron reflection experiments.[5] In the case of bilayer formation, an area per molecule of 25–30 Å^2 and a layer thickness of about 40 Å would be expected. The results obtained from the DPI study fall between these values, suggesting an intermediate structure, such as a disorganised bilayer or hemi-micelles. Since there was some reordering of the layer structure above the CMC, the formation of hemi-micelles is the most likely. Given that the neutron-reflection measurements were obtained using an octadecyltrimethylsilane surface, which is more hydrophobic than the TMS surface used in this study, the results are in excellent agreement.

NanoFlex enables the detailed, real-time, high-resolution study of how molecules organise on surfaces, giving results that are in excellent agreement with neutron-reflection measurements. The DPI technique lends itself well to the study of the assembly of thin-film systems, such as lipid layers or membranes, as well as surfactants. The technique can be extended to quantifying the real-time dynamics of partitioning or molecule insertion

Summary

Many nanotechnology labs around the world are now using DPI to characterise complex molecular structures and behaviour, both as a standalone technique and in combination with other analytical methods. Nanotechnologists using neutron reflection have adopted DPI more rapidly than most because it provides two key benefits for their community. First, it is an essential tool for them to prequalify and design their experiments, allowing them to optimise the use and productivity of their highly valuable neutron beam time. Second, NanoFlex gives them the opportunity to continue and extend their research on the benchtop in their own laboratories when their access to neutron beam time is limited.

● Farfield would like to acknowledge that these applications were carried out in collaboration with Prof. Jian Lu of the Biological Physics Group, School of Physics & Astronomy, University of Manchester, UK.

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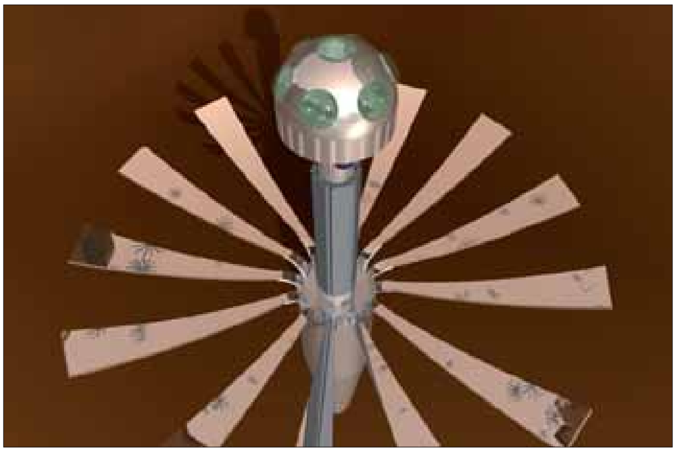
Maggi Blakebrough and Simon Carrington are with Farfield Scientific Limited. Tel: +44 (0)870 950 9717 or E-mail enquiries@farfield-scientific.com.

Cogent plans to send

Imagine that we could use MEMS and NEMS sensing technologies to build a probe 6 × 40 mm. Made of titanium, it would weigh 5 g. For the mass of *Beagle 2*, space scientists could land 3000 such probes on Mars, achieving an equally high scientific payload ratio. Moreover, for the equivalent mass of one of the NASA Spirit and Opportunity rovers, 37 000 microprobes could be deployed. **Elena Gaura** explores these exciting possibilities.



JIM TABOR

Fig. 1: The Mars DAISY.

On the face of it, such imaginings may seem like pure fantasy. However, they bridge the gap between the systems of today and tomorrow, they provide a vision of why the research is worthwhile and they offer a mental test bed to determine where detailed research is needed. Indeed, staff at the Cogent Computing Applied Research Centre at Coventry University are busily researching the scenario described above as a way of pushing the limits of their expertise in the design, implementation and evaluation of leading-edge distributed sensing and computing systems.

Bringing other technologies into the equation (MNT-based sensors in the Mars explorer case) illustrates the centre's fundamental belief that, in creating future sensing systems, a mixture of diverse expertise and disciplines is important. All of Cogent's work is marked by an approach that blends theory and experiment. The theory enables the scoping of the journey forward while the practical expertise grounds and validates the research.

The centre's expertise covers the whole of the pervasive applications deployment chain, from gathering large amounts of data to the provision of the information to the end user. This enables it to provide rapid solutions to real-world problems. The variety of projects within the centre's portfolio of research ranges from the development of hardware/software prototypes to fully deployed applications.

The MEMS mission to Mars

The work on the Mars probes is a thought experiment as to the feasibility of using large-scale wireless sensor networks as a vehicle for high-level scientific investigation. It is framed by a demanding scenario, and the assessment of feasibility is driven by the available micromachining technologies and recent advances in the areas of *ad hoc* networking, communications and intelligent sensing. A sensor payload is proposed, which includes sensor types to gather data such as pressure, temperature, chemical analysis and images as per recent planetary missions. Each sensor package must be able to communicate with an orbiting satellite.

Members of the Cogent Computing Applied Research Centre are calling their dream design of such microlanders DAISY, (distributed artificially intelligent sensor), its outline being shaped like a flower and bearing some resemblance to an earthly daisy. The petals are an active optical antenna (figure 1).

It's worth remembering that the researchers are not planetary scientists and that it is a scenario that is being developed, not a physical product. Any shortcomings in the design demonstrate that to design complex systems such as this requires a range of expertise and advanced design methodologies. A probe such as this would thus require the integration of a number of different micro- and, potentially, nanodevices and would be built using a variety of technologies.

A device-level feasibility study driven by the available micromachining technologies showed that MEMS and VLSI may be successfully integrated to produce the 40 mm self-contained space probe to fulfil the sensing requirements. Aspects of the sensor technology are described below.

Communications A consequence of a homogeneous network is that every node must be capable of sending information back to the explorers on Earth. In this case the commonly used technique of communication via a satellite is adopted. This will require the transmission from the sensor to be highly directional. To achieve such directional transmission, optical communication is necessary to allow an antenna with sufficient beam-forming power to fit within the 40 mm size and allow communication to the host satellite. Given the predominantly red coloration of the planet, blue has been selected as the colour of the laser to ensure maximum contrast against the background.

Power budget For long-term operation on the surface of Mars, some of the techniques of power harvesting will need to be used. Photovoltaic solar power generation is the most likely candidate, this being the only easily accessed and predictable power source available on another planet.

Antenna The communication is optical, so a combination of adaptive MEMS optics (with a number of adaptive mirrors) is required. The Daisy profile shown assumes an upward firing photodiode. A membrane deformable mirror (or mirrors) reflects the beam onto the main focusing mirror. The petals of the Daisy can provide other functions as well as forming part of the antenna. First, they can focus incident solar radiation onto the photovoltaic/optical reception cell. Also they could have a role in controlling the descent of the Daisy by altering the aerodynamic drag as it falls. Using the onboard accelerometers, which are part of the instrument package, it may be possible for the probe to navigate as it descends.

Sensors Given the initial design decisions to use a single type of node, every node needs to carry a complete sensor package. If the probe is to be kept within the envisaged dimensions, the overall sensor package will need to be designed in an integrated way to allow for the reuse of as many subsystems as possible.

Accelerometers are a key part of the instrument package on the Daisy, reflecting their ubiquity in the overall field of sensing. The designers of this part of the sensor package could take their pick from a variety of fabrication techniques and ensure that appropriate pick-off electronics are designed. High-performance capacitive pick-off accelerometers can be integrated side-by-side

microprobes to Mars

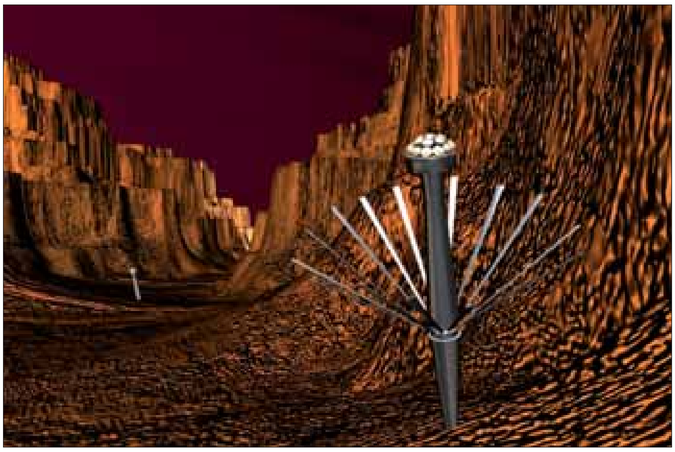


Fig. 2. The Daisies arrive on the Martian surface.

Fig. 3. Communication using blue lasers and the optical petal antennas.

with adequate ancillary electronics using a CMOS process.

The technology to sense the atmosphere and soil composition requires a further design choice. Electronic noses are an established MEMS technology but they generally need to be tailored for the detection of a specific chemical or class of chemicals. For scientific investigation a more generally capable chemical sensor is needed. One type of general-purpose sensor is a gas chromatograph. A MEMS based Fabry–Perot (FP) chromatograph includes an FP interferometer (essentially two parallel semireflective plates). The FP chemical sensor is a further example of the use of active optical MEMS techniques and could be fabricated using nitride film techniques.

Pressure sensors were one of the earliest MEMS applications, and well established designs are available using either capacitative or piezoelectronic pick-off techniques. Alternatively, a very sensitive pressure sensor can be fabricated using an FP cell, the pressure causing a displacement of one of the plates, which in turn modulates the intensity of light passing through the cell.

The difficulty in chemical sensing soil in an environment without water is conveying the constituent chemicals to the analyser. A simple solution would be to use the transmission laser to vaporise the sample. The power available should be sufficient, so long as it can be focused onto the sample to be vaporised. This provides a further application (and design challenge) for the adaptive optical MEMS researchers. The gaseous sample needs to be conveyed to an FP gas sensor for analysis. The sample could be collected on landing by providing a bore through the spike so that soil is forced up into it on impact. Physical arrangements for routing the laser beam and conveying the gaseous sample to the sensor are not straightforward and require detailed design of the probe to verify practical solutions. The imaging system should be relatively straightforward, being a silicon CCD or CMOS image sensor, as used in modern digital cameras.

Sensor package

Clearly, from the above, established sensing and micromachining technologies can potentially provide the sensing capabilities required for the probe. The precise packaging and format of the various sensors would not be known until a detailed design had been created, which is outside the scope of this thought experiment. However, it is possible to speculate about possible configurations. Sensors using these different technologies could be integrated together on a single chip to form a lab-on-a-chip. The level of integration achievable depends on the features of available VLSI technologies. A technology that could integrate all of the above onto a single chip would need to be specially developed for this application and would likely be prohibitively expensive. Therefore a more probable scenario is that separate chips would be needed to provide some of the more specialist sensing types, the precise allocation of sensing devices to chips being a detail of the design decision. These chips would need to be integrated into a single sensing package using side-by-side or vertical integration, with the form factor of the probe described indicating a “vertical” arrangement. The geometry of some of the sensing devices suggests that it would be possible to integrate the sensors here within 5 mm chips, so this would fit with the speculative profile of the Daisy probe if arranged vertically. The integration of four chips in a stack would be an advance on the current state of the art.

Summary

Overall it seems that a close look at a number of diverse technologies, methods and theories reveals a “thumbs-up” answer to the posed problem of deploying microprobes in large numbers on planets, provided that a way of integrating such theories and technologies can be found and, most important, the right interdisciplinary team of scientists can be set to work. Keeping the right mindset as to the multiuse of a particular technology is especially important in such a team, given the mass, size and multifunctional nature of the probes, for instance. The best example here, from the Cogent Daisy design work, is that of multiple uses of advanced optical MEMS for the triple purpose of communications (blue laser steered by a complex optical MEMS steerable antenna), gas sensing and gas analysis (both based on FP devices).

While the design and fabrication of hardware such as this is a huge challenge, the implementation of the systems software that would allow thousands of the probes to operate together (locating the phenomena to be observed, finding energy-efficient routes to transmit back the information, and detecting and repairing faults) is a challenge of the same order. This software would need to be both subtle and complex, and would require a considerable amount of processing power to run. Thus the Daisy probe would need to be a powerful computer in its own right. Luckily, high processing power does not exclude low energy consumption. In fact for many complex processing tasks a capable processor consumes less energy than a small “efficient” processor.

● To find out more about the work of the Cogent Computing Centre and to view a Mars movie, visit www.cogentcomputing.org/cds/sensing/demonstrators.html.

Elena Gaura is reader in pervasive computing and director of the Cogent Computing Centre at Coventry University. E-mail: e.gaura@coventry.ac.uk.

Bristol centre can solve your colloid problems

Colloids can present their own special set of problems to users, but there's no need to despair: you can get the help you need from the experts at the Bristol Colloid Centre.

The Bristol Colloid Centre (BCC) is a consultancy group that provides solutions to the formulation and processing problems of companies worldwide. It works with a variety of industries and technologies, ranging from biomedicine and agrochemicals to printing inks and oil recovery. Clients vary from the largest corporations to individuals developing their own businesses. Among many projects, in the last year it has worked on optimising materials for use in fuel cells, the formulation of a latex coating with a new surfactant (the old one being phased out due to REACH regulations) and investigating novel methods of drug delivery.

A strong track record

Since the BCC has worked on a vast range of products over the 13 years of its existence, it has built up considerable expertise and know-how. This has contributed to a very good track record in knowledge transfer from the laboratory to the market-place. The work is carried out (usually within the terms of a non-disclosure agreement) by a team of highly trained scientists who are specialists in colloid chemistry and who have backgrounds in a variety of industries.

Contract research forms the primary activity of the BCC. This includes single measurements, trouble-shooting and longer-term research projects. In addition, the BCC carries out consultancy, including patent and technology reviews. For companies wishing to train personnel in colloid science, an annual Spring School in Colloid and Surface Science is organised and two short courses are run each year. A course on Dispersion Stability is to be held in Bristol on 28–29 November and an Awareness Forum on a current area of interest is organised annually, this year's topic being composites and nanocomposites.

The BCC is housed in newly refurbished labs in the School of Chemistry at Bristol University. Staff there are able to undertake:

- rheological characterisation;
- particle size and size distribution measurements;
- contact angle, surface tension and interfacial tension measurements;
- particle surface area determination and micropore analysis;
- particle surface charge measurements;
- SEM and light microscopy.

Also available is access to state-of-the-art structural characterisation techniques within the Colloid Group in the University's School of Chemistry. Techniques include small-angle X-ray scattering, ellipsometry, NMR (including solid-state and imaging), high-resolution TEM, confocal microscopy and atomic force microscopy, which allow the whole colloidal lengthscale to be probed. The BCC has expertise in the preparation of colloidal particles, such as polymer lattices, core-shell particles and metal alloy nanoparticles, and in formulating systems to obtain the correct rheological and stability properties necessary for a manufacturing process or end-product.

Case-study: Riverlynx

Riverlynx is the UK's leading supplier of sprayers and carriers for the controlled droplet application (CDA) of herbicides. Carriers are formulations that are mixed with herbicides at the point of use. The BCC was involved with Riverlynx in a Knowledge Transfer Partnership (formerly a Teaching Company Scheme) to develop a carrier formulation, which had previously been bought in by Riverlynx. The target specifications were the inclusion of material to reveal where the CDA had been sprayed, adequate thickening to produce discrete droplets on the leaves, rheology control to allow easy spraying, and stability to sedimentation and coagulation during storage.

Clearly there is a trade-off in some properties, such as storage stability versus ease of spraying (i.e. its rheology control). This was the trickiest part of the programme, but a robust solution was developed. A critical feature was the integration of the engineering of the application device with the physical chemistry of the formulation. The success of the programme was confirmed when Riverlynx employed the researcher on the Teaching Company Scheme and went into production with a new carrier.

- To contact the BCC, tel: 0117 929 8388; e-mail: bcc@bristol.ac.uk; Web: www.thebcc.co.uk.


SAMPLES PREPARED BY R DOHERTY, PHOTO BY DR D H MARSH AND COURTESY OF DR JASON RILEY

Fluorescence from capped CdSe nanoparticles in the 2–5 nm size range.

WHAT IS A COLLOID?

A colloidal system comprises two phases: a dispersed phase of colloidal dimensions (from a few nanometres to a few micrometres in size) distributed throughout a continuous phase. For example, paints are colloidal systems because they consist of a solid (typically titanium dioxide particles of 0.2–0.3 μm in diameter) dispersed in a continuous liquid carrier. The study of colloids has always included looking at dispersed phases down to the nanometre level, so the BCC has been expert in nanoscience for a considerable time.