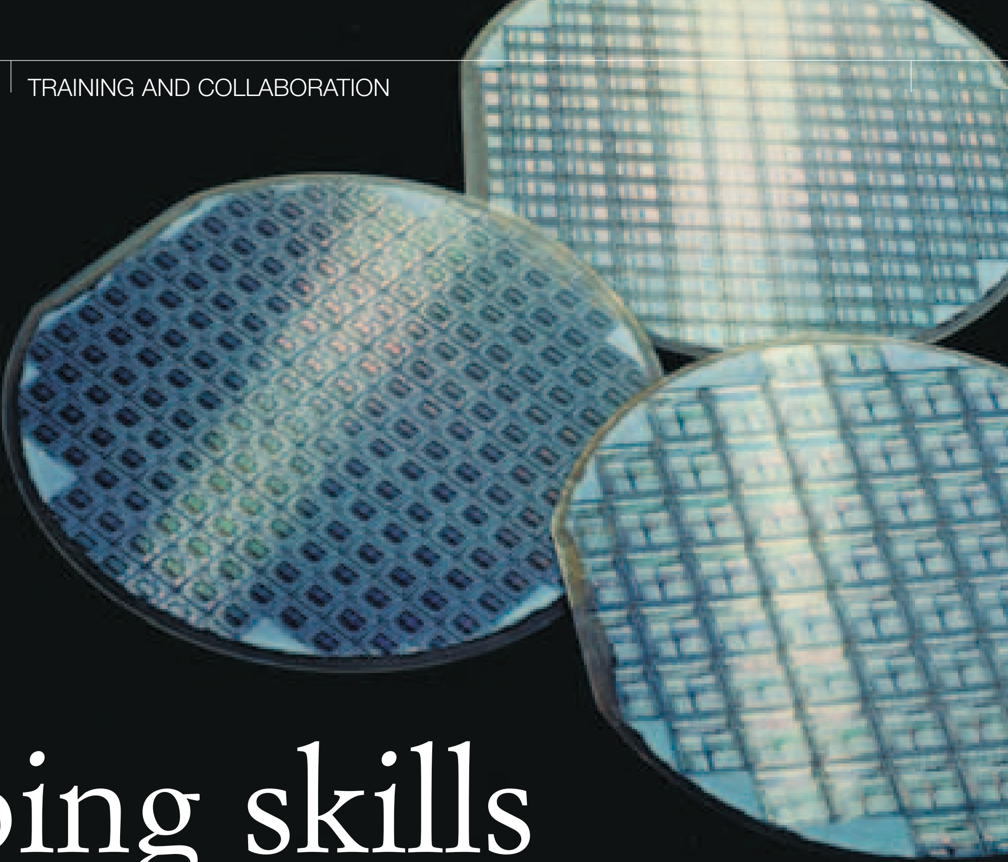
DR CLIVE DYSON
CHIEF EXECUTIVE, NATIONAL MICROELECTRONICS INSTITUTE



Developing skills for high-technology industry

The UK semiconductor industry has been working with academia and the government to overcome the skills shortage that all high-tech industries are presently facing. The National Microelectronics Institute was created to provide a focus for collaboration and to establish initiatives that are relevant and directly beneficial to industry. Clive Dyson gives examples of what can be achieved and highlights areas in which changes still need to be made.

Introduction

High-technology industry faces a global skills shortage. However, we are often accused of complaining loudly but – with notable exceptions – doing nothing about it. This article discusses collaboration between the semiconductor industry, academia and government in the UK, as one example of what can be achieved. It also discusses some of the barriers to progress that have been identified during our work.

Our experience has shown that the best progress is made if industry is proactive and provides impetus and guidance to ensure that initiatives will meet its needs. This requires action. Far too often, we are faced with reports from governmental, regional or other working groups that analyse the problem and provide a host of recommendations. Typically, these reports either result in no action being taken or in a new initiative being formed that is underfunded and duplicates existing activity in an uncoordinated manner.

The semiconductor industry in the UK has addressed these difficulties by establishing the National Microelectronics Institute (NMI) to provide a focal point for collaboration within the industry, and with academic and regional partners. The approach used is one example of best practice in the UK and provides a framework that can be extended to support the wider industrial community.

Coping with rapid but cyclic growth

The number of students graduating with a technical degree has remained roughly constant over the last five years, even though the total number of degrees awarded has risen. More details are given in the box.

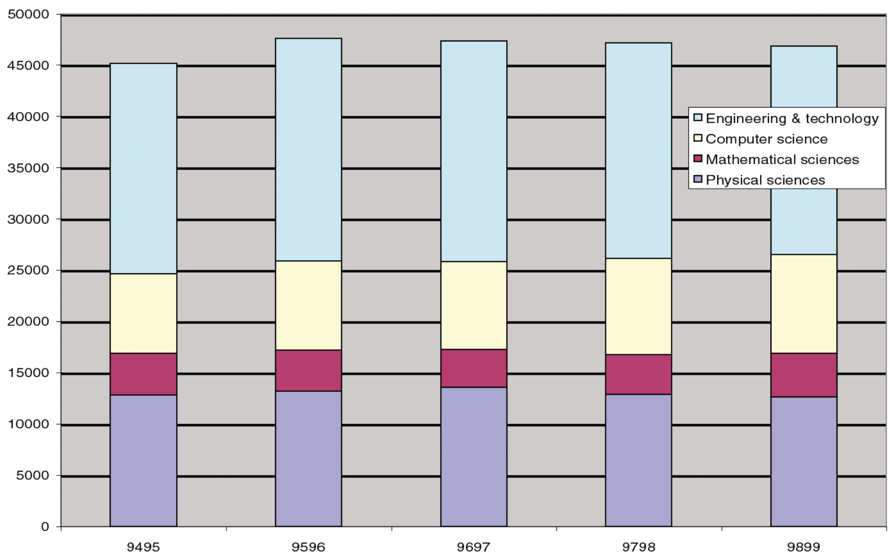
Changes in student numbers

We have seen a steady decline in the relative number of 'A' level passes in mathematics and physics in England and Wales. While the overall number of 'A' level passes rose by 17% between 1993/94 and 1998/99, the number passing mathematics grew by 15% and the number passing physics by 3.3%. However, we hear continually from universities of the increasing need to provide remedial classes in mathematics for first-year students on science and engineering degree courses – often for students with reasonable school grades.

The number of students taking design, technology and computing degrees has risen rapidly to 23,000 per year. However, this is still small compared to the 56,000 taking mathematics and 27,000 taking physics.

In higher education, just over 4000 students graduated with electronic engineering degrees in 1999, a 13% increase on the number graduating five years previously. Over the same period, the overall number of graduates rose by 11%. However, the number of computer science graduates grew by 25%, the number of graduates in physics, mathematics and material science and the number of non-electrical or electronic engineering graduates remained broadly static, while the number of students with degrees in electrical engineering declined.

In 1999, there were almost 50,000 graduates with some form of technical degree – see graph. This figure has been roughly constant for the last five years, despite a rise in the total number of graduates. Technical degrees have fallen from 22% to under 20% of the total number of degrees awarded over the last five years.



Number of 'technical' degrees awarded in the UK.

Against this background of a relatively fixed supply of new staff, high-technology companies in the UK have been expanding. At the same time, the demand for technically competent employees has been increasing across the economy, due to the increasing use of technology in most aspects of business and modern life.

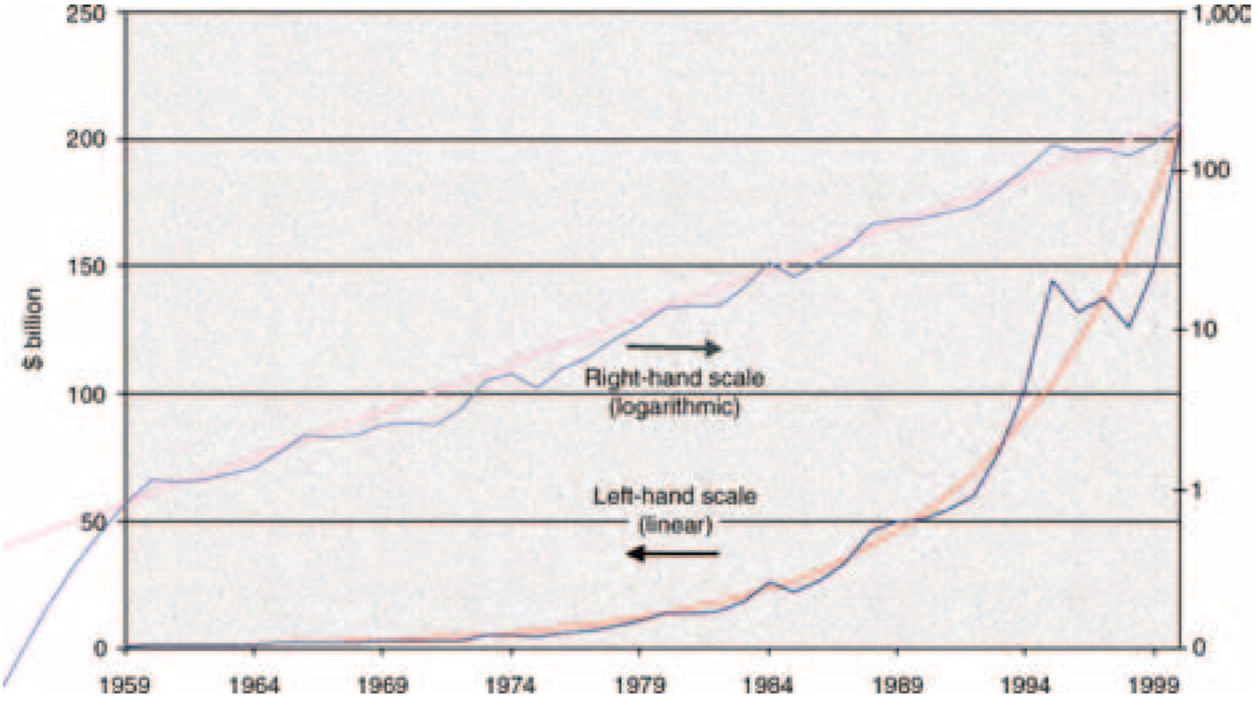
The semiconductor industry is a good example of high-technology industry, with average growth in manufacturing output of about 17% per annum (see graph below) and a rapidly expanding design and product development community. Although its long-term growth shows no signs of abating, this consists of periods of hectic growth followed by periods of consolidation. Such cyclic growth is not uncommon, and is typical of most high-growth areas of the economy. It would appear that successful economies are those that have learned to cope with the problems that cyclic growth causes through flexible education provision and flexible labour markets.

Cyclic growth does, however, pose particular problems to educators. How can they plan to provide qualified individuals when industry itself has difficulty forecasting the capacity it will require? We need to find a way for the education and training system to cope with rapid fluctuations in demand for staff from individual industry sectors. We must avoid taking the easy route of not encouraging students to undertake engineering and science qualifications. These are the very skills that are enabling economic growth.

The best solution is for government to ensure an adequate supply of generic high-technology skills in the UK. It is not possible to forecast which sectors of industry will have expanded rapidly or reduced in size in five years' time. However, we can be certain that there will still be a strong demand for technical skills. Government must take the strategic lead to ensure that our education system is producing graduates and technicians with broad-based skills that are applicable to a wide range of industrial sectors. These skills are not difficult to identify. They include electronics, physics, mathematics, computer science, communications, biotechnology, mechatronics, chemistry, marketing, manufacturing and product introduction.

The design and manufacture of semiconductors requires graduates with skills in fields such as electronics, computer science, chemical engineering, physics and mathematics. We require technicians with skills in the installation and maintenance of complex capital equipment. These skills include programmable control, pneumatics, robotics, vacuum, RF equipment and process control.

But these graduate and technician-level skills are broadly applicable across a wide range of industries. This



World semiconductor sales.

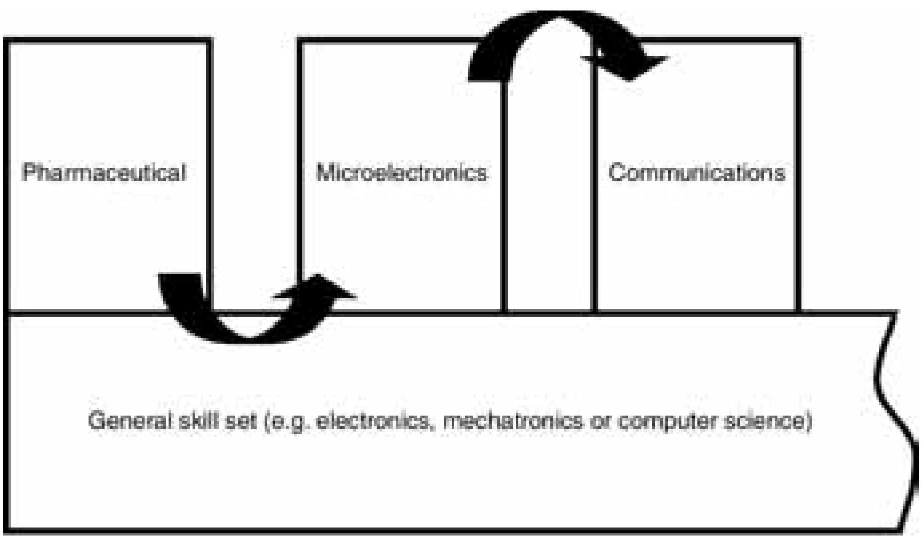
observation can be exploited to allow those broad areas of knowledge and skills that are likely to be in short supply to be identified and for the education and training system to be well resourced in these fields. On receiving their qualification, individuals will naturally flow to the sectors where growth is occurring at any point in time.

However, supplementary education and training are required to provide specific skills for given industry segments. Students can be allowed to choose optional modules that may be relevant for careers they expect to follow on qualification. For individuals already in employment, sector-specific (continual development) courses at Masters level can be offered.

The semiconductor industry has been following this approach, as described below, by working with academia to develop optional units to be offered as part of FE college qualifications, undergraduate degrees and as postgraduate, Masters-level modules. This facilitates training for specific industrial sectors and facilitates retraining between sectors.

This approach provides a number of benefits:

- It is flexible for young people, who can initially target a range of industry sectors without making a final choice and take sector-specific modules later in their education.
- It makes engineering more attractive to young people – they see that common modules give them access to a wide range of job opportunities.
- It insulates individuals from a given sector's 'ups and downs' as they can easily retrain for jobs in other sectors.
- It allows rapid retraining between industrial sectors, thereby allowing industry to grow without having to train staff from scratch, as shown by the arrows in the figure below.



Relationships between generic and specialist skills.

The semiconductor industry has been following this approach for over five years. It has worked with both Further Education (FE) colleges and universities and the results to date are summarised in the next three sections.

Qualifications for technicians and operators

Over the last ten years the semiconductor industry has worked with a group of 10 FE colleges and with EMTA (the National Training Organisation for Engineering Manufacture) to develop a number of National Qualifications (NC, HNC and HND courses) and a series of Vocational Qualifications (VQs) to meet the industry's needs.

The VQs used for operators and technicians within the semiconductor sector are mainly awarded by EMTA. The following VQs are available in the UK:

- Foundation Award for Modern Apprenticeship (level 2) – currently moving to Performing Engineering Operations.
- Performing Manufacturing Operations (level 2) – for operators.
- Engineering Maintenance (level 2) – 3 variants for Facilities Technicians, Equipment Technicians, and Test and Assembly Technicians.
- Engineering Maintenance (level 3) – 3 variants for Facilities Technicians, Equipment Technicians, and Test and Assembly Technicians.
- Technical Services (level 3) – 2 variants for Process Technicians and Calibration Technicians.

Although there are some differences between National Qualifications in England and Wales, and in Scotland, it has proved possible to develop (via SQA and Edexcel) a series of courses that are effective for the industry throughout the UK. Following an informal needs analysis, a joint college/industrial working group identified which existing mechatronics modules would satisfy the generic skills requirements of related industries. A number of specific specialist modules were then developed and added to the list of optional modules for HNC and HND qualifications, first in Scotland and later in England and Wales. This resulted in the HNC/NND in Mechatronics with Semiconductor options in Scotland and HNC/HND in Plant & Process Engineering in England and Wales.

Courtesy of Applied Materials.

The industry also supports the FE colleges through four programmes:

1. College workshops. These are three-day events run by industry specialists to provide in-depth training to college lecturers. They include visits to manufacturing sites and equipment vendor training facilities.
2. Lecturer development plans. An industrial working group has produced a lecturer development plan, which outlines the training needed for any lecturer supporting the semiconductor industry.
3. Regional college consortia. Three regional college consortia have been formed by Development Agencies in the North East of England, Scotland and Wales. The NMI acts to ensure that these consortia work to a common framework and exchange teaching materials. This avoids duplication of effort and makes the best use of regional funds.
4. Donation of equipment. Manufacturing equipment that is no longer required is made available to colleges.

The NMI is presently chairing EMTA's working group to refine the National Occupational Standards for electronics technicians. This should ensure that the standards correctly reflect industry's requirements.

The collaboration between industry, the FE colleges and the regions has been very successful. It has demonstrated the benefits of focusing industry's support on a limited number of institutions and ensuring that they can offer courses to the required standards. It has led to the development of a sense of community between staff in the colleges involved, which has allowed lecturers to build on each other's experience and to minimise the duplication of work. They have also been in a better position to influence the development of qualifications.

Postgraduate courses

Since its formation, the NMI has been working with a network of UK universities to establish two complementary programmes of postgraduate modules at Masters level.

The first programme of modules, on semiconductor manufacturing, is now successfully operational. Five modules have been delivered to about 100 participants and a further six modules are scheduled to be run in 2001. This is equivalent to training 25 full-time MScs for the industry.

Semiconductor manufacturing demands knowledge of materials, device physics, process chemistry, batch manufacturing, statistics, quality management and other disciplines. There is general agreement that this breadth of knowledge cannot be achieved through undergraduate courses. The industry prefers to attract employees with undergraduate training in a wide range of relevant disciplines. The modules are therefore designed for graduate engineers employed in the semiconductor-manufacturing sector. They provide specialist training for staff wishing to extend their technical knowledge and provide a ‘fast track’ for the development of future senior engineers and engineering managers.

Sixteen modules are presently available from Glasgow, Edinburgh, Heriot-Watt, Newcastle, Liverpool, UMIST, Cardiff, Swansea, Surrey, and Southampton Universities. The programme is very flexible. It is designed so that delegates can register to take just a single module. Subsequently they can take additional modules to gain an academic qualification. For example, they can gain an MSc by taking eight modules and carrying out an in-company project.

Each module involves the equivalent of two weeks’ distance learning (over a period of two to three months) plus an intensive one-week residential course held at the specialist university. Industrial experts have been actively involved in the development of the modules to ensure that the technical content of the course is fully up to date and relevant to industry’s needs.

A second programme of modules, on IC design and embedded software development, is now being assembled. It follows the framework established by the manufacturing programme and offers the same degree of flexibility. However, it will also provide delegates with remote access to industry-standard design software to use as part of the course.

This programme builds on the wide range of modules already available to support IC design and embedded software development, including those offered by:

- The Institute for Systems Level Integration (ISLI) – consisting of the Universities of Edinburgh, Glasgow, Heriot-Watt and Strathclyde.
- The Radio Frequency Engineering Education Initiative (RFEEI) – consisting of the Universities of Bristol, Bradford, Surrey, Portsmouth and York.
- The Advanced Microelectronics for Industrialists IGDS offered by Bolton Institute and UNN.

The new course is structured to allow industry to request other specialist universities to offer modules in their fields of expertise. Because the programme is based on existing courses it will be possible to offer modules starting in October 2001. Updates on the status of the development of this programme are available via the NMI web site.

I would like to acknowledge the Engineering and Physical Sciences Research Council for their contribution to the cost of development of both of these programmes, under the Integrated Graduate Development Scheme and Masters-level Training Programme initiatives respectively.

Undergraduate education

As an industry, we need graduates with a broad range of engineering, scientific, manufacturing and mathematical skills, coupled to an understanding of the key aspects of microelectronics – one of the world’s vital industries. We do not wish to focus on specialised microelectronics degrees (although there is a place for a small number of these) as this would fail to provide the diverse range of knowledge that we require.

Through the two postgraduate initiatives described above, we have established links with most of the relevant universities in the UK. Most of these already offer microelectronics design and/or manufacturing modules as part of their undergraduate degrees.

In general, the UK would benefit greatly if a relatively large number of technical graduates included one or two ‘microelectronics technology’ modules in their final two years, as part of a broad (or related discipline) degree. We expect that many would continue to find their final careers outside of engineering in, for example, finance, consultancy, and the media. They would still find that a good understanding of the technology supporting their endeavours would be highly beneficial.

We are currently working with industry and academia to develop outline syllabuses for undergraduate modules on IC design, embedded software and semiconductor manufacturing. Industry believes that it needs to contribute its expertise to the development of such modules, because the industry is advancing rapidly and using capital-intensive software and equipment. This puts work on industrial-scale problems outside the scope of university activity and means that industrial inputs are needed to make university courses more relevant to our immediate needs.

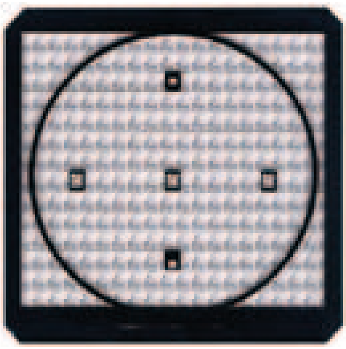
In parallel with this, we are investigating whether there is scope for optimising the use of the industrial funding already provided to universities and complementing it with EU or UK government funding in support of the sector.

Obstacles remaining

The semiconductor industry has made good progress by collaborating with government and academia. However, much remains to be done and, based on our work to date, we would suggest that the following issues require urgent attention:

- Action is required to increase the number of students choosing to take technical degrees, especially in mathematics, physics and electronics. We recommend that government adopts a target to increase the number of students graduating with a technical degree from the present figure of about 50,000 per year to 70,000 per year within five years. This will be a difficult target to achieve, but would provide a strong guide to policymakers and a clear goal for activities. The action that is required really deserves an article in its own right. However, key steps will be to convince 10- to 14-year-olds of the career opportunities that will be opened up to them by technical subjects; to provide differential salaries in subjects where there is a shortage of able teachers; and to provide specific additional resources to universities and FE colleges to support courses in technical subjects.

- The education system in the UK is already unnecessarily complex. We currently face a proliferation of initiatives intended to improve the system, but these are in danger of making the system even more complex and less understandable to employees and students alike. It would be preferable to adopt a policy of simplification. For example, we would have welcomed an approach to ‘rebrand’ Higher National Diplomas as Foundation Degrees, accompanied by a close linkage to the Vocational Qualification system. Instead Foundation Degrees have been launched in competition to Higher National Diplomas, which are likely to wither away. Industry will be faced with having to replace a set of qualifications that we have worked on for many years to meet our needs.
- Another result of the proliferation of initiatives has been the fragmentation of the available funding and the duplication of effort. Action is required to coordinate the many initiatives underway and to coalesce them whenever possible. For example, initiatives are presently arising from working groups associated with the Information Age Partnership (a DTI/DFES consultation), Foresight, the Engineering Council’s Engineering and Technology Board, the Scottish



Executive, the Welsh Assembly, the English RDAs, the LSC and its regional operations, from new bodies such as the University for Industry, and from the DTI and DFES themselves. It is not surprising the industrialists find themselves confused.
- The move to specialist colleges will provide an opportunity to fund a number of ‘high-technology colleges’, fully equipped to offer courses such as mechatronics, electronics, and laboratory work.
- The present limit on Modern Apprenticeship funding to those completing the qualification by the age of 25 needs to be removed. I believe that this is already being implemented in Wales and we would welcome the extension of this policy to the rest of the UK. It is a significant barrier to the practical realisation of life-long learning for employees.
- Funding for full-time Masters courses has been reduced over recent years. Combined with the debts that students are accumulating at universities, this is cutting the number of UK students taking postgraduate courses dramatically. One possible solution would be to provide competitive grants for a number of places on such courses with the level of grant sufficiently high to ensure that students’ debt did not increase. This may be complemented by industrial support.

These are some of the major issues that we perceive from an industrial perspective. The NMI is currently working with EMTA, FEI, Electronics Scotland, and the Welsh Electronics Forum to develop proposals for the support of the electronics industry as a whole.

Summary

This article has used the work being carried out by the semiconductor industry in the UK, in collaboration with its academic partners, as an example of what can be achieved within the constraints of the existing educational system. I have argued that government must take the lead in ensuring that the UK generates more graduates with technical degrees and qualified technicians. This must involve a specific allocation of funding to these subjects areas. Nonetheless, I hope that the work described in this article demonstrates that industry is anxious to play its part. ■

Web sites

NMI: www.nmi.org.uk

IGDS: www.icprocessing.com

MTP: www.bolton.ac.uk/technology/ceesi

Clive Dyson is Chief Executive of the National Microelectronics Institute (NMI). He joined the NMI from GEC Plessey Semiconductors where he was first Technical Executive for GPS’s CMOS lab in Plymouth and, subsequently, Engineering Manager for the company’s ASIC Systems Business Unit. Previously he served in a number of management and technical roles with SGS-Thomson, Inmos, STL and Philips. He holds an MA in Natural Sciences from Cambridge University, a PhD from Southampton University, and an MBA from Bath University

Email: clive.dyson@nmi.org.uk