

INNOVATIVE NANOTECHNOLOGY-BASED SYSTEMS

Takao MIWA

Department of Electronic Materials and Devices Research Materials Research Laboratory
Energy and Environment Laboratory Advanced Research Laboratory
Hitachi, Ltd.

1-1 Omika-cho 7-chome, Hitachi-shi Ibaraki-ken, 319-1292 Japan
takaom@hrl.hitachi.co.jp

NANOTECHNOLOGY is becoming an important field, as its development leads to scientific, industrial and business applications. In this paper, we introduce application examples of new systems made from industrial *NANOTECHNOLOGY*.

1. INTRODUCTION

Nanotechnology raises the functions and characteristics of a substance sharply by controlling the substance at a nano size level. In this way it contributes to realization of a rich and eco-friendly society. In this sense, nanotechnology is the technology of dreams in which changes are brought to production systems and then society at large. Nanotechnology is expected to activate national economies and it can be called a leader of the industrial world.

Here, we introduce new system solutions and lifeline solutions based on nanotechnology which are expected to achieve a rich, safe and healthy society.

2. PRESENT STATUS OF NANOTECHNOLOGY

Nanotechnology and nano science started with Feynman in 1959, and in the succeeding years they have undergone remarkable developments. The domestic market is presumed to be about 27 trillion yen, and the U.S. market is presumed to be about 90 trillion yen.

In the U.S., President Clinton promulgated the nanotechnology state strategy in February, 2000 as a nano-technology research promotion strategy, and thus kicked off the nanotechnology boom. The US nanotechnology research budget in fiscal year 2001 was about 50 billion yen, and about 60 billion yen in fiscal year 2002. Thus, the U.S. supplies a large amount of money to nanotechnology research, and it has begun to promote long-term basic research for applications even 20 years away.

In Europe, state organs have taken the lead and they are promoting research and development of nanotechnology in Germany, Britain, France, Switzerland, etc.

In Japan, the Federation of Economic Organizations proposed its fundamental viewpoint about nanotechnology in March, 2001 as n-Plan21 and the

Council for Science and Technology Policy has decided upon the promotion strategy. Nano devices and materials for next-generation telecommunications systems, materials promoting energy conservation and environmental preservation, and materials for medical treatments were all specified as important domains, and the importance of base research was also acknowledged.

3. NEW SOCIETY WHICH NANOTECHNOLOGY AIMS TO ACHIEVE

The technical trends of nanotechnology are classified as for a comfortable information society (ubiquitous information society), a clean energy and eco-friendly society, and a safe and healthy society. We discuss trends of each class below.

3.1 Comfortable information society (ubiquitous information society)

The realization of the ubiquitous information society in which anyone can access an information terminal anywhere at any time is an important subject in Japan.

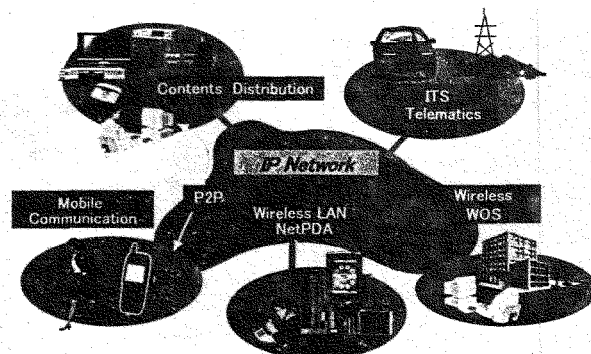


Fig.1. Comfortable information society (IP network system)

Realization of this society requires further "large-scale-ization", speed improvement, power consumption reduction, and advanced features development in storage devices and information networks. These devices have already attracted attention. For example, in the field of storage, a perpendicular magnetic head with a magnetic pole width of 140 nm was developed, and a record density of 107 Gb/inch² was attained. Moreover, a super-high density recording medium, known as a patterned media and a high density optical disc technique are being actively developed. In the semiconductor field, a high speed transistor with short gate length, the SESO (Single Electron Shut Off) memory, was developed and an optical switch applying MEMS (micro-electro-mechanical system) and a display using an organic transistor have attracted attention.

3.2 Clean energy and eco-friendly society

Development of an energy network system represented by the distributed power supply is an important subject from the viewpoint of effective use of energy resources and resolving environmental issues.

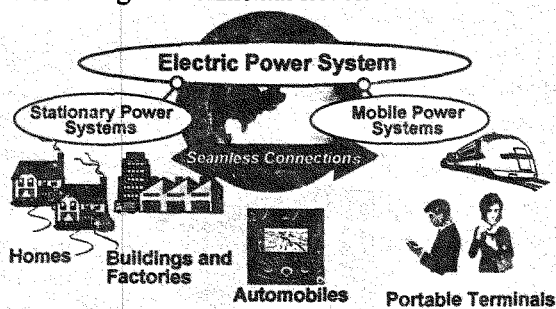


Fig.2. Energy network system

Fuel cells and rechargeable batteries serve as key components in energy network systems. Development of the polymer electrolyte fuel cell (PEFC), which makes full use of nanotechnology is being furthered. A hydrocarbon type polymer film has been adopted as an electrolyte film, and the technology to reduce membrane cost to 1/50 of conventional film was achieved. Moreover, using nanotechnology in a direct type methanol fuel cell (DMFC), reduced the amount of platinum catalyst used to 1/10 that of conventional cell. Furthermore, for Li batteries, a polymer electrolyte film which has superior Li conductivity compared with conventional film is being energetically developed.

In another area, a minute oscillating power generation element which is one of the key devices for a sensor network society is being studied. Realization of the sensor tip which operates self-sufficiently, without supplying electric power from outside, is expected.

3.3 Safe and healthy society

A Safer and healthy society is called for with changes in community and personal living environment, and arrival of an aging society. Various sensors which can provide a simple and inexpensive illness diagnosis and

risk judgment are being developed. There is a strong possibility that a micro biosensor incorporating the information processing tip can be realized by nanotechnology. This takes the approach of a micro machine and the technology is called MEMS (micro-electro-mechanical system). A highly precise micro style manufacturing is possible at low cost.

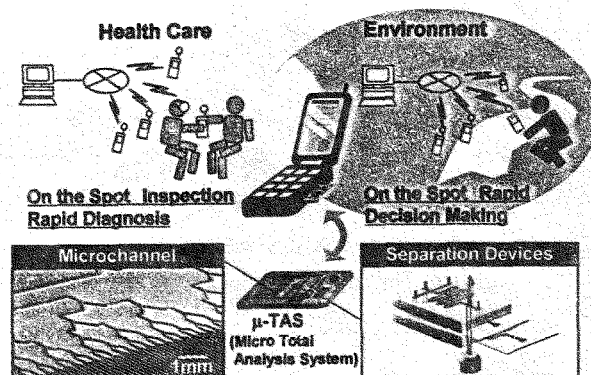


Fig.3. Health and environmental check up system

A food traceability system has attracted attention. For example, if a μ -tip, a 0.4mm square, is used, the history of foods from raw-material, through processing to sale to consumers can be recorded, and the information can be provided to consumers.

4. NANO BASE TECHNOLOGY

The technology which serves as a base for all nanotechnology applications is measurement, processing and simulation technology of super-high precision. One device offering this super-high precision is the super-high-voltage FE-TEM which has a 1 million volt accelerating voltage to get resolution of 49.8 pico meter (a world's record). Moreover, very precise analysis technology has been developed in an elemental mapping technique using an electron microscope, and analysis of surfaces and interfaces by X-ray measurements.

In the field of nano processing, the device formation method called nanoprining is being actively developed, it uses metallic molds with nano scale structure.

Regarding simulation technology, the development of high-end computing technology draws attention for its contribution to the discovery of new materials and promotion of nanotechnology research.

5. SUMMARY

Nanotechnology which aims at the comfortable information society, clean energy and eco-friendly society, and safe and healthy society was outlined. In the future industrial world, nanotechnology will occupy an important position. By utilizing the accumulation of nano science knowledge through cooperation between industrial, administrative and academic sectors, both domestically and internationally, international cooperation, we expect to realize and utilize new system solutions, and lifeline solutions.