Oyo-Buturi International

Interview

Professor Ryoichi Ito, the President of The Japan Society of Applied Physics

Professor Ito is the new President of the jsap. He has generously given his time to talk about his experiences in industry and academia and share his vision of the future of jsap.

OBI: Can you tell us about your research activities when you were in industry?

Professor Ito: I was in industry for 18 years altogether. In the 1960's I was part of a group involved in research on semiconductor physics. Then, in the 1970's I worked on semiconductor lasers for about 9 years; this research was started a year before the announcement of continuous lasing at room temperature by Bell Labs in 1970. This was, yet extremely enjoyable, a demanding and difficult area of research.

OBI: What was the aim of your research?

Professor Ito: I started this research in the days before optical fibre became available as a means of transmitting signals. I started it because of some ideas related to "optical holographic memory". In those days there was no semiconductor memory but there were a lot of other ideas about what the next computer memory could be. The "optical holographic memory" was one of those ideas. There followed proposals to use the second harmonic of a yag laser for holographic memory applications. The goal was to use a semiconductor laser as an optical excitation source for the yag laser. Since the reason for starting the research was well defined and justifiable, my company supported the research. However, the announcements by Bell Labs about room temperature operation of a semiconductor laser and by Corning of low-loss optical fibres changed the focus more towards communications than optical memory.

Many groups were working on this type of research and there were major problems to be solved before the technology could be commercialised. One particular aspect of the research that I remember was that towards the end of the 1970's we decided to sell our lasers; we made a catalogue and I became a "salesman". It was probably the first ever example of the sale of semiconductor lasers. In those days one laser cost from ¥200,000 to ¥300,000; these days they cost only ¥100! The process of finding buyers was also useful for gathering information about the real needs of users and the market place. The whole experience was very interesting.

OBI: These were GaAs lasers?

Professor Ito: Yes, this was the only material system available at the time. Later on, the InGaAsP system was developed and used for laser applications.

OBI: How were these lasers grown?

Professor Ito: By liquid phase epitaxy; techniques like mocvd and mbe were not available in these days. The new methods were not proposed by American and European researchers until the early 1970's. Japanese researchers then made significant contributions to the development of semiconductor lasers in the 1970's.

OBI: I would like to move on to education and ask what you think is the reason so few students want to study science and engineering nowadays-the so called *rika-banare* phenomenon in Japan.

Professor Ito: I think the reason is quite simple; we are surrounded by "black-box" technology. For example, when you open up a traditional watch you can see the cogs moving around; but nothing moves in modern watches. The fact that a television produces a moving image is taken for granted. In the days of the vacuum tube, if you opened up a radio you could see glowing valves and could see something "working". These days, equipment is all solid state and it is not possible even to begin to imagine how it might function. The only things that you can still see working are bicycles. It's becoming almost impossible to carry out basic repair to a car by yourself. Yet another black box! It is an easily stated problem, but I do not think there is a simple solution. In Japan we could begin by revising the primary and junior high school curriculum to include more about the mechanisms behind how things work. At the present time there is too much emphasis on acquiring lots of knowledge without asking "Why?"

OBI: Have you noticed any differences in the students who are entering your university nowadays?

Professor Ito: Yes, there have been many changes in the type of students we teach. One characteristic is that most of them have never carried out any experiments. They've never soldered joints or used tools to build equipment-or even repaired a bicycle. It's very difficult to teach them how to carry out experiments. They have never experienced that "small electric shock" that many people used to receive. when playing with electrical equipment. They don't have a feeling for what electricity is and how to use it in practice.

OBI: Does your own department have any particular education policy to overcome these shortcomings?

Professor Ito: Yes. In our department it is necessary for undergraduates to carry out experiments and to write a report in order to graduate. This encourages students to use equipment and gain first-hand experience of constructing electrical systems of one kind or another. Students cannot graduate by doing just theoretical work.

OBI: I would now like you consider the history of science in the 20th century and ask you what aspect of science you think has had the most dramatic effect on our lives during this time?

Professor Ito: Quantum mechanics! Why is the sky blue? At what temperature does iron melt? The new ideas of quantum mechanics completely changed our understanding of natural phenomena – phenomena that could not be explained by Newtonian mechanics.

OBI: What other aspects of modern science and technology do you think have had a great effect on society?

Professor Ito: In my lecture course I always say "the transistor and semiconductor laser" have greatly affected our lives. For other reasons, we could say nuclear power and knowledge of the structure of dna – but the transistor really changed our lives; the ic, too, should not be forgotten of course. It's interesting to note that the inventor of the transistor was awarded a Nobel Prize but the inventors of the ic and the computer have not received such an award even though they have also have changed our lives dramatically.

OBI: What inventions or discoveries would you like to see in the next century?

Professor Ito: That's a very difficult question! There are so many problems that need to be addressed, such as the environment, population growth and energy supply. I do not think that young people, who will have to find solutions to these problems, actually recognise that these are key issues. I sometimes set homework related to such issues. An example is, "What would be the total surface area of solar cells required to supply the world's energy requirements, assuming a solar cell efficiency of about 10%?" The answer is quite simple if you know the amount of energy consumed per unit time. The calculation gives an answer of about 800,000 square kilometres. As a follow up question, I ask the students to comment on the answer. Most reply by saying that it's "unrealistic" or "not practical"; quite a disappointing assessment of the situation. My view would be that if we could supply the world's energy needs using an area only about one tenth of the size of the Sahara desert, then it's not a great price to pay to save the world's population! Youngsters should have a wider view of the world and be prepared to devise plans to solve the major problems that lie ahead.

OBI: Do you have time for hobbies and pastimes?

Professor Ito: I used to play a lot of tennis and badminton. These days I enjoy walking and reading books about a wide range of subjects, in Japanese, *zatsugaku*. I have read about 30 books by *Shuhei Fujisawa*, who died last year. His novels are about the Edo Period and I enjoy comparing the lifestyles of Edo and present day Japan. I am also interested in economic issues. A book that strongly impressed and moved me was Milton Friedman's "Freedom and Capitalism". His arguments were very convincing and still hold true today.

OBI: Do you recall the experience of your first overseas visit?

Professor Ito: Yes, I remember it well. In 1968 I went to Pennsylvania University for 15 months. It was the time of the Vietnam war; man landed on the moon in 1969 and Neil Armstrong spoke the famous words, "A small step for man, a giant leap for mankind..." In those days, America was very affluent but Japan was not. The huge differences in salary, a factor of ten, was a surprise. It was also the first time I used an expressway and went shopping at a supermarket. These were unforgettable experiences.

OBI: Finally, how would you like to see the jsap develop during your presidency?

Professor Ito: I would like the Society to be even more useful to its members and I have a few proposals in order to achieve this goal. One relates to reviewing the vast number of scientific societies and associations that exist in Japan. Most have considerable overlap in terms of the research interests of their membership. It may be best to amalgamate them in order to serve the needs of the members better. A good example of one large society representing a wide range of technical areas is the ieee. The ieee is well respected and extremely well organised. However, size brings with it problems flexibility and management, so a balanced approach would be required. I would also like to make more use of the Internet, thereby making jsap accessible to a much larger number of people. I would particularly like to increase our readership overseas. In that regard, I am certain that the obi section will contribute immeasurably.

Resume

Professor Ryoichi Ito received his BS degree in applied physics from the University of Tokyo in 1961 and doctorate in physics from Osaka University in 1967. From 1961 to 1979 he worked at the Central Research Laboratory, of Hitachi, Ltd., investigating laser diodes and semiconductor physics. He was also with the Institute for Solid State Physics of the University of Tokyo, from 1963 to 1965, and a visiting scholar at the Department of Physics of the University of Pennsylvania from 1968 to 1969. Since 1979, he has been with the Department of Applied Physics, in the University of Tokyo, working in the area of photonics. In 1983, he received the Achievement Award of the Institute of Electronics, Information and Communication Engineers for the development of buried-heterostructure lasers.

Interview by Adarsh Sandhu

Essay: Science as a Cultural Activity

Essay by Professor Harold Kroto, joint winner of the 1996 Nobel Prize in Chemistry for the discovery of C_{60}.

In the 19th century, the likes of Byron, Shelley, Walpole and many others would go to the Royal Institution Discourses to learn about science and technology. Indeed, there was a deep interest in understanding the forces changing society and an awareness, too, that without such an understanding one could not be considered adequately educated. How is it that, at the end of the 20th century, people can consider themselves well educated without any intrinsic understanding of the greatest intellectual achievement of this century, namely, quantum mechanics, which underpins chemistry, biology and physics, nor of the genetic factors that threaten to shake the foundations of society to its very roots in the next century?

If the "public lecture" was the popular medium of a past era, television is undoubtedly the most powerful visual medium of communication today – yet we find little real science there. After all, one is never going to appreciate Beethoven's late string quartets without significant exposure to his earlier music, and the same is true of modern science. It seems incredible to me that the arts have had a regular forum on television for decades, whereas no analogous outlet exists for the sciences. I am convinced that such a forum would have enabled us to avoid making the errors that led to the bse catastrophe and could help us to avoid making similar errors in the future.

You never truly understand a subject until you have solved a problem that is central to that subject. Yet most of the decisions about what aspects of science are to be shown on television are made by non-scientists who are more interested in form than in content. I find the assumption that people can assess the place and importance of scientific culture without any scientific understanding to be a disturbing aberration.

A producer once told me that even bbc's "Horizon" series, which has the best track

the same is true of science, particularly mathematics. Attempts to redress the balance later in life are costly in time and effort, and in general will not be successful. It is about time that we took account, in our educational programmes, of the fact that the brain's ability to acquire new knowledge and use it decreases rapidly with age.

It may help to see science as perhaps the only truly international culture. Just as we must learn the Japanese language in order to appreciate the true culture of Japan (their great writers such as Kawabata) and the Japanese must learn English to appreciate our culture (which is embodied in Shakespeare, say), so those who want to understand science must familiarise themselves with mathematics and the symbolism of chemistry and physics. There is no point in complaining that we scientists do not come down to some level or other. They must meet us halfway. The chemical term c_6h_6 for benzene has as much significance in chemistry and biology as the name Hamlet does in English literature. Just as one might ask how to describe a Rothko painting to someone who cannot see and has never done so, one might wonder how to explain the essence of particle physics to someone without a basic knowledge of mathematics. It is, as the late American physicist Richard Feynman said, a severe limitation.

The Vega Science Trust, which I chair, was set up to create television programmes that treat science as a cultural activity. The programmes aim to give scientists as much flexibility as possible to present their own science in their own way. We also want to capture an archive of key scientists talking about their discoveries and enthusing about what turns them on to science.

There will soon be numerous television channels and the Vega Trust will enable the science community to acquire its own home base. I have heard the comment made that we must avoid making a ghetto but, as the physicist Frank Close has said, let's have a ghetto because anything is better than the present situation. How have we scientists, who created communications

record in the world, is more about entertainment than about science. In a recent programme on Fermat's Last Theorem, we were treated to a fascinating account of how the mathematician Andrew Wiles holed himself up in his room for six years to solve the problem, but we were left with little insight into the nature of the solution. The programme told a great personal story but it was like going to the opera without hearing the music.

Television is a direct medium. The Royal Institution's *Christmas Lectures* series similarly exploits the direct approach by demonstrating science through experiments involving a live audience. For example, when Susan Greenfield presented her lectures on the brain, she said she wanted the children to pick up a real one. That is the essence of science.

Despite the success of Stephen Hawking's recent series on the universe, I am not sure that cosmology is the best topic to start people on as it is extremely complicated. We are moving into an age when people do not even understand what happens when they switch on a washing machine, so it is far more important for kids to learn how computers and transistors work.

It is true that there has recently been an increase in science-related material on television. However, I maintain that it seldom contains real science. It usually offers some perfunctory description of a recent contribution by science and technology that has been deemed useful. More often than not it is a nature programme, the archetype of which is an eagle shoving bits of gerbil down the throats of eaglets. After a while, the fascination for watching the animal kingdom eating itself wears thin. It is debatable whether this material conveys much useful scientific information.

We scientists are continually being asked what our discoveries are useful for, but never what the nature of discovery is nor why it triggers a cathartic response. What is furthermore, we could discuss the long-term value of basic research until we were blue in the face by describing how it took 100 years to find a use for liquid crystals (in display devices such as wristwatches) or for platinum compounds (as powerful anti-cancer agents), only to be told, as I was by the assistant editor of a newspaper, that we were discussing whether or not public money should be spent on useless research like my own which, it turned out, led to the discovery of the most elegant forms of carbon and for which numerous applications are appearing on the horizon.

To understand science, one needs to understand the language of science. Scientists have been bending over backwards for a decade to explain themselves to non-scientist, but it is time to accept that there is a language barrier. Science is a cultural and intellectual activity, the language of which must be learnt if its ideas are to be understood. Like all languages, it must be acquired very early in life; if a child does not learn language early, he never learns, and technology, allowed ourselves for so long to be told how and what science should be broadcast by those who have so little understanding of science? The same attitude does not occur in other areas of broadcasting and, indeed, would not be tolerated.

It is high time to recognise that the true nature of science is bound up with the intellectual nature of discovery the greatest attribute of the human species. Until this fact is grasped, science will never be appreciated as part of our cultural heritage, and scientists will not be respected. Instead they will be called on to provide ever more material wealth for a society becoming ever more ignorant about how precariously its very existence is balanced on the achievements of science and technology.

Edited by OBI Committee

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`http://www.ibm.com/patents`
A free patent search engine. Actual illustrations can be seen when searching.

`http://www.oanda.com/cgi-bin/ncc`
A currency converter

`http://www.atrium.com/ad/search.html`
A comprehensive directory of Japanese search engines operated in both English and Japanese. Although not included and entirely in Japanese, `http://www.goo.ne` is one of the most powerful engines available in Japan today.

`http://mac122.icu.ac.jp/ridge_html_book/jc0.html`
Hypertext version of the book *A Practical Guide to Working as a Scientist in Japan* written by Robert W. Ridge. It was commissioned by the Australian Academy of Science and is now freely available as a contribution to international exchange.

Upcoming JSAP Conferences

11th International Microprocess and Nano-Engineering Conference, Hyundai Hotel, Korea, 13-16 July, 1998. Contact jsap secretariat at +81 3 5814 5800 or see *Oyo Buturi* **67**(2), 228 (1998) for details.

Let's Experience the Microscopic World! – A popular science festival, Children's Science and Cultural Centre, Hiroshima, Japan, 25-26 July. Contact jsap at +81 3 3238 1041 for details.

Symposium on Applied Physics Education, Tokai University Yamanakako Seminar House, 5-6 September, 1998. Contact Prof. Hiramatsu, Fukuoka University at +81 92 871 6631 ext. 6174 or see *Oyo Buturi* **67**(6), 227 (1998) for details.

International Conference on Solid State Devices and Materials, Hiroshima International Congress Centre, 7-10 September, 1998. Contact jsap secretariat at + 81 3 5814 5800 or see *Oyo Buturi* **67**(2), 227 (1998) for details.

59th Fall Meeting of the JSAP, Hiroshima University, Nishi-jo Campus, 15-18 September, 1998. Contact jsap at phone +81 3 3238 1044, fax +81 3 3221 6245, or see *Oyo Buturi* **67**(5), 612 (1998) for details.

Optics Japan '98, Okayama Science University, 18-19 September, 1998. For further information, contact Prof. Takeda, University of Electro-Communications at +81 424 43 5276, fax +81 424 89 6072, or `oj98info@cas.uec.ac.jp`

Scientific Japanese

As in any language, there are words in specialist fields which do not appear in dictionaries of the standard vocabulary. In this section, an abstract from this month's Oyo Buturi is translated into English and a vocabulary of scientific and technical Japanese terms is provided.

III-V 族化合物半導体低次元量子構造の作製

結晶成長技術を利用して異なる2つの半導体材料を積み重ねた、半導体ヘテロ接合構造形成の研究の進展は、量子井戸のみならず、量子細線及び量子ドット構造の形成を可能にしつつある。ここでは、GaAs を中心とした III-V 族化合物半導体ヘテロ構造のエピタキシャル成長技術を利用することにより、電子（あるいは正孔）を 1 次元及び 0 次元に閉じこめた量子細線、量子ドット構造の作製法に関して報告する。

Fabrication of III-V Compound Semiconductor Low Dimensional Quantum Structures

The progress in the research of fabricating semiconductor heterostructures, which are formed by using crystal growth techniques to deposit 2 different semiconductor materials on top of each other, makes possible the realisation of not only quantum wells, but also quantum wires and quantum dots. In this paper, we report on the methods of fabricating quantum wires and quantum dots, which respectively provide one or zero dimensional confinement for electrons (or holes), using epitaxial growth techniques for producing heterostructures of III-V compound semiconductors, of which GaAs is a principal member.

III-V 族化合物	san-go zoku kagōbutsu	III-V compound
半導体	handōtai	semiconductor
低次元	tei-jigen	low-dimensional
量子構造	ryōshi kōzō	quantum structure
ヘテロ接合	hetero-setsugō	hetero-junction
量子井戸	ryōshi ido	quantum well
量子細線	ryōshi saisen	quantum wire
量子ドット	ryōshi dotto	quantum dot
エピタキシャル	epitakisharu	epitaxial
成長技術	seichō gijutsu	growth technique
電子	denshi	electron
正孔	seikō	hole
1 次元	ichi-jigen	one-dimensional

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