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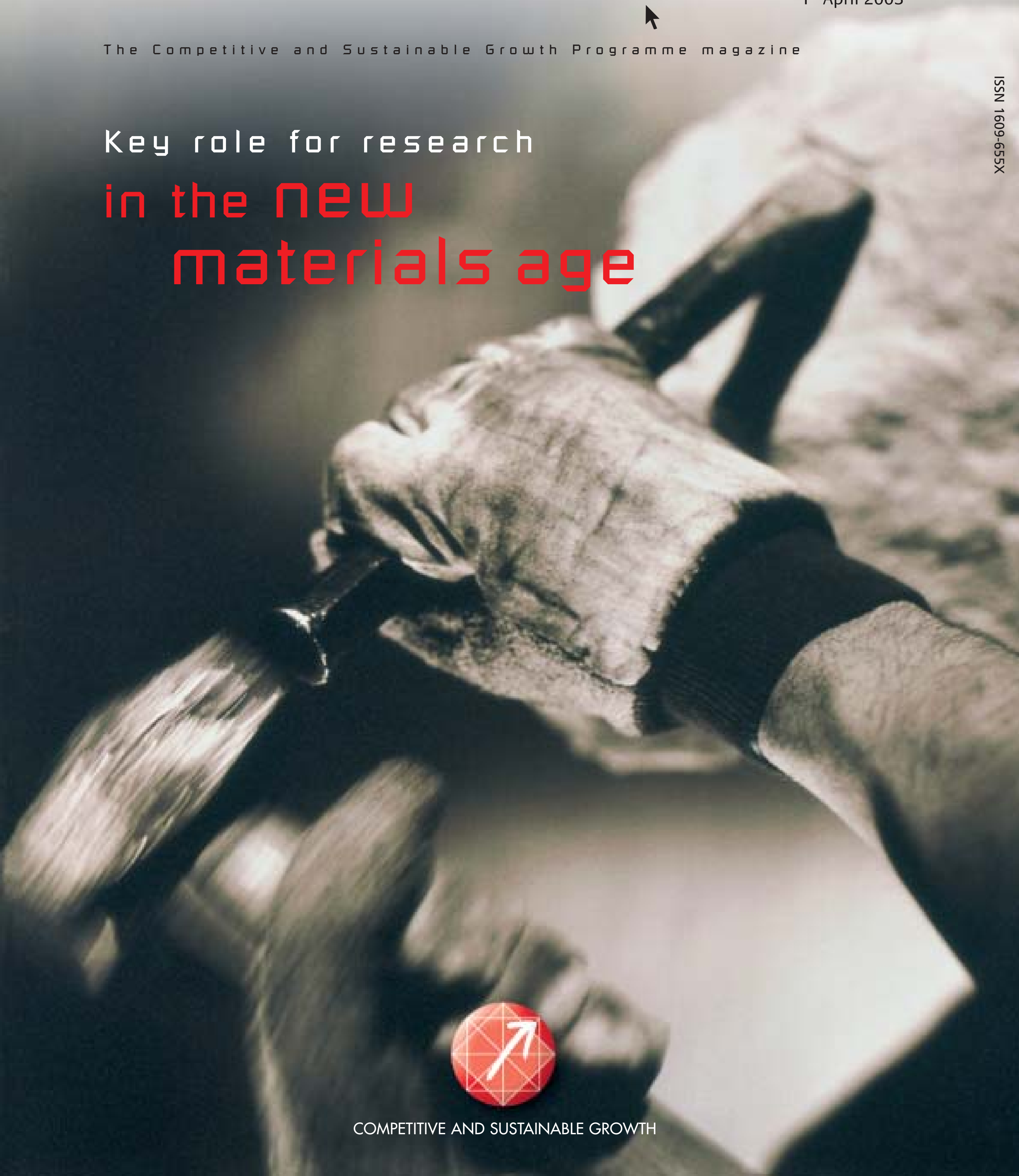
Key role for research in the new materials age



COMPETITIVE AND SUSTAINABLE GROWTH

This special issue of Growth in Action *looks at the key role materials play in everyday life for individual citizens and society as a whole. EU funded research has therefore focused on solving problems and advancing solutions in priority areas across a broad range of industries – changing scales and approaches and enlarging impacts.*

Growth in action is the magazine of the GROWTH Programme, one of the thematic programmes of the Fifth Framework Programme for Research and Technological Development.

The articles and information featured in this magazine are based on material already published on the GROWTH Programme website, which can be found at **http://europa.eu.int/comm/research/growth/index.html.** Readers are invited to consult the website for more extensive coverage of the issues addressed in this magazine and to discover many more themes and articles added and updated on a regular basis.

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Foreword

The value of curiosity

The European Union has long recognised the contribution of research and technological development (RTD) to its general objective of 'strengthening the scientific and technological basis of Community industry and encouraging it to become more competitive at international level'. Recent European Councils in Lisbon, Barcelona and Gothenburg have added increasing socio-economic and environmental expectations.

From 2002 to 2006, these will be reflected in the industrial research activities that will be carried out under thematic priority 3 – 'Nanotechnologies and nanosciences, knowledge-based multifunctional materials, new production processes and devices' (NMP) – of the Sixth Framework Programme (FP6). The overall aim is to help industry to re-engineer its products and processes in ways that make them more knowledge-based and less resource-intensive, and to develop sustainable solutions through radical innovations.

Today, cyberspace and virtual reality are widely regarded as the new frontiers for enquiring young minds, and data the staple commodity for successful new businesses. Yet materials scientists are equally determined to transform the world. Promising to 'turn Mother Nature green with envy', they are mining their imaginations for totally new structures. Tomorrow's inorganic-organic and biological entities will be tailored from individual atoms or molecules, to provide the precise properties needed for each specific application. The possibilities are endless and, every day, new discoveries are inspiring new dreams.

The latest innovations in carbon nanotubes, for instance, may become the basis of carbon-based computer chips in ten years time – and a new approach to assembling molecules into patterns may ultimately lead to molecular-based devices within 15 years.

There is a natural tendency to focus on the semiconductors, magnetic materials and optical fibres that have allowed the development of information and communications technologies; and financial pressures have resulted in a move away from basic research in recent years. However, good research can and should also be curiosity-driven. Curiosity is necessary to foster creativity, whereas accountability should link technological developments with societal and policy goals – not only in terms of employment and industrial competitiveness, but also of sustainability, quality of life and safety.

The Commission acknowledges the importance of long-term fundamental research, and plans to realise the European Research Area by balancing the mobilisation of critical mass in RTD and the integration of research capacities across Europe. Materials science is a broad and multi-disciplinary field of study, and one with a very bright future. Increasing public awareness and understanding of this fact, especially among the younger generation, will be a fundamental goal of FP6.

Ezio Andreta
Director, Research DG, Directorate G
Industrial Technologies

Dawn of a new materials

The discovery, development and application of advanced new materials is crucial to Europe's future competitiveness, and to attaining the goal of decoupling economic growth from the increasing consumption of finite resources. Nanomaterials, high-tech ceramics, polymers, metal alloys, and bio-inspired and hybrid molecules can bring radical improvements in the quality of life for EU citizens, through new and better products and services. The European Research Area (ERA) will provide a multi-disciplinary, socially responsible environment for the research and technological development (RTD) needed to reap the full benefit of tomorrow's technologies.

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Steps along the path of human evolutionary progress have been characterised by the ability of mankind to manipulate the most advanced materials of successive epochs – hence the 'stone age', 'iron age' and 'bronze age': On a shorter time-scale, the past two decades – in which information and communications technologies came to the forefront – could be described as the 'silicon age'. And now, the world is poised to enter yet another new materials era.

It is not yet clear whether there could be a single defining material of the future, but researchers have identified a number of highly promising areas that warrant continuing investigation. What is clear is that tomorrow's products will be smaller, smarter and more multifunctional.

Integrated approach essential

While there is a need for more emphasis on nanoscience and nanotechnology, it is also essential to address and integrate a bottom-up approach through creation of materials, control and manipulation at atomic level and a top-down approach towards miniaturisation. Long-term research must explore new and emerging scientific and technological problems and opportunities that already anticipate future industrial applications.

The study of nature and learning from its vast paradigms will increase the understanding of complex physio-chemical and biological phenomena relevant to mastering and processing novel materials. The objective is to learn from nature how to build up complex molecules from ubiquitous material resources such as carbon dioxide, methane, water and hydrogen. A biomimetic approach might give rise to evolutionary materials and processes. Bio-inspired materials, biomimetic behaviour and relevant methodologies for developing multifunctional nanomaterials are key issues to be covered.

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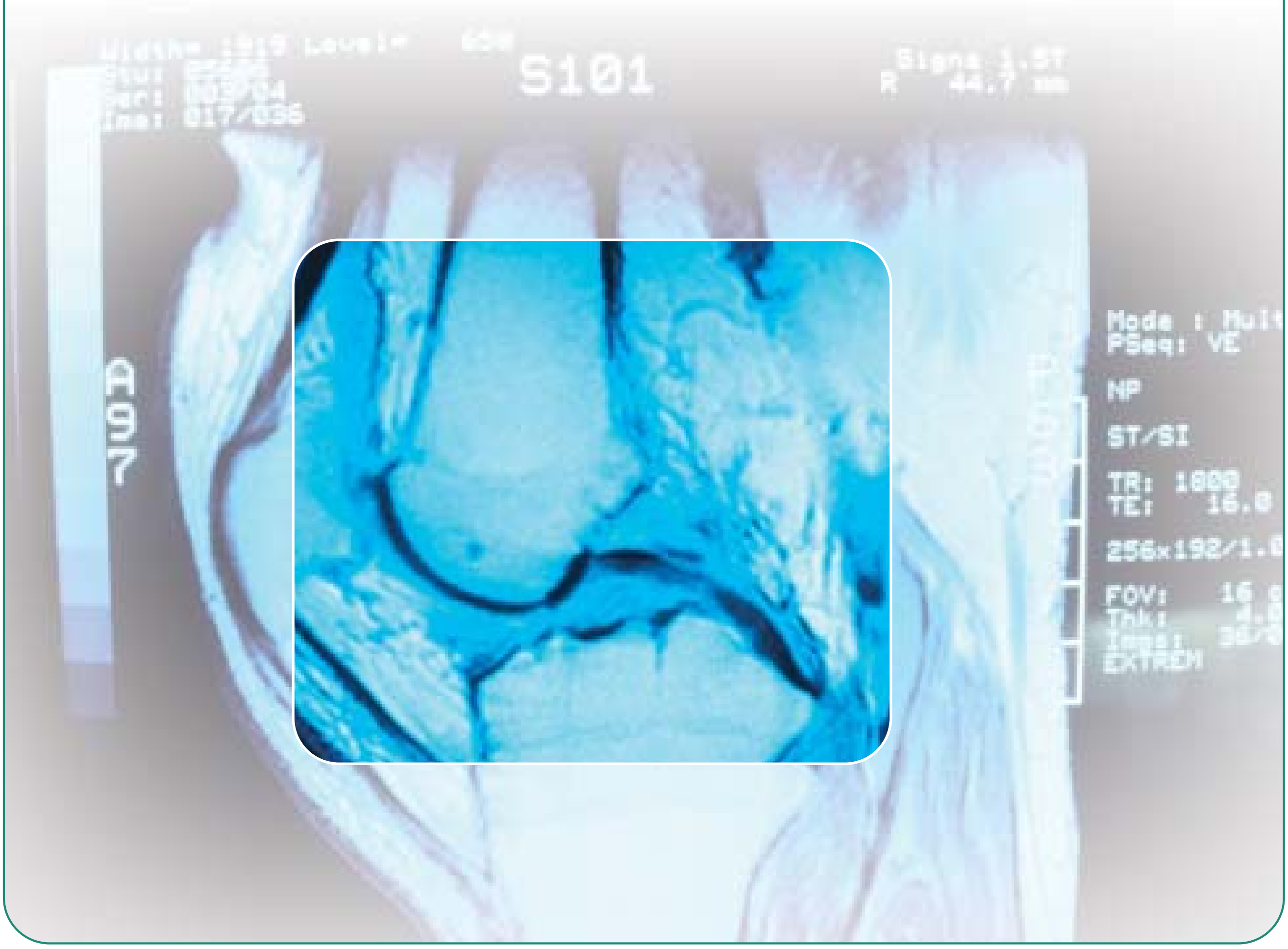
Nanocomposites promise longer-lived surgical implants

BIOKER[1], a running GROWTH project, is developing and evaluating nanostructured ceramic composites as an answer to problems of premature failure in artificial hip and knee implants. The ten-year average lifetime of conventional implants places a serious limitation on their use, especially in relativity young and active people. Ceramics such as alumina and zirconia dramatically reduce wear rates, but introduce further risks of stress cracking and hydrothermal degradation. However, the BIOKER consortium is studying zirconia-toughened alumina, a ceramic material with much greater fracture resistance than that of its individual components. Manufactured by an innovative pressure-casting technique, this promises to increase the life span of prostheses to up to 30 years. Safety and performance testing for surgical implants is a lengthy process, but co-ordinator Ramon Torrecillias of the Spanish National Institute of Carbon (INCAR-SCIC) is confident that this work will lead to an enhanced quality of life for many patients.

(1) Extending the life span of orthopaedic implants: development of ceramic hip and knee prostheses with improved zirconia toughened alumina nanocomposites



Emphasis is given to multi-materials, composites and hybrid substances such as biomaterials and hybrid tissues. Interconnection of organic and inorganic matter is a key issue as well as the entire field of surface interactions and surface engineering. Nanotechnologies play a central role in this field.

Traditional science has already abandoned the distinction between functional and structural materials. For example, polymers have now expanded their function to include conducting electricity, emitting light or react and change form while stimulated. A wide range of actuators already exists in the market. These smart materials led to sensors and to intelligent systems.

The real challenge is now to incorporate that intelligence into the material so that the intelligent 'system' is no longer a mechanism, but is embodied in the smallest part of the matter. New materials are also asked to perform different functions that should also be embodied in the same smallest part of the matter. The final characteristic required is autonomy – including auto-maintenance, self-repair, auto-diagnostic and auto-organisation.

The material of the future will be an integrated substance where intelligence, multi-functionality and autonomy are designed at the smallest level.

Trend to multidisciplinarity

Such advances will only be realised through the combined efforts of physicists, chemists, biologists and engineers. The trend towards multidisciplinarity poses challenges in the education and motivation of future scientists. Individuals must learn to operate in teams that integrate both highly specialised knowledge and more trans-disciplinary skills, and universities will need to provide curricula that build broadly based capabilities.

Cutting edge technologies are no longer the exclusive domain of the scientists. They have a huge impact on people and society. Everyone, both citizens and stakeholders, need to participate in discussing and understanding the impact of technologies and in taking responsibility for the ways in which the latest discoveries are used.

This implies a need on the part of researchers to address the socio-economic, ethical and cultural issues, requiring the cultivation of public acceptance and respect for human dignity. It entails the reorientation of means and models of production and consumption that are no longer compatible with the concept of sustainability. Research is no longer asked to provide innovative solutions to existing problems, but to offer added opportunities through the development of novel materials and as yet unimagined applications aimed at enhancing the quality of life and the welfare of populations.

Europe can demonstrate a solid knowledge base in many aspects of materials science, yet is often less successful in converting results into commercial success. Integrating new materials development into the manufacturing cycle will accelerate innovation, by contributing to the development of sustainable industries, products and services.

New opportunities in ERA

The advent of ERA will strengthen links between materials research, industry and society, making research more coherent, responsive and accountable than before. As the main tool for its implementation, the Sixth Framework Programme (FP6) introduces funding instruments that are designed to channel the Community effort into larger scale, longer-term research initiatives targeting pre-defined strategic priorities where co-operation at the European level is seen to be most beneficial.

With a total budget of € 1 300 billion over the next four years, Priority 3 brings together nanotechnologies, materials science and manufacturing, as well as other technologies based on bio- or environmental sciences. Consequently, it is expected to lead to real breakthroughs and radical innovation in production/consumption patterns. The intention is to promote a transformation of today's traditional industries into a new breed of interdependent high-tech sectors.

In this environment, scientists will be able to develop their knowledge, creativity and enthusiasm. They will have opportunities to explore the frontiers of little-known materials domains, to build successful new businesses in Europe, to improve the quality of life for all, and to share in the creation of a new materials age.

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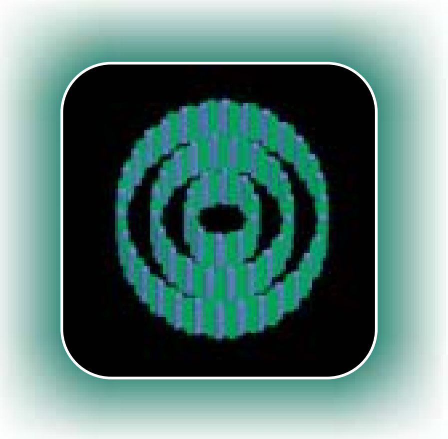
Chemical innovation already leading to novel materials



The wide-ranging CHEMAG(2) project is currently pursuing several discrete but overlapping avenues of materials science for applications in biology, health, diagnostics, chemistry, process engineering and the environment. Specific objectives include developing new varieties of paramagnetic nano-materials, novel synthetic nucleic acid modification chemistries, and improved surface-activation chemistries for the even application of coatings. The three-year GROWTH project started in September 2001 and now involves technology innovators, manufacturers and users from Germany, Italy, the UK and Israel. Significant successes had already been achieved at the end of the first year, including world patent applications covering novel synthetic nucleic acids for application in molecular diagnostics, and the development of new varieties of paramagnetic nano-materials. "This work would not have happened without European funding," insists project co-ordinator Professor Ian Bruce of the University of Greenwich in the UK.

(2) Novel paramagnetic materials, surface activation and nucleic acid modification chemistries with applications in biology, chemistry, health/ medicine/diagnostics and the environment

Laying the foundation for

Structuring the European Research Area (ERA) is an underlying objective of the Sixth Framework Programme (FP6). Its new funding instruments are designed to encourage stronger links between research activities conducted at national, regional and Europe-wide levels. In anticipation of this transition, GROWTH created a number of initiatives that reflect the larger-scale, longer-term character of integrated projects and networks of excellence.

The progression from FP5 to FP6 will bring a general shift towards larger-scale 'integrated projects' with the critical mass to achieve more radical advances, and 'networks of excellence' developing into longer-term collaborations between more extended groups of partners. To qualify for funding, proposed initiatives will be required to demonstrate a solution-providing approach, designed to meet the needs of European citizens and society as a whole.

In the latter stages of its preparation for this evolution, the GROWTH programme sought to anticipate the changing emphasis by creating thematic networks and 'clusters' of projects linking consortia sharing common problems and interests.

Nanotech network

Launched in July 2002, the NANOFORUM(3) network will, in fact, continue through the four-year FP6 period. Its broad frame of reference will provide a basis for raising awareness, supporting and encouraging the adoption of new nanotechnologies, and facilitating the development of new industrially oriented nanotechnology research across Europe.

A website(4) launched in December 2002 provides a portal for access to information, exchange of experiences, and news of NANOFORUM activities – including conferences, workshops, publications and press releases. The aim is to integrate actions at a European level, and offer a means of identifying and implementing best practices in all aspects of nanotechnology.

Multi-project cluster

A typical example of clustering is NANOTRIB(5), which establishes synergies between pre-existing GROWTH projects – MICLUB(6), LUBRICOAT(7), HIDUR(8), TRIBO(9), NANOCOMP(10) and SMART QUASICRYSTALS(11) – working concurrently in the field of nano-scale lubrication films and low-friction surfaces. The grouping involves a total of 60 partners from 16 countries, including 24 SMEs. Backed by an investment of € 16 million, of which the Commission provides half, it conforms to the criterion of reaching a critical mass from which significant results with wide-ranging application can be expected.

NANOTRIB embraces the complementary 'top-down' and 'bottom up' methodologies – i.e. approaching the nano-world from the macro-scale or from the atomic scale. It involves multidisciplinary teams addressing multi-sectoral applications, from metal forming and machine tools, to automotive engines, wind turbines and satellite mechanics. Moreover, its implications extend beyond the achievement of early commercialisable results, into the medium and longer term – again in line with the spirit of FP6.

Metrology remains central to FP6

The existence of ERA will depend on the ability to share and compare results across the whole Community and with the rest of the world. While measurement and testing (M&T) is not designated as a specific FP6 research priority, the fundamental importance of metrology means it will be fully integrated into all thematic areas.

Innovation in most fields of science and technology depends on accurate and verifiable measurement. The availability of measuring equipment and the ability to use it are essential to scientists as a means of objectively documenting the results they achieve. At the same time, cross-border collaboration requires the adoption of calibration and measurement standards that are either internationally recognised or easily cross-referenced.

for ERA

EUROPEAN RESEARCH AREA

The key to successful exploitation of modern materials is the understanding and control of the relationship between their composition, structure, properties and processing. But, with the emergence of scientific disciplines such as nanotechnology and biotechnology, which require new metrological capabilities, national capacities and budgets are coming under increasing strain.

There is a continuing requirement for improved methods to characterise materials. New and more powerful analytical techniques must be developed to keep pace with the scientific advances. Consequently, M&T will need to be solidly embedded within the seven thematic priorities of FP6. Commissioner Busquin underlined this in a speech at the Warsaw conference 'Towards an integrated infrastructure for measurements' in June 2002: "Measurement, testing and the definition of common standards, are essential elements in the establishment of a knowledge-based economy that the European Union is striving to build".

It is often said that 'there is no science without measurements, no quality without testing and no global market without standards'. In the absence of suitable metrology, the 'boutique materials age' will not become a reality.

(3) Pan-European forum for nanotechnology

(4) http://www.nanoforum.org/

(5) Sustainable tribological coatings through nanoscale surface engineering

(6) In-process structured hard coatings for microlubrication

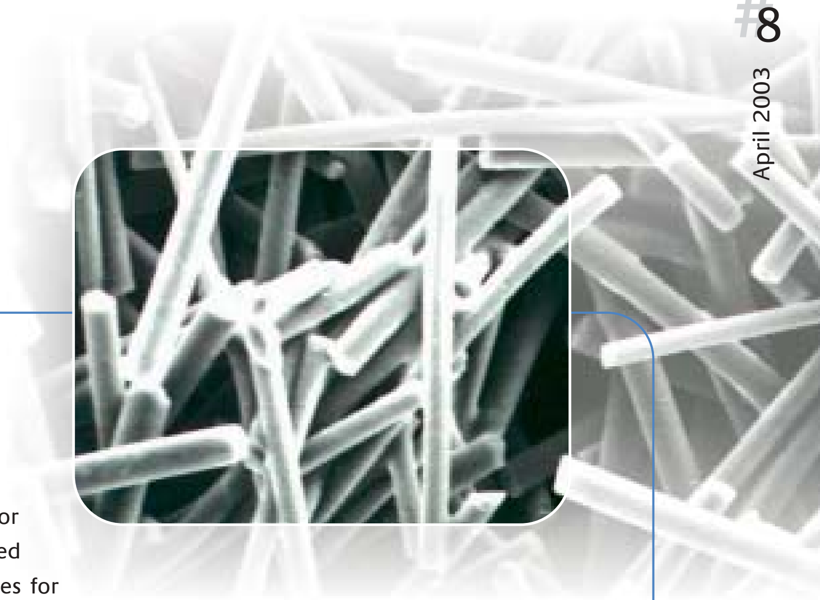
(7) Environmentally friendly lubricants and low friction coatings. A route towards sustainable products and production processes

(8) Improving competitiveness and conserving the environment through high durability nanocomposite coatings

(9) Nanostructured coatings for engineering tribological applications

(10) New nanocomposite-based wear-resistant and self-lubricating pvd-coatings for future applications in tools and components

(11) Tailored quasicrystalline surface layers for reduced friction and wear



European standards strengthen high-tech industry

The VAFTEM[12] project covers standardisation of methods for the characterisation of ceramic and carbon fibres (CMCs) used to reinforce ceramic matrices and carbon-carbon composites for high temperature applications in aerospace and other high-tech industries. Currently, Europe depends heavily upon fibres produced in the USA and Japan. By developing a set of independent and reliable test norms, VAFTEM will strengthen EU competitiveness in a high-employment, capital-intensive sector.

(12) Ceramic and carbon fibres: validation of testing methods

Extending the frontiers of

The European Commission's philosophy towards the funding of co-operative research and technological development has progressed from a national focus in the earliest days, to EU-wide integration and beyond. Under the Fifth Framework Programme (FP5), much was done to encourage broader collaboration. FP6 removes still more barriers to external participation, while international agreements offer a means of addressing problems with a global dimension.

Already under FP 5, the involvement of the EU applicant countries in collaborative research was actively promoted. The Sixth Framework Programme marks a further step forward by allowing the associated applicant countries to participate on a completely equal footing with the Member States. Now, their enterprises and institutes will be able to form consortia without the former requirement for inclusion of one or more Member State partners. Programmes to facilitate the mobility of individual scientists and technologists will also be extended, and funds made available to institutions wishing to host foreign researchers.

"Following the European Council on 25 and 26 October 2002, this is the concrete nitty gritty reality, designed to create a European Research Area," said Research Commissioner Philippe Busquin. "Research is the first area where enlargement becomes a reality, well in advance of the accession schedule. This is recognition of the scientific potential that applicant countries possess."

Lucija Cok, Minister of Education, Science and Sport in Slovenia, welcomed the signature of the association agreement, saying that people will be coming together now because of their capabilities and not their country.

Assessing what difference EU enlargement will make to the field of research and development now that the applicant countries are fully integrated in the field, Andras Siegler, Deputy State Secretary of the Hungarian Ministry of Education, said that "...the focus will be on the uses of membership, not the problems of enlargement". In his opinion, more attention would be given to science and education in an enlarged EU.

Integration of the applicants will be eased by a reduction in participation costs for the first two years of FP6. However, Commission President Romano Prodi urged them to do everything they can to meet the target of raising research spending to 3% of GDP, and to prevent a brain drain from Europe. Making the region an attractive place to conduct research will be vital to achievement of the ambitious goals of FP6.

Broader opportunities for international co-operation

Europe's experience and long tradition of international scientific and technological co-operation based on dialogue and partnership provide a model for broader collaboration, giving the ERA an enhanced international dimension.

As an essential component of FP6, international co-operation will allow the European research community to benefit from the knowledge and expertise of third countries and institutions through the participation of researchers and teams from these countries in projects within the different thematic priorities.

The new rules for participating in FP6 allow partners from all third countries and from international organisations to join in the research activities covered by Priority 3. Consortium members from developing countries, the Mediterranean and Western Balkans countries – as well as Russia and the New Independent States – are entitled to financial support from the European Commission (although other third countries will not normally be financed).

Bilateral scientific and technical co-operation agreements with a number of countries provide further opportunities

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Protecting buildings in eastern Europe

INSUMAT[13], a three-year GROWTH project launched in March 2002 is developing more effective renovation materials that offer insulation and protection from damp for both historic buildings and more recent constructions. The consortium assembled to solve this problem is led by the Dresden University of Technology and includes the Technical University of Prague, the Polish Academy of Sciences and the Slovak Institute of Construction and Architecture, together with industrial partners from the Czech Republic, Poland, Slovakia and Germany.

Central and eastern European countries have many old buildings. Efforts to restore them are complicated because exterior insulation is not appropriate, while interior insulation often gives rise to condensation between the layers. The need to avoid damage to ancient structures is yet another important consideration.

In order to determine optimal solutions for heat retention in combination with the transfer of water and water vapour, the team is designing and validating special modelling and simulation software. Candidate materials are tested in a special climatic chamber that simulates large outside-inside temperature differences, together with variable humidity gradients. Field-testing on actual buildings is also being carried out.

The work focuses on two new materials displaying capillary action, the most important property for moisture protection. Rudolf Plagge of the Dresden University of Technology comments: "One of our German partners, Calsitherm Silikatbaustoffe, is particularly involved in developing these new products, which use mortar, mineral wool and a special capillary layer."

An important spin-off will be the applicability of this technology to the low-cost housing that is prevalent in central and eastern Europe. It could improve the quality of life for new EU citizens, reduce energy costs for the Community as a whole and make a valuable contribution to the fight against global warming.

(13) Development of insulation materials with specially designed properties for building renovation

for industrial and academic players to establish international partnerships aimed at addressing global challenges.

Where industrialised countries, including emerging economies, already have considerable scientific and technological research capabilities, the specific objective is to provide reciprocal access to knowledge and skills, while respecting the rules of diffusion and protection of research results.

Furthermore, by sharing resources, co-operation of this type means that the risks and benefits can be distributed fairly – and large-scale, high-quality joint research can be carried out in the mutual interest and at a reduced cost for all concerned.

A particularly fruitful agreement has been that concluded with the USA in October 1998, which led to an implementing arrangement between the EC's Research RTD and the American National Science Foundation (NSF) in the area of materials science. From a virtual nil participation in previous Framework Programmes, 65 proposals including American partners were received under GROWTH.

Similar accords with countries such as Argentina, Australia, Canada, China and South Africa have enabled a number of organisations to join individual projects for which their particular skills or resources were appropriate (but without Community funding).

Based on this positive experience, and on an extensive exchange of information, even stronger co-operation in matters of nanotechnology and knowledge-based materials is foreseen within FP6. This will be realised through co-ordinated calls for proposals; support for the training of scientists, engineers and technicians; and the joint organisation of scientific seminars, conferences, symposia and workshops.

Transatlantic team explores turbine coatings

As a result of the EU/US co-operation agreement, university teams from California, Michigan and Princeton joined with European counterparts in HIPERCOAT(14), a GROWTH project initiated in January 2002 to investigate the dynamics of temperature-resistant multifunctional coating systems, primarily for use in gas turbines.

The societal and economic benefits of extending materials capability in this area are evident from the fact that gas turbines predominate as a power source for global electrification, aircraft, marine transportation and many industrial processes. Transatlantic co-operation is therefore a logical means of assembling the critical mass to overcome a current lack of scientific understanding, in order to reach a swift and cost-effective solution.

The work, which includes experimental evaluation of the microstructure and properties of as-processed and thermally treated materials, will be complemented by theoretical studies. While initial efforts focus on thermal barrier systems, the results should be applicable to a much wider range of applications for which structural integrity must be sustained under severe environmental conditions.

(14) Science of high performance multifunctional high temperature coatings

External contributions in aircraft weight saving

POSICOSS[15], currently at the halfway stage of a four-year funded period, concerns the development of new aircraft fuselage structures with weight savings of up to 20%. Led by the German Aerospace Centre in Braunschweig, the consortium has partners from Latvia and Israel, as well as contracting members in Germany and Italy. The objective is to study the use of advanced fibre composite materials for fuselage components. While these materials allow very significant weight reduction, extensive research, testing and simulation are needed to establish their performance as part of the aircraft shell.

The GROWTH project draws on the resources of industrial and research partners to examine the behaviour of structures made of fibre composite materials in their so-called 'post-buckling' range. Until now, normal practice in testing has been to load aeroplanes so fuselage materials can flex within their elastic range, i.e. the material recovers its former shape when the load is released. However, fibre composite structures can be loaded beyond the onset of buckling, often having a reserve capacity of 100 to 300%. In the first part of the post-buckling range, the structure experiences extremely small elastic deformations, from which the material recovers without loss of strength.

Testing this sort of behaviour has so far been very time-consuming and costly, and new simulation tools and design procedures are needed. "The POSICOSS project is developing computer software which will simulate the behaviour of materials without testing, and will be at least ten times faster," explains Richard Degenhardt of the German Aerospace Centre.

As well as allowing lighter structures, the composites will reduce aircraft development time, fuel consumption and use of raw materials. The project began by assembling all available knowledge and defining the shortcomings of existing software, benchmarks and methods. It is now proceeding to design fibre composite structures for verification, and will successively test, simulate, modify and refine both simulation and design procedures.

The Riga Technical University in Latvia and the Israel Institute of Technology (Technion) are contributing to the expertise in manufacturing, testing and development of simulation tools, while Israel Aircraft Industries adds to the European pool of aerospace experience.

(15) Improved postbuckling simulation for design of fibre composite stiffened fuselage structures

Encouraging a dialogue with

Encouraging a dialog

Research and technological development (RTD) activities are assuming increasing importance in shaping the future of society. In addition, the EU added-value, ethical and socio-economic impacts of research are coming under ever-closer scrutiny. An initiative launched under the GROWTH programme is exploring ways to improve communications between governments, the scientific/industrial community and the general public.

'Encouraging Dialogue' is an initiative launched by the GROWTH programme to evaluate the need for academic and industrial research players to work together with policy-makers and the general public in contributing to a more visible and responsible research policy for the years to come.

In an initial pilot survey, the co-ordinators of 16 current projects were requested to express the views of their consortia on how they considered that society would perceive their RTD activities and the consequences of their results. Participants were invited to respond to questions addressing four main topics:

1. Frontier technologies: economic and industrial perspectives;

2. Society needs and sustainable development;

3. Ethical issues, risk assessment and governance; and

4. Educational needs and social acceptance.

Two key sectors

Target projects were selected from two key sectors: biomaterials (tissue engineering and implants) and superconductivity.

Biomaterials constitute a field of high strategic significance to the EU. The nature of the products is such that they have a direct impact on the quality of life for citizens – particularly in view of the needs of an ageing population.

The range of disciplines involved – including nanotechnologies, biotechnologies, computer modelling and simulation – makes this a key area for the development of multi-faceted scientists and technologists. In addition, it offers the prospect of raising EU industrial competitiveness, and of creating stimulating new employment.

IGOID[16], for example, is developing a new bi-layer treatment for dental and orthopaedic prostheses, which should speed the integration of implants with natural bone, and extend their life by forming a stable barrier against corrosion by biological agents. The coatings consist of a first titanium carbide (TiC) layer deposited by means of a high-energy process, and a second polymeric resorbable layer containing growth-stimulating molecules.

In the bioengineering field, questions of ethics and risk assessment are certainly of paramount importance. Superconductivity research, on the other hand, does not involve any sensitive ethical issues. However, two aspects of this work, i.e. its long-term character and the large array of potential applications, make social acceptance an essential prerequisite to the justification of continuing public subsidy.

ue with society

society

As a result of recent breakthroughs in high-temperature superconductivity (HTS), this is currently an international hot topic. There is fierce competition between the EU, the USA and Japan, with each region focusing on different aspects. Europe is very strong in some areas, but – in order to maintain current leading positions and become competitive in others – intensive and co-ordinated research efforts need to be undertaken.

Eventual successes will again impact strongly on everyday life, as the ability of superconductors to carry huge power loads with no resistive losses will revolutionise all kinds of electrical equipment. Healthcare will profit from advances such as the introduction of new magnetic resonance imaging (MRI) devices to replace x-ray systems in medical diagnosis. The global environment will benefit from energy savings and the consequent reduction in CO_2 emissions. Employment will be created for the highly skilled, multidisciplinary people required to service the new markets – and economic growth will ensue.

To date, the major barrier to commercial adoption of HTS materials has been their high cost. OPTIMISE[17] succeeded in improving the price/performance by one order of magnitude and laying the ground for an additional improvement of the same magnitude. These advances were obtained by development of the powder-in-tube (PIT) technique, which is the only proven method for production of long HTS tapes.

Ultimately, this could cut the total energy requirement of MRI and other medical systems by 6%, thus initiating a widespread use of superconductors that could create thousands of new jobs in EU and reduce the length of hospital stays.

The fruits of development in terms of functional and competitive applications, products, or even entire industries, may not be harvested until long after the initial investment has been spent – as will be the case with HTS materials. Despite two Nobel prizes awarded to Europeans, dialogue with society therefore remains fundamental to raising public awareness of the potential benefits.

Although confined to a limited number of GROWTH projects, responses to the 'Encouraging Dialogue' survey revealed a good level of interest in promoting exchanges. In general, the feedback from the scientific community was very positive and enthusiastic. Suggestions included the use of education and awareness campaigns – mainly through summer schools, secondary school tuition, demonstration events, seminars, press releases, radio and TV broadcasts, etc.

Preliminary results already indicate that any eventually adopted approaches will require a sound methodical approach and overall management at European level and that active and co-ordinated reinforcement is vital in achieving a broader awareness and greater appreciation of the benefits of RTD in ERA.

(16) Interfacial guided osteogenesis in implant device

(17) Optimising powder-in-tube tapes in MRI systems as ice-breaker for HTS socio-economic benefits

Expressions of Interest

Prior to formal adoption of the Sixth Framework Programme (FP6), the European Commission invited potential research consortia to submit expressions of interest (EoI) for participating in future actions. The objective was to provide input for the preparation of work programmes and the first calls for proposals – as well as to assess the RTD community's awareness of, and readiness to use, the new funding instruments. Thematic priority 3 on nanotechnologies and nanosciences, knowledge-based multifunctional materials, new production processes and devices attracted one of the highest response rates.

In March 2002, the European Commission invited the submission of expressions of interest to participate in research actions taking the form of Integrated Projects (IPs) or Networks of Excellence (NoEs) within FP6. Respondents were free to address topics relating to all seven thematic priorities of the FP6 programme proposal 'Integrating and Strengthening the ERA' – as well as to certain priorities of the 'Nuclear Energy' proposal.

The intention was not to convert the EoIs directly into actual funded projects. Rather, the initiative provided the Commission with a means to better identify S&T priorities and measure the research community's readiness to prepare actions using the new funding instruments, while also stimulating potential participants to familiarise themselves with the requirements for larger-scale integration. This exercise served as a valuable input to the preparation of relevant work programmes and definition of the first calls for proposals.

Huge response

Response to the call was huge, demonstrating widespread keenness to participate in research with a European dimension. Even after the removal of incomplete and duplicated submissions, more than 11 700 EoI were available for analysis by the Commission services.

Submissions came from over 50 countries, with France, Germany, Italy, Netherlands, Poland, Spain and UK each contributing 5% or more. It was not evident, however, whether the co-ordinator of an eventual proposal would be the same partner or from the same country as the EoI submitter.

Most of the responses came from academic institutions (46%) followed by research organisations (32%), with industry at no more than 14% overall.

High interest in industrial technologies

Of the 1 670 EoI assigned to Priority 3, 914 (54.7%) were for IPs and 622 (37.3%) for NoEs.

The overall assessment of the EoIs showed that:

1. 396 (24%) were clearly relevant, demonstrating both clear or potential breakthroughs and good understanding of the instruments;
2. 882 (52.5%) were considered not mature; and
3. 392 (23.5%) contained proposals that were not relevant or showed lack of understanding for the intention.

Several points emerged from a closer examination of the 396 mature and promising proposals:

- Lack of industry leadership, with weak participation by industry as co-ordinator (11%);
- Fairly even split between integrated projects and networks of excellence;
- SME participation mentioned in just over half the EoI; and
- International co-operation outside the EU and applicant countries mentioned in 27% of EoI.

Germany had the highest score as country of origin for EoI (20%), followed by the UK (15%), France (13%), Italy (8%) and Poland (3%).

guide FP6 planning

First FP6 calls published

The first major calls for Industrial Technologies projects under FP6 were published on 17 December 2002, split by the new funding instruments – Integrated Projects (IP) and Networks of Excellence (NoE). In all, three calls were involved with an overall indicative budget under Priority 3 for these three calls of € 485 million. Around 70% of this will be devoted to Integrated Projects and Networks of Excellence:

- The first call covered the entire Priority 3 programme with a total indicative budget of € 400 million, split as € 260 million for the new instruments and € 140 million for Specific Targeted Research Projects (STREP), Co-ordination Actions (CA) and Specific Support Actions (SSA). Closing dates were 6 March 2003 for the first stage of evaluation of the new instruments, and 10 April 2003 for the others;
- The second was a joint call with the Information Society Technologies (IST) thematic priority. It addressed 'manufacturing, products and services engineering in 2010', focusing on products and services engineering, and creation of 'knowledge communities' in production technologies. The total indicative budget was € 45 million for the new instruments – € 25 million for IST and € 35 million for Priority 3 – and € 15 million for CA and SSA (€ 5 million for IST and € 10 million for Priority 3). Closing dates are 24 April 2003 for the first stage of evaluation of the new instruments and 24 April 2003 and 16 September 2003 for the others; and
- The third call targeted Integrated Projects intended specifically to enable SMEs to support development of new knowledge-based, added-value products and services in traditional less RTD-intensive industries. This goal should be achieved through incorporation of emerging technologies driving new production paradigms in all phases of the complete/extended value-chain (design, production, distribution, recycling) to allow development of new knowledge-based, added value and quality products and services. The indicative budget is € 40 million and the closing date for the first stage evaluation is 10 April 2004.

Details of the individual topics covered under these headings can be found on the Commission's CORDIS website at: **http://fp6.cordis.lu/fp6/calls.cfm**

Overall a very wide range of research topics was indicated, but the opportunities offered by the new instruments were not well exploited: particularly the integrating aspect of Integrated Projects and structuring necessity of Networks of Excellence. In addition, only a quarter of EoI refer to overall costs – average costs for these were € 25 million for Integrated Projects (ranging from € 8 to 80 million) and € 34 million for Networks of Excellence (ranging from € 15 to 60 million).

Materials for tomorrow's

The views of experts from European institutes and industry were sought on promising directions for future materials research to meet the desired economic and societal objectives of the Sixth Framework Programme (FP6). Their conclusions highlight a number of specific categories with the potential to create wealth, improve health and protect the environment.

Workshops arranged by the Materials unit of the Research DG's Industrial Research Directorate brought together a panel of 36 European experts with backgrounds in academic and industrial RTD. As part of a wide-ranging discussion on future challenges and opportunities for the EU, the panel identified the principal materials categories likely to reward a concentration of research effort. These covered catalysts, optical and opto-electronic materials, organic electronics and opto-electronics, magnetic materials, biomimetics, nanobiotechnology, superconductors, composites, materials for medical applications, and high-tech textiles.

Future research on materials will be characterised by three main lines:

1. **THE ART OF MAKING** – developing new processing and fabrication methods to transfer the production of materials from the laboratory to the industrial plant;
2. **THE ART OF MIMICKING** – learning to copy from nature to and to achieve hybridisation of materials; and
3. **THE ART OF PREDICTING** – developing modelling and testing methods capable of limiting materials trials and defining optimum solutions.

Catalysts

Catalysts occupy an important place in modern industry, and represent a market of € 10 billion/year. They are central to the production of chemicals, oil derivatives, fertilisers, plastics, drugs and pharmaceuticals worth around € 2 000 billion/year – and make a huge ecological impact by reducing emissions from cars, power stations and chemical plants.

With the aid of surface science tools such as the scanning tunnelling microscope, scientists are beginning to understand the nature of nanomaterials used as catalysts. This, together with new procedures for producing nano-sized structures, is pointing the way to design strategies for 'atom-by-atom' assembly. Equally promising is the biomimetic approach, where mechanisms used by natural enzymes are translated into inorganic analogues.

Optical and opto-electronic materials

Photonics materials are key progress enablers in optical communications, data-storage and processing – as well as in sensing, display and lighting technologies. Devices such as light emitting diodes (LEDs) and lasers have end-uses in most walks of life: from automotive dashboards to computer systems and environmental monitoring. Developments in this area relate to novel materials systems, and to the ability to control them on a nano-scale, leading to devices in which the light emission is related to the 3D nano-structure – e.g. quantum dot LEDs and lasers. A particular challenge is the development of large and efficient white light emitters, which could bring substantial energy savings by replacing the omnipresent light bulb.

In the longer term, the development of digital systems in which some or all of the data processing is implemented in optical, rather than electronic, devices would reduce the present need for 'light to electronic' and 'electronic to light' conversion.

Further increasing the capacity of two-dimensional storage media such as CD or DVD, and developing three-dimensional data storage using interference phenomena and holographic techniques, are yet more promising avenues.

Fast route to high-performance catalysts

The development of new and efficient solid catalysts for heterogeneously catalysed reactions often involves expensive, time-consuming steps. In the GROWTH COMBICAT[18] project, due to commence in July 2003, a combinatorial approach will be used to streamline the process. The targets are to develop innovative methods for high-speed catalyst preparation, testing and selection. These methods would then be used to discover new compound combinations capable of functioning as high-performance catalysts for industrial reactions. Such improved catalysts could lead to energy savings and reduced levels of undesired by-products. The resultant technological concepts and equipment would be sold as a spin-off through a high-tech SME.

(18) Catalyst design and optimisation by fast combinatorial analysis

#8
April 2003

Organic electronics and opto-electronics

Many classes of organic material exhibit properties such as electro-luminescence, conductivity and/or semiconductivity. One research goal is to develop a cheap, high-volume alternative to mainstream silicon-based electronics for applications where the performance requirements are modest.

Manufacturing techniques now under investigation for organics do not require the high levels of capital investment associated with inorganic electronics. Furthermore, emerging technologies will make it possible to produce the organics on large areas and flexible substrates such as textiles. Early envisaged applications include smart cards and tagging devices. Eventually, these could extend to smart and responsive fabrics, lab-on-chip or micro-reactors, car components and large data displays.

Magnetic materials

Constant demand for higher data storage densities has stimulated the shrinking of magnetic media from micro- to nano-scale. Following the discovery of giant magneto-resistivity (GMR) about fifteen years ago, all magnetic disk read heads and many magnetic sensors are now based on GMR or related forms of magneto-resistance. The eventual aim is to have one magnetic nano-particle to represent one bit of information.

A second development in nano-magnetism is that of magnetic random access memory (MRAM), which is being explored as an alternative to present-day CMOS-based memory chips. The advantages of MRAM are that it is non-volatile, and that it can in principle be miniaturised to well below 100 nm per bit.

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Other important areas for study are the development of magnets and micro-magnetic systems with the capability to operate at higher temperatures, and the development of low-cost device manufacturing technologies, such as printing and sintering.

Because magnetism is an extremely complex property – often requiring compounds of three, four or five materials to optimise the required performance – it represents a great challenge for the material scientists.

Biomimetics

Learning from nature and marrying biology to materials science is generating fresh ideas in many fields. Living organisms employ a plethora of materials, architectures, systems and functions that have been optimised during the long evolutionary process. Some micro-organisms, for example, use a template mechanism involving the self-assembly of organic molecules as structure-directing agents in the synthesis of protective silica shells. By simplifying the natural pathways using synthetic polymers, researchers are now able to mimic similar functionalities.

A notable feature of biological materials is their structural organisation on many scales, as is the case for the ceramics and composites found in animal shells, bone and dental tissues. Integration of these 'intelligent' systems involves two important aspects: miniaturisation, to include many functions in a small volume; and hybridisation, to gain from associating mineral and organic components. The field holds an enormous exploitation potential, and is recognised as one of the most promising for the coming decades.

Nanobiotechnology

Nanobiotechnology seeks to integrate artificial and biological matter, by designing synthetic materials on a nano-scale and assembling them into molecular architectures. These could form the basis of a wide variety of high-value products: medical and environmental lab-on-a-chip devices, targeted drug delivery systems and biologically compatible implants, among others.

Techniques for the study of biology at nano-scale and molecular level are crucial for the development of the entire field of nanobiotechnology – but the activities will cover a wide spectrum of development time-scales. For elements such as transplants, a ready market already exists. For lab-on-chip devices, while present demand is small, a strong growth is predicted. Drug delivery systems are at an active research stage, but may take significant time to reach markets, if only because of the related regulatory procedures.

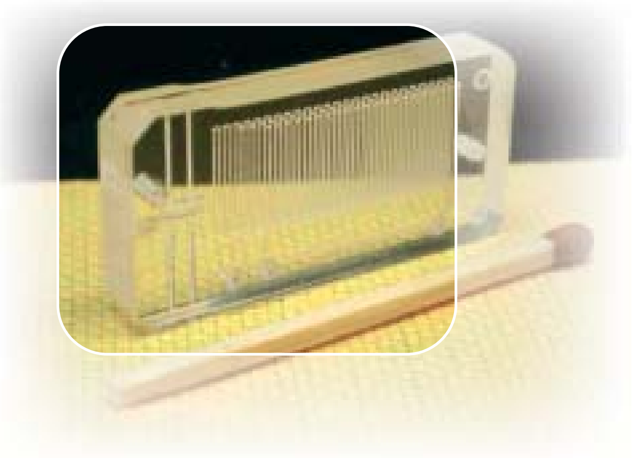
#8

Polymer semiconductors cut cost of electronic circuits

The cost of electronic device manufacture can be reduced dramatically by using soluble semiconducting polymers in place of conventional silicon. Although these materials are not suitable for high-speed data handling, they will find application in a wide range of simple mass-produced circuits such as remotely-readable 'smart labels' for luggage and packages, flexible displays for personal computers or dashboards, and 'electronic paper'. The GROWTH PLASTRONIX(19) project, concluded in December 2001, validated a semi-industrial scale process for the production of polythienylene vinylene (PTV) polymer. It went on to develop an industrial technology for polymeric integrated circuits on 150-mm flexible foils, and demonstrated both a smart label and a 256 grey level active matrix liquid crystal display (LCD).

(19) Low-cost all-polymer integrated circuits for low-end high-volume identification applications

Lab-on-chip analyses water on nano-scale



Lab-on-a-chip technology is attracting great attention in many sectors – from environmental analysis to biochemical assay and DNA-based diagnostics. Benefits include portability, minimal consumption of energy and reagents, and substantial cost savings as new systems enter mass production. The GROWTH MicroChem[20] initiative, completed in October 2001, culminated in the successful demonstration of prototype miniaturised systems suitable for rapid field-testing of wastewater streams. Methods and microchips were developed and verified for optical detection of ammonium, phosphorus and aluminium in nanolitre-sized samples. While these remained too complex for immediate commercialisation, a number of potential low-cost subsystems have been shown to work well. Given the small amounts of reagents needed, robustness of the sampling unit developed under MicroChem, it is clear that economical, low-maintenance systems can ultimately be produced.

(20) A miniaturised industrial chemical sensing system

Superconductors

While the performance of high-temperature superconductors (HTS) is attractive for energy-related, medical and analytical applications, their costs remain too high. The fabrication of affordable HTS devices requires technology for local material control at a scale of just a few nm. At present, there is strong competition between the EU, USA and Japan for leadership in this domain.

The application field of superconductivity is very extensive, embracing large-scale energy-related applications (transformers, power cables, current limiters, magnets) and small-scale electronics (passive/active signal processing, current leads for low temperature systems...). HTS magnets can be used in medical magnetic resonance imaging (MRI) systems, superconducting quantum interference devices (SQUIDs), high-energy particle detection and nuclear magnetic resonance spectrometers, while filters for mobile phone base stations have already made it to the market.

Composites

The European composites industry has expanded rapidly, from just a few companies in the 1950s to more than 15 000 today, most of which are SMEs. Lightweight composite structures are employed to advantage in construction/civil engineering; and in surface, water and air transport – with the most high-end applications found in the aerospace industry.

There is unprecedented scope for a further acceleration in growth. New matrices, fibres and compounds need to be explored in order to realise tailored functions such as electrical conductivity in polymer composites, or to permit the recycling of residual materials. Bio-composites, molecular electronics, biomimetic materials, nano-phasic composites, ceramics and reinforced metal-matrix composites are all attracting global attention. The implementation will require a multi-disciplinary approach that encompasses design, synthesis/processing, fabrication and production.

Materials for medical applications

In Europe, life expectancy at birth has increased approximately fourfold in 300 years. Yet after the age of 40, bones, joints and organs begin to wear out and the incidence of severe disability increases. The resulting healthcare costs and quality-of-life issues are major concerns in an ageing population. To save lives and maintain people's mobility, independence, and quality of life for as long as possible, it is necessary to assist, repair or replace parts of the human body.

Biomaterials and medical devices represent a fast-emerging world market that is estimated at about € 25 billion per year, with a 12% annual growth rate. Europe holds a share

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of around 30%, and has particular strengths in areas such as tissue engineering. Continuing advances in this technology could satisfy the ever-growing demand for tissue and organ repair and replacement, while avoiding the risks of rejection, infection and disease transmission inherent in dependence on human donors or xenotransplantation.

Nano-biotechnological materials will also be needed for drug delivery systems to combat hitherto incurable diseases – as well as for minimally invasive surgery and non-invasive diagnostic systems.

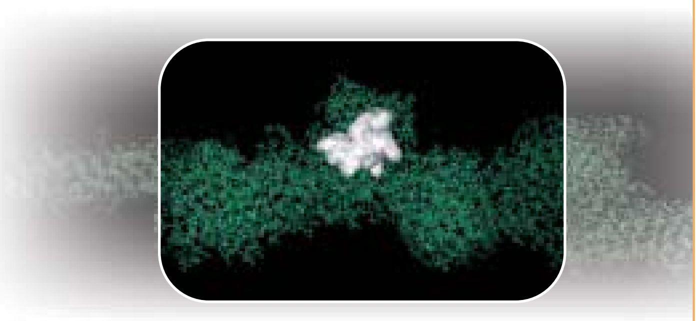
Intelligent technical textiles

The textile and clothing sector is a prominent part of the European manufacturing industry, giving employment to more than two million people. Its importance for social and economic cohesion is increased by the fact that it is dominated by a large number of small and medium-sized enterprises (SMEs), which are often concentrated in particular regions, thus contributing greatly to local wealth and cultural heritage.

Over the past decade, EU industries in this sector have undergone significant restructuring and modernisation, geared to increasing productivity and innovation. The main imperative for enhanced competitiveness is recognised as

Nanoparticles deliver drugs

TATLYS[21] is a current GROWTH project studying the development of a new biocompatible and bioerodable nanoparticle delivery system for targeted release of drugs for the dispersion of blood clots (thrombus) in the cardiovascular system. New polymeric matrices suitable for the formulation of nanoparticles are being prepared on laboratory scale, while specific thrombus-targeting compounds are being modelled and synthesised. These are combined with appropriate drugs under experimental conditions, in order to derive effective nanoparticulate systems. After optimisation of the experimental parameters, promising candidate combinations will be scaled-up to pre-industrial level. The stability and toxicity of the nanoparticles will be investigated.



(21) A new biocompatible nanoparticle delivery system for targeted release of fibrinolytic drugs

Virtual institute on composites to be created

The quantity and quality of composite materials research in Europe is high, but its commercial exploitation trails behind Japan and the USA – particularly in terms of spin-off knowledge-based companies, technology push into established start-ups and the commercial exploitation of new applications. To remain competitive in areas such as the aerospace, automotive, marine and wind-generated power industries, sustaining a high level of innovation and technology transfer is vital. The European Commission therefore published a dedicated call under GROWTH for the setting-up of virtual institutes on composite materials. The aim was to develop 'a new capability that is created by linking geographically scattered complementary research and industrial expertise in order to transfer and implement research results into application'. Several consortia responded, and one proposal is now under negotiation. Special emphasis is placed on keeping the access threshold as low as possible to allow start-ups and SMEs to profit from the know-how available in Europe.

being the shift to a more high-tech status, achieved by introducing emerging technologies and new 'knowledge-based' materials and products.

Technical textiles already enjoy a growing market in transportation, healthcare and special-purpose clothing. New multidisciplinary research will bring still more advances. Examples are the development of multi-functional textiles by fibre-surface functionalisation – e.g. to provide anti-bacterial or anti-mite effects, or the controlled release of drugs via a textile interface with the skin. Intelligent textiles for workplace protection, blood pressure control and comfort, plus new nonwovens for structural applications in railways, aeronautics, and construction, figure among a vast spread of additional possibilities.

Across the whole field of materials research, much work remains to be done in identifying and synthesising new combinations of atoms and molecules, devising the relevant tools; promoting closer interaction between industry and academia; training the much-needed multi-disciplinary scientists and engineers, and encouraging the entrepreneurs who will bring the fruits of scientific endeavour to the marketplace.

Building with textiles

New construction technologies such as 'tensile structures' contribute to modern issues of urban planning. Due to their flexibility, minimal resource use and capability of easy removal, they have enormous potential and are waiting to find more applications.

The TensiNet[22] project addresses specialists such as urban planners, architects, designers, engineers, material suppliers, constructors and research institutes. The partners, under the co-ordination of the University of Brussels (VUB), are forming a complementary group of 21 organisations with representatives from nine EU Member States, representing multi-disciplinary industries and institutes.

Through its website and databases, TensiNet makes state-of-the-art information on structural membranes available to external interested parties and encourages the further use of lightweight materials in the building industry. Especially in this field, where materials and tools are continuously evolving, a 'life-long-learning' support is of great importance.

(22) The communication network for tensile structures in Europe

Market study on textile use in construction

The use of structural membranes has attracted much attention in recent years and some spectacular examples of tensile structures to be found in public buildings, sports stadia, etc. As this market is still in its infancy, the volumes of technical coated woven fabrics so far employed remain relatively small. Overall applications of textiles in the construction sector have nevertheless been growing steadily, and are expected to continue growing.

The following table summarises textile use by region in the construction industry, indicating the estimated trend from 1985 until 2005:

'000 tonnes	1985	1990	1995	2000	Growth	2005	Trend
West Europe	119	178	208	241	50%	277	13%
East Europe	11	20	15	22	50%	37	40%
North America	308	344	405	458	33%	528	13%
South America	5	8	13	18	72%	26	25%
Asia	55	114	173	239	77%	323	26%
Australasia	4	6	9	11	64%	14	21%
Rest of World	6	13	27	38	84%	60	37%
Totals	**508**	**683**	**849**	**1026**	**50%**	**1266**	**19%**

Source: 'The World Technical Textile Industry and its Markets: Prospects to 2005', David Rigby Associates, 1997

Sustained investment in industrial research: Finding your way in the Sixth Framework Programme

The European Commission's Sixth Framework Programme (FP6) was launched in November 2002 with a budget of € 17.5 billion and runs until 2006. The key actions and generic activities of the FP5 GROWTH Programme have been replaced by a number of thematic priorities in industrial research, designed to support the creation of the European Research Area. FP6 is built on larger-scale research integration and a longer-term perspective, and offers a series of new funding instruments – particularly Integrated Projects and Networks of Excellence.

Technologies and policies

- FP5 key action 1 **Innovative products, processes and organisation** and the generic actions on **Materials** are now part of the industrial technologies FP6 thematic priority 3: **Nanotechnology and nanosciences, knowledge-based multifunctional materials and new production processes and devices.**
- FP5 key action 2 **Sustainable mobility and intermodality** and key action 3 on **Land transport and marine technologies** are part of FP6 thematic priority 6: **Sustainable development, global change and ecosystems.**
- FP5 key action 4 on **New perspectives for aeronautics** is part of FP6 thematic priority 4: **Aeronautics and space.**

Generic research

- FP5 Generic Activity 1 **New and improved materials and production technologies** is part of Thematic Priority 3: **Nanotechnology and nanosciences, knowledge-based multifunctional materials and new production processes and devices.**
- FP5 Generic Activity 2 **New materials and production technologies in the steel industry** mostly covered work carried out under the European Coal and Steel Community (ECSC) research programme. Following the end of the ECSC in July 2002, a new programme for steel research has been established, separate from the Framework Programme.
- FP5 Generic Activity 3 **Measurements and testing** will be distributed through all the thematic priorities of FP6.

More information

For more information about FP6, see the European Commission FP6 website
http://europa.eu.int/comm/research/fp6/index_en.html

For details on how to participate in FP6 projects and the latest information on calls for proposals, see the CORDIS FP6 website
http://www.cordis.lu/rtd2002/home.html

For information about FP6 thematic priority 3: **Nanotechnology and nanosciences, knowledge-based multifunctional materials, and new production processes and devices**
http://europa.eu.int/comm/research/industrial_technologies/index_en.html
http://www.cordis.lu/fp6/nmp.htm

More information about steel research can be found on the CORDIS steel website
http://www.cordis.lu/coal-steel-rtd/steel/

For information about FP6 thematic priority 4: **Aeronautics and space**
http://europa.eu.int/comm/research/fp6/p4/index_en.html

For more information on European activities in space, see the European Commission space website
http://europa.eu.int/comm/space/index_en.html

For information on FP6 thematic priority 6: **Sustainable development, global change and ecosystems**
http://www.cordis.lu/rtd2002/fp-activities/sustainable_development.htm

New literature

Synopses of projects under the 'Land transport and marine technologies' and 'New perspectives for aeronautics' key actions as well as the 'Measurements and testing' generic activity are now available. For copies, please email: growth@cec.eu.int.

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