Materials Science and Engineering in Britain

Editorial Essay

By Colin Humphreys *

Mankind is poised to move into a revolutionary era: the age of new materials. For example, materials scientists are designing novel liquid crystals which will enable television sets of the future to be thin and light, so that they can be hung on a wall like a picture. We can make superconductors in which an electric current will circulate for ever with no battery required to keep it going: well known recent developments in materials chemistry have led to higher critical temperature superconductors which may ultimately result in cheaper electricity and ultrafast levitating trains. We can make materials which store information so compactly that the entire contents of the Encyclopaedia Britannica can be contained within the space occupied by this full stop →. (see Fig. 1) We can make semiconductor lasers so thin that one million of them can be stacked side-by-side within the thickness of a one penny coin, and the color of the laser light emitted can be chosen simply by varying the laser layer thickness: such lasers are being used in the latest generation of compact disc players. Laser surgery, using novel lasers developed by materials scientists, is enabling the blind to see and artificial heart valves, made from advanced materials, are giving life to some who would otherwise be dead.

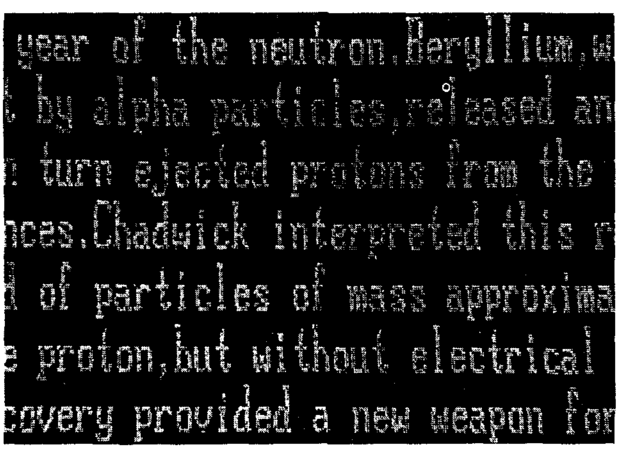

Fig. 1. A portion of the Encyclopaedia Britannica written in AlF_3 using an electron beam. The beam has a diameter of only 0.5 nm and each letter is composed of a double row of dots 4 nm in diameter. Each dot is a hole etched through the 50 nm thick AlF_3 specimen directly using the electron beam. At this scale of lithography the entire contents of the Encyclopaedia Britannica could be written on a pinhead. The potential for information storage, molecular filters, etc, is clear. The nanometer scale lithography was performed using a 100 keV electron beam in a computer controlled VG HB501 scanning transmission electron microscope.

Many readers of this article will require artificial hip joints in the future. Twenty years ago the average lifetime of an artificial hip joint was only three years. Today the average life time is ten years, and current research on advanced materials has improved the lifetime of the next generation of artificial hip joints to thirty years. Since the cost of an artificial hip joint is only £ 100, and the cost of the operation is about £ 3000, these recent developments in materials science and engineering are not only of benefit to the patient but also to the financial benefit of the health service. Research into artificial skin is in progress, and longer term research into an artificial pancreas so that diabetics would no longer need to inject insulin is also underway.

Novel materials are essential for use in protecting our environment in, for example, solar cell technology or in catalytic converters.

The main force driving developed nations into the age of new materials, however, is not the desire for improved health care nor for a better environment, it is that for economic growth. The economic growth argument was concisely summarized in an issue of Scientific American entirely devoted to advanced materials which stated: "Advanced materials are essential to the future growth of the aerospace, electronic device, automobile and other industries. Progress in materials science sets ultimate limits on the rate at which key sectors of the economy can grow."

For the above reason, the importance of new and improved materials is clearly recognized in developed countries. *George Keyworth*, President *Reagan*'s former chief scientific advisor, stated: "Materials science is probably the most important subject in the US today." In Japan, the Ministry of International Trade and Industry (MITI) has targeted three key areas for massive research and development: new materials, new electronic devices and biotechnology, and top of the list is new materials. In the Japanese government's Basic Technology for Future Industries Program there are eleven major projects, seven of which are in the area of new materials. About two years ago the UK government set up the Advisory Council on Science and Technology (ACOST) to advise it on priorities in science and technology. ACOST has recently identified new materials as a key enabling technology.

Materials research is a strategic research area which is essential for future industries and in which research discoveries can be transformed into market place products in a peri-

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od of typically three to twenty years. Our competitors have already realized this and overseas governments have selected new materials for priority funding in order to make their future industries competitive, to improve their future balance of trade and to reduce their future unemployment. For example, the US government invests well over £ 700 million per annum in materials research, and the Japanese government invests an estimated £ 500 million per annum. On the other hand, the UK government invests only about £ 60 million per annum in materials research of which about £ 20 million is allocated to the Science and Engineering Research Council (SERC). Last year the annual increase in spending of the Japanese government on materials research in the civil sector exceeded the total spending of the UK government in this area. With such a massive funding discrepancy in materials research between the UK and our competitors it is essential that the UK makes the best use of its limited resources, and that it invests more heavily. The UK has been slow to wake up to what has been happening in materials research in Japan, the USA and parts of Europe (notably West Germany and France). However there are now clear signs that Britain is increasingly aware of the strategic importance of materials research.

Perhaps the first evidence of this increased awareness was the decision of the SERC (which funds science and engineering research in all UK universities and polytechnics) to set up in 1987 a panel to study the funding of materials science and engineering by the SERC. The panel, chaired by Dr. *Peter Day*, reported in January 1988 that although much UK materials research is of the highest standard internationally, many areas are in rapid decline. The panel presented evidence that the funding levels are totally inadequate. Their report also stated that the administration of materials research within the SERC was very fragmented, with materials research being funded by the Physics Committee, Chemistry Committee, Materials Committee, Process Engineering Committee, etc. As a result of this report, and of further consultations, the SERC under its Chairman, Professor *Bill Mitchell*, decided to reorganize totally its funding of materials research and the Materials Science and Engineering Commission of the SERC was established in September 1988.

The Mission Statement of the Commission has recently been drawn up and is as follows:

The Commission will promote excellence of research and training in both the science and engineering of materials. It will take an integrated view of materials research from synthesis through processing to demonstrator projects. It will seek to maintain and enhance the world class materials research record of the UK. It will encourage the creation of new materials and facilitate the competitive exploitation of materials by British industry in international markets.

The breadth of the Commission can be seen from the titles of the seven committees it controls: ceramics and inorganic materials, polymers and composites, metallic and magnetic materials, semiconductors, superconductors, molecular electronics, and medical engineering and sensors. The Commission and each of its seven committees is multidisciplinary and contains chemists, physicists, materials scientists, electrical engineers, etc. Roughly half the Commission members are from universities and polytechnics and half from industry. The inherited budget of the Commission was about £ 15 m p.a., but in its first year of operation this has been increased to £ 20 m p.a. The increase is a very welcome first step to what is required.

The Commission will determine a coherent SERC strategy for the support of materials research and it will take a leading rôle in identifying national priorities in materials research. In addition to having research priority areas, the Commission fully recognizes that unpredictability is part of the fascination of research, and that many major breakthroughs have been unexpected and unplanned: it will therefore have a balance between funding priority areas and funding high quality research in any area and it will respond quickly and flexibly to the unexpected.

The Commission is very keen on fostering links with Europe and internationally in general. It has already held small scientific meetings with France, Italy and Japan. As we move into the highly competitive age of new materials, the SERC Materials Science and Engineering Commission will do its utmost to ensure that UK universities and polytechnics are at the leading edge of materials research, and that the results are transferred to industry and to medical care.

Professor Colin Humphreys obtained a B.Sc. from Imperial College, London in 1963 and a Ph.D. from Cambridge in 1967. From 1966 to 1985 he was a Research Fellow and then Lecturer in the Department of Metallurgy and Materials Science, University of Oxford. He was appointed the Henry Bell Wortley Professor of Materials Engineering and Head of the Department of Materials Science and Engineering at the University of Liverpool in 1985 and from January 1, 1990 his new address will be at the Department of Materials Science and Metallurgy, University of Cambridge. He is a Member of the Electron Diffraction Commission of the International Union of Crystallography, and a Council Member of the Science and Engineering Research Council (SERC) and of the Institute of Metals. His main research interests are electron diffraction and microscopy, semiconductors, superconductors and nanometer scale electron beam lithography. He was published over 160 papers. In 1988 he became the first Chairman of the newly formed Materials Science and Engineering Commission of the SERC.