Advanced Materials for Sustainable Development

Edited by
Atsushi Suzuki
G. Sundararajan

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Selected, peer reviewed papers from the
JSPS-DST Asia Academic Seminar 2009 (AAS2009),
which was held in Yokohama, Japan
from December 8 to 10, 2009

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Preface

This special issue contains selected papers from JSPS-DST Asia Academic Seminar 2009, which was held in Yokohama, Japan from December 8 to 10, 2009. The purpose of the seminar was to provide young scientists from Asian countries with chances to exchange information of scientific research. This year seminar covered progress in the recent achievements and innovations in the fields of advanced materials research and technology for a sustainable future in the world, especially in India, Japan, and Asian countries.

With around 40 young scientists from across Asian countries (17 from India, 13 from Japan, from Bangladesh, China, Korea, Nepal, and Vietnam) among 66 participants the seminar proved to be a successful follow-up to the previous one, which was held in Hyderabad, India, 2001.

The selected papers concern, inter alia, experimental studies of structure, electrical and magnetic properties, thermodynamic and electrochemical properties, absorption, luminescence, permeability, and self-assembly in systems of steel and aluminum alloys, nanoparticles, nanowires, nanoplates, multilayers, thin films, membrane, and multifunctional materials.

We would like to gratefully acknowledge the support of the seminar sponsors, JSPS (Japan Society for Promotion of Science) and DST (Department of Science and Technology). Special thanks to the participants, especially the invited speakers without whom the seminar could not be so successful. We are also indebted to the Scientific Committee and to the support of officials in Yokohama National University.

Guest Editors
Atsushi Suzuki (Yokohama National University, Japan),
G. Sundararajan (International Advanced Research Centre for Powder Metallurgy and New Materials, India).

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Materials, Humankind, and Peace

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Keywords: Humankind

Abstract. The ages used by humankind can be divided in the Stone Age, the Bronze Age, and the Iron Age. In twentieth century instead of one material, a number of diversified materials dominated, and all are diversified. “Right materials in right purposes” was the motto in the last century. In the twenty-first century, the limitation of natural resources and balance of earth have to be considered. Global warming is one of the most important problems in the present world. Materials development and utilization should be done as shown in the model of double helices. Use of comparatively clean nuclear energies is important. Here we discuss the education about the materials from Japanese viewpoint.

Introduction

Humankind has most developed brain on the planet earth. The human learned to use fire and tools. In early years, mankind used stones as they were, then to learn processing them. Then humankind used metals. The tools they used for hunting food and struggle among them. At present, human has developed even atomic bombs which may destroy human themselves.

Ages Used by Human

The ages: Stone Age, Bronze Age, and Iron Age are named according to the materials which were used mostly by human in that period of time. In the Stone Age, all human cultures were based on stones used by men. The Stone Age began about a million years ago and ended in Mesopotamia and Egypt about 3000 B. C. when people atarted using bronze. Old Stone Age lasted from about one million years ago to 8000 B. C. The Middle Stone Age, lasted from 8000 B. C. to 6000 B. C. The New Stone Age began about 6000 B. C. and lasted until the invention of metals. In the New Stone Age, green copper ores were used for ornaments on walls and bottles, copper balls were made in Ali Kosh, Iran. Earliest use of bronze occurred in Misopotamia, about 5000 B. C. Bronze (Cu-Sn alloy) melts at lower temperatures than copper. People continued to use it until about 1100 B. C., when iron widespread for tools and weapons. The iron was first appeared in Asia Minor. To melt iron higher temperatures are required. This age has continued to the present. In China, iron products were made using meteprites but they were not widely spread. Forged steel and cast iron were used from 403 B. C. to 221 B. C. during the War Period. Real Iron Age in China started in 206 B. C.

The Twentiesth Century: In the twenties century, science and technology have been developing rapidly compared with those of preceding centuries. In the twentieth century, metallic materials, ceramic materials, semiconductor materials, organic materials or composite materials, advanced materials fitting the right materials in the right purpose have been developed. One kind of materials did not dominate over other materials. Some people say that twentieth century was the Plastic Age. Nylon was invented at Du’Pont. This was called “The Second Clothing Revolution”. Some people say that the twentieth century is the Semi-Conductor Age. Silicon as semi-conductors completely changed electronic industry and information technology. Some people say that the twentieth century is the New Ceramics Age. Ceramics is strong in compression but weak in tension. Cracks grow. Some people say that the twentieth century is the composite Materials Age. However, one kind of materials did not dominate, and all are diversified. The right materials in right purpose. For example steel composite metals, high temperature steels have been developed aiming the best performance at high temperatures. Low temperature steels have been developed aiming the best performance at low temperatures, not brittle at low temperatures. Seemless steel pipes have been developed aiming the best performance during the use as oil lines. Two phase steels are good for automobile bodies. Stainles steels are now widely used for walls at kitchens and chemical industries. Directionally oriented electro-magnetic steels are used as iron cores of transformers, etc.

The Twenty-first Century and Future. Materials have been developed only to satisfy their purposes. At present, however, due to a rapid increase of the world population (150 persons per second), plutocracy, mass production, mass waste, raw and natural waste, and enlargement of the gap between the rich and the poor people, the concepts of research and development have been greatly changed. The limitation of natural resources and the earth has to be considered. Global warning is one of the most important problems in the present world. The most important point is due to the emission of carbon dioxide to atmosphere from many sources, much from burning fossil fuels. Energy waste, pollution due to exhaust fumes, exhaustion natural resources and energy are becoming very serious problems. In Japan, Prime Minister Hatoyama proposed 25 percent reduction in greenhouse gas emission in Japan by 2020 from 1990 levels. Developing materials having good physical and chemical properties is not the final object anymore. This has been clearly shown with the development and accidents of PCB (polychlorinated biphenyl).

Economy in the twenty first century has to consider limited natural resources and global environment. Materials which minimize natural resources, energy and environmental pollution should be widely propagated. Green products and natural resources are the center of attention. With these properties, high productivity, high recycle performance, minimum burden are demanded. The life cycle assessment (LCA) covers from mining, extraction, row materials, processing, use, to waste including energy consumption and recycles. The concept has been changed in forty years, from diversification to unification in materials. The present author proposes a model of double helices as shown in Fig. 1. Process, structure, properties, performance and function are on one helix. Life cycle assessment, safety, environment, product responsibility are on the other helix. Evaluations are connected these two helices. Pollution increase, waste of natural resources and waste of energy pull down the whole system, on the other hand, research beneficial to mankind pulling up the whole system. We hope the helices go up and up.

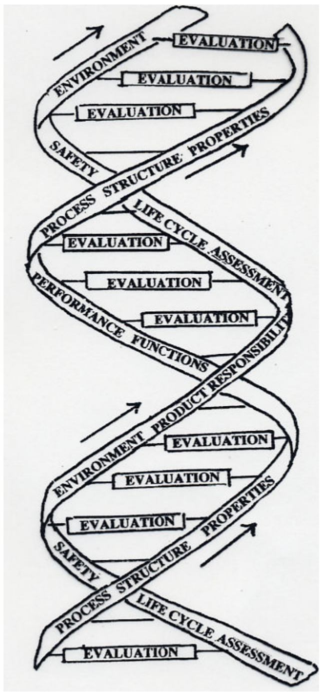

Fig. 1. Double helices of Materials development.

Global Warming, CO_2, Atmosphere and Oceans are not Waste Baskets

In the twentieth century and present, humankind has burnt much fossil fuels, as a consequence much carbon dioxide has been emitted in the atmosphere and the earth is annoyed by the global warming. This is one of the greatest problems for humankind. Humankind used to dispose wastes to oceans, but even oceans are limitted and we cannot throw away wastes.

Nuclear Energies

According to Einstein, energy and materials are convertible by the relation $E=mC^2$. The present author worked as a permanent staff for five years at the Argonne National Laboratory which was started by Enrico Fermi at the basement of University of Chicago during the World War II. Humankind developed atomic reactors and developing fusion reactors. In these reactors the materials developedand used in real are crucial. Humankind developed even atomic bombs, and they were used to destroy the cities of Hiroshima and Nagasaki.

U.S. President Obama Proposed the Ban of Nuclear Bombs

In U. S. President Barack Obama's speech in Prague, he mentioned the ban of nuclear weapons. Nobel Peace Prize 2009 was awarded to him. The author wishes that the President visits Hiroshima and Nagasaki someday. Atomic bombs are miserable to all humankind.

The author visited twice the President Truman's Museum and Library in Independence, Mo. In his President Office at the Museum, he wrote himself , "Invade Jap Homeland Fall Of 1945". Although the author does not accept the use of atomic bomb, if atomic bombs were not used during the conflict many American and Japanese would have been killed.

United Nations

United Nations, UN was established on October 24, 1945 in San Francisco by 51 countries. The original Charter was made in 1944 (during the World War II), in Washington D. C. by the representatives from the United States, Great Britain, China and the Soviet Union. Japan was addmitted to join in 1956 as the 80th country. In 2006, the countries perticipating are 192. The central object of UN is "Keeping the Peace and Safty". The UN Army has not established yet. As for the share of the expenses of UN, Japan contributs the second next to the U. S. (76% of the U. S., about 20% of the total expenses of U. N.), the third is Germany (39% of the U. S.) . Japan and Germany, etc., are still defined as "Former Enemy".

Mottainai

We should spread concept of "MOTTAINAI" (save, or don't waste, be generous). Do not waste. "Stint ourselves in everything" should be considered as a virtue. "Increase GDP! Or "Increase individual consumptions!" is inconsistent with "Saving from human crises". Japanese and many governments encourage for people to increase consumptions to keep good economy situation. The government is encouraging to buy things not really needed, then the government says, "business will be brisk". This is against saving mankind. Development of world new economic system is necessary. How can we eliminate discrepancy? Spendthrift habit should be purged. "MOTTAINAI" is not only for saving money but also saving humankind.

Materials Education in Japan

Before going to the materials education in Japan, the education in Japan should be overviewed. Japan has the second lowest expenditure on education in 2006 among the 28 member states of the Organization for Economic Cooperation and Development in terms of state spending to gross domestic product, "the OEC"

In 2009, Japaneses regime has changed from the Liberal Democratic Party to the Democratic Party. The philosophy changed from "concrete" to "humankind and wisdom". The anual budget of MEXT (Ministry of Education, Sports, Culture, Science and Technology) in 2010 of 5.5926 x 10^{12} Japanese yens increased 5.9% compared with that in 2009. The increase is the largest in 30 years. The MEXT budget and education budget is shown in Fig. 2. [1].

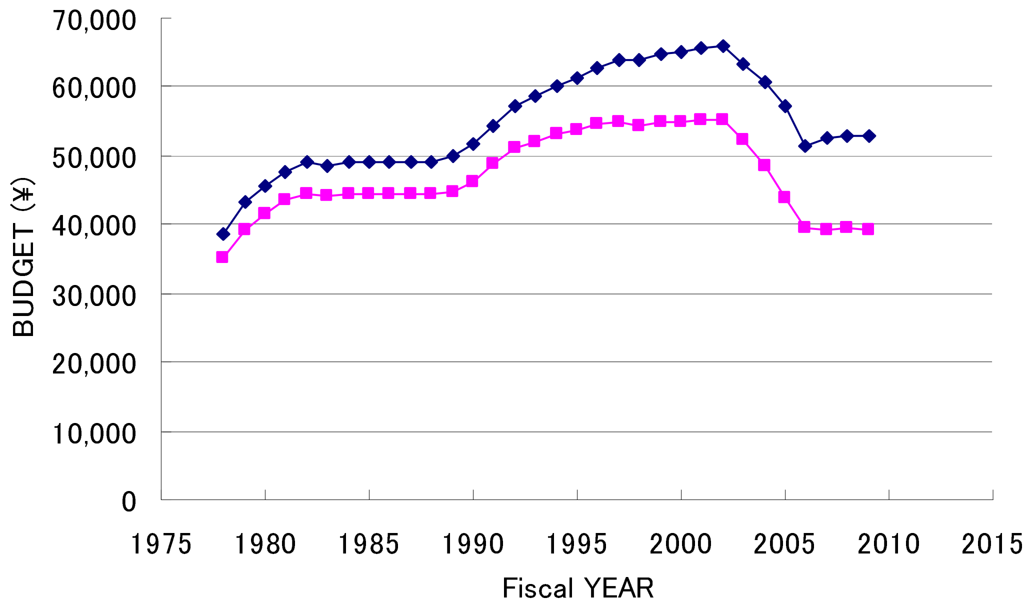

Fig.2. Anual budgets of total MEXT (upper curve) and education (lower curve).[1]

Universities in Japan: There are about 90 national universities and about 500 private universities in Japan. In 1955, 10.1% of the 18 years old population entered universities. In 2005, 51.5% of the 18 years old population entered universities. In 2007, all 18 years old people can entered universities, if they wish. Private universities which cannot get enough students allow lower grade students to accept. The grade of the lowest students entering such universities have to supplement high school level classes, many universities are taking "bottomless students". Many science and engineering students do not take physics and chemistry in high school at all. They come to Materials, Engineering, and Biology. The present author feels that up to high schools, they should not allow selective classes, or they should take outline of physics and chemistry.

Education of Ease: In 1976, the Advisory Committee of Ministry of Education, Sports, Culture, Science and Technology (MEXT) proposed "Education of Ease", instead of "Packing Education". They emphasized "self-studying and self thincking". Children became lazy with fewer exceptions. Study days a week changed from 6 days to 5 days. The contents of teaching were cut down 30%, emphasized "thinking and cultivating creativity" not "memorizing". There were opinions opposing this movement from the start. MEXT said "it will be changed again, if it does not fit", but it did not change for thirty years. "Creation needs knowledge, as business needs capital". To increase kowledge we have to memorize.

About twenty years ago, Japanese children studied quite hard, but now children are not hungry for food and learning knowledge, they watch TV programs for many hours a day. They lost the desire to be heroes. After youngsters graduate from universities and colleges, they become NEET which means Not in Employment, Education and Training. Youngsters in twenties do not wish to buy cars, nor do not wish to drink much alcohol.

Capacity. In Japan, capacity of a school is quite important. It is not a capacity of accepting number of student but also it is the basis of all, budget, aids, etc. If private universities take too many students compared with the capacity of the university, they can not obtain government supports nor if they cannot take enough students, they can not also obatin the government support.

Due to the recent recession, the applicants to national universities increased after decreased for three years because the tuitions at national universities are lower than those of private universities. The ratio of the numbers of applicants to number of capacities in political and economical schools, medical schools are 1.0 and 1.1, respectively, but the ratio in natural science and engineering is 0.8 in 2010.

Materials Education.

Good universities do not have much problems getting students. There are no metallugy department anymore in Japan. They have changed to materials. Students are very short sighted. When an area is depssion, students do not go into that area. The time when the students look for jobs is years after and usually the situation changes. Unfortunately, according to the MEXT category, there is no "materials", but include in "others".

At the Institute of Solid State Physics, the University of Tokyo, some scientists perform "Liquid" research. Former name of Institute of Materials Research, Tohoku University is the Research Institue of Iron, Steel and Other Metals. MEXT controls Japanese names but they do not control English names.

Summary

The ages used by humankind can be divided in the Stone Age, the Bronze Age, and the Iron Age. In the twentieth century, one kind of materials did not dominate, and all are diversified. "Right materials in right purposes" was the motto in the last century. In the twenty-first century, the limitation of natural resources and the earth has to be considered. Global warming is one of the most important problems in the present world. Materials development is represented by double helices. Nuclear energies are important. In the development of atomic reactors and fusion reactors, the materials are the key to commercialize them. President Obama received the Nobel Peace Prize. He is trying to eliminate atomic bombs from the world. United Nations is trying to keep peace and security. Materials education in Japan is discussed.

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[1] Information on http://www.mext.go.jp/component/b_menu/other/__icsFiles/afieldfile/2010/01/28/1288506_4.pdf

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Fabrication and Applications of Silver Sulphide Based Ion Sensors

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Keywords: Ion selective electrode, hydrogen sulphide, thiamine, solubility product, cigarette smoke

Abstract

An electrochemical sensor based on the silver sulphide precipitate was fabricated in the laboratory and characterized by x-ray diffraction, SEM equipped with EDAX, and electrochemical techniques. Ion selective electrode (ISE) was found to be sensitive enough to sense the sulphide ion concentration from 10^{-1} to 10^{-5} M in alkaline medium. The change in electrode potential per decade change in sulphide ion concentration was found to be 31.5 mV at laboratory temperature indicating adherence of the ion selective electrode to Nernst's equation. The sensor have been successfully used for the quantitative determination of thiamine in pharmaceutical preparations, hydrogen sulphide in cigarette smoke and determination of solubility products of sparingly soluble silver salts. A trace amount of hydrogen sulphide, a toxic gas, is present in the cigarette smoke. The quantitative estimation of hydrogen sulphide in cigarette smoke is a challenging task to analytical chemist. Hydrogen sulphide in cigarette smoke had been determined by absorbing the cigarette smoke in 0.1 M sodium hydroxide and the resulting solution was analyzed using silver sulphide based ion sensor by standard addition technique using modified Gran plot. The average amounts of hydrogen sulphide produced by a stick of cigarette in 8 different brands of Nepalese cigarette ware found to range from 0.0332 mg to 0.0766 mg. The sensitivity and reliability of these home made ion sensors were excellent and in par with commercial electrodes. For developing countries like Nepal, who can not afford to procure high cost commercial ion selective electrodes, these home made ion sensors are especially appealing since the sensor can be fabricated with ease from the materials that are readily available in the chemistry laboratory and the sensor is quite sensitive and gives reproducible results which are sufficiently accurate for the analysis with ion selective electrodes.

Introduction

From the beginning of 20^{th} century many efforts had been made to develop ion sensors for the determination of hydrogen ion in aqueous solution. Determination of concentration of hydrogen ion in aqueous solution is of great importance in chemistry, biochemistry, microbiology, industrial process, food chemistry and so on. In this regard the development of hydrogen ion sensor based on glass membrane is a milestone in accurate determination of hydrogen ion concentration in aqueous solution. Hydrogen ion being a lightest and smallest ion has high mobility and highest ion conductance among other ions. Owing to small size, hydrogen ion can penetrate easily and attain equilibrium readily with glass membrane. Hydrogen ion in aqueous solution is highly hydrated and some kind of hydrated surface is favorable to attain equilibrium quickly. Cremer [1] in 1906 separated two solutions with different hydrogen ion concentrations by a thin hydrated glass membrane and electrical potential difference between glass membranes was observed. This electrical potential in the interface of glass had been exploited by Haber and Kleimensiewicz [2] in