



**日本国際賞 2010
受賞記念講演会**

**JAPAN PRIZE 2010
Commemorative Lectures**

PROGRAM April 22 (Thursday) Yurakucho Asahi Hall

6:30 PM Opening Remarks

6:40 PM Prof. Peter Vitousek
An Islander's Perspective on Global Change

7:40 PM Prof. Shun-ichi Iwasaki
Perpendicular Magnetic Recording
- Its Development and Realization -

8:40 PM Closing

2010 (26th) Japan Prize Laureate



Field : Biological Production and Environment

Prof. Peter Vitousek (U.S.A.)

Professor of Biology, Stanford University

Born in 1949

Achievement

Contributions to solving global environmental issues based on the analysis of nitrogen and other substances' cycles

An Islander's Perspective on Global Change

I was born in Hawaii, which was an interesting place culturally as well as biologically. It was economically dominated by the United States, and by a Caucasian minority. However, by the time Hawaii became a state in 1959, it was dominated politically by ethnic Japanese and their allies. The Native Hawaiian population was then at a low ebb in power and influence. Nevertheless, Hawaiian history and culture pervaded the land, in place names, in history, and in the myths and legends we learned in school. It was just what I knew, growing up – but later I learned that this powerful Asian and Indigenous Hawaiian influence made Hawaii a very different place from the mainland states. Now I understand that the experience of growing up on islands, and influenced by island cultures with deep histories, shaped both my science and my worldview.

I left Hawaii to attend Amherst College in Massachusetts in 1967, where I studied Political Science as an undergraduate.

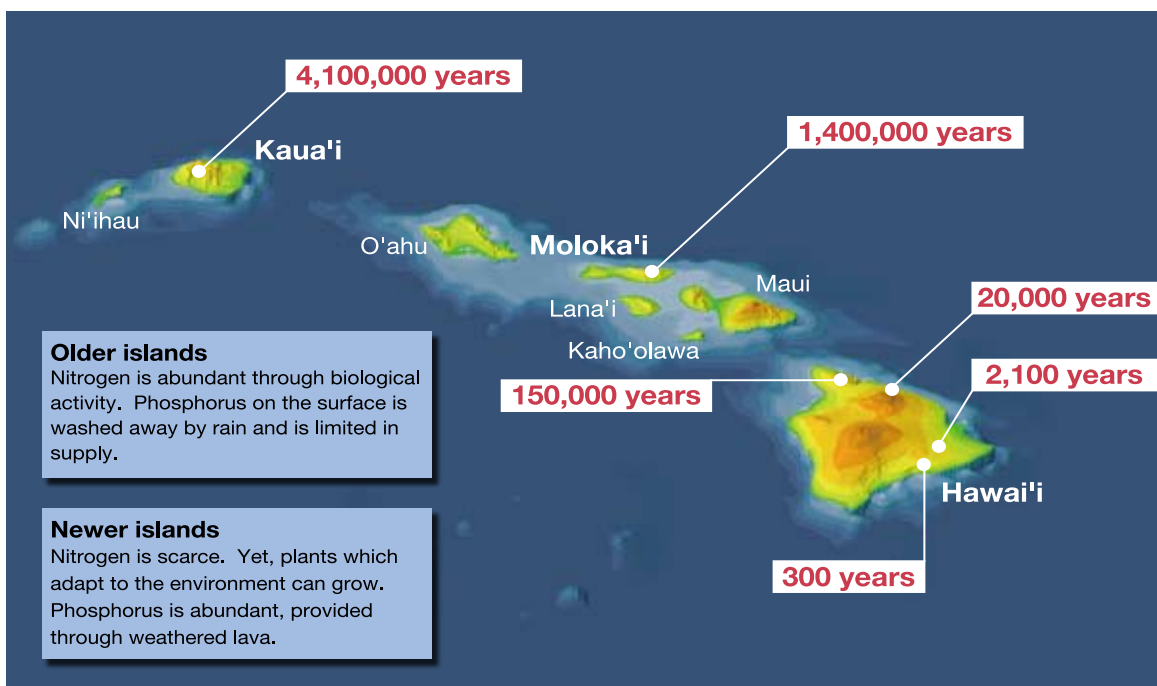
However, in my third year in college, I was fortunate enough to take a course in the literature of science; that inspired me to change my focus to ecology. I finished my degree in Political Science, and at the same time sought a PhD program in ecosystem ecology that would be willing to admit me despite my brief and weak background in the subject. I was fortunate that Dartmouth College was willing to take a chance on me. After completing my PhD in 1975, I taught at Indiana University and the University of North Carolina, before moving to Stanford University in 1984. Looking back, it is easy to see that good fortune has played a major role in my education and development – as I think it does for most of us. Above all I was fortunate to grow up in a system that doesn't channel students into careers at a very early age.

Now I will change my focus to biogeochemistry, the science of the cycles of elements. I will focus on human alterations to the biogeochemical cycles – but it should be recognized that

our ability to evaluate changes in those cycles and to manage systems in ways that reduce the impact of those changes depends on our fundamental understanding of biogeochemistry. In terms of human impacts, most educated people have been aware of one biogeochemical cycle, that of carbon, at least since the Kyoto meeting (COP3) in 1997. There is less awareness that we have changed the global cycles of other elements, most notably nitrogen and phosphorus used in fertilizers, to a much greater extent than we have the cycle of carbon. Nitrogen and phosphorus additions are inefficient, and a large and variable fraction of nutrients intended for crops is lost to the environment instead. Nitrogen is particularly mobile, and by multiple pathways. Human activities now equal or overwhelm natural fluxes of nitrogen and phosphorus to the atmosphere and oceans –

where they cause eutrophication in streams, lakes, and the coastal ocean. While we often think of biological production as a good thing, eutrophication very definitely represents too much of a good thing.

Eutrophication resulting from alterations to element cycles is widespread, and efforts to control it have met with mixed success. The Yaqui Valley of Mexico provides one useful illustration of the challenges and opportunities involved in controlling nutrient losses from agriculture. There, an interdisciplinary research group led by my partner Pamela Matson demonstrated very high nitrogen losses from intensively irrigated and fertilized fields. They then developed an alternative set of fertilization practices that required less fertilizer and reduced nitrogen losses to the environment substantially, while maintaining both wheat yields and grain quality – and they



Formation of the Hawaiian Islands and changes in its material cycle

studied the decision-making system in the Valley, finding that risk-averse credit unions played a central role in determining fertilizer applications. Working with the credit unions, they developed technical means of assuring the credit unions that individual farmers were applying sufficient fertilizer – and the lower-input approach they developed is now practiced widely in the Yaqui Valley. Similar opportunities exist in rapidly developing economies, in which fertilizer applications often exceed efficient and productive levels.

My discussion of biogeochemistry of agricultural systems illustrates an important point – that human alteration of the Earth System already is substantial and pervasive. In response to anthropogenic changes, many biogeochemists and other scientists are transforming how we choose our research topics. Broadly, this new direction can be characterized as moving from thinking in terms of a science focused in part on global change, to a science that (in part) defines its role as supporting a transition towards sustainability. I believe (and hope) that this approach, which is aimed not only at understanding the world and our influence on it, but also guiding a transition towards living more sustainably, will become a more prominent and important part of our

science.

Now I want to return to Hawaii, and to other islands in the Pacific. The Polynesians who discovered these islands were remarkable explorers, and they developed remarkably different societies on the very different islands they colonized. To their inhabitants, these islands were worlds in themselves in a very real sense. Polynesian societies faced the challenge of ‘global’ changes to their island world, and the need for a transition to more sustainable ways of living. Some of their societies made striking transitions from exploitive to explicitly sustainable social and production systems; others failed to adjust, and suffered environmental degradation coupled with declines in population and well-being. What can we learn about making a transition to sustainability, from studying islands where cultures clearly made or failed to make such transitions in the past? I believe that island people and cultures have a great deal to contribute to this global challenge; their ways of thinking – which were shaped by generations of experience when their island was the world – could be a useful guide to a culture of sustainability. Some Polynesian leaders are working to articulate that vision, and we should support their efforts.

2010 (26th) Japan Prize Laureate



Field : Industrial Production and Production Technology

Prof. Shun-ichi Iwasaki (Japan)

Director, Tohoku Institute of Technology
Professor Emeritus, Tohoku University
Born in 1926

Achievement

Contributions to high-density magnetic recording technology by the development of a perpendicular magnetic recording method

Perpendicular Magnetic Recording - Its Development and Realization -

1. Introduction

In May 2005, Toshiba Corporation launched the world's first music player equipped with a perpendicular magnetic recording hard disk drive (HDD). It took 28 years for this moment to come from the time I first presented my theory on perpendicular magnetic

recording. Thereafter, perpendicular magnetic recording type HDDs for personal computers have been successively put on the market by both Japanese and U.S. manufacturers, thus accelerating the changeover to the perpendicular type HDD (Figure 1). It is estimated that all

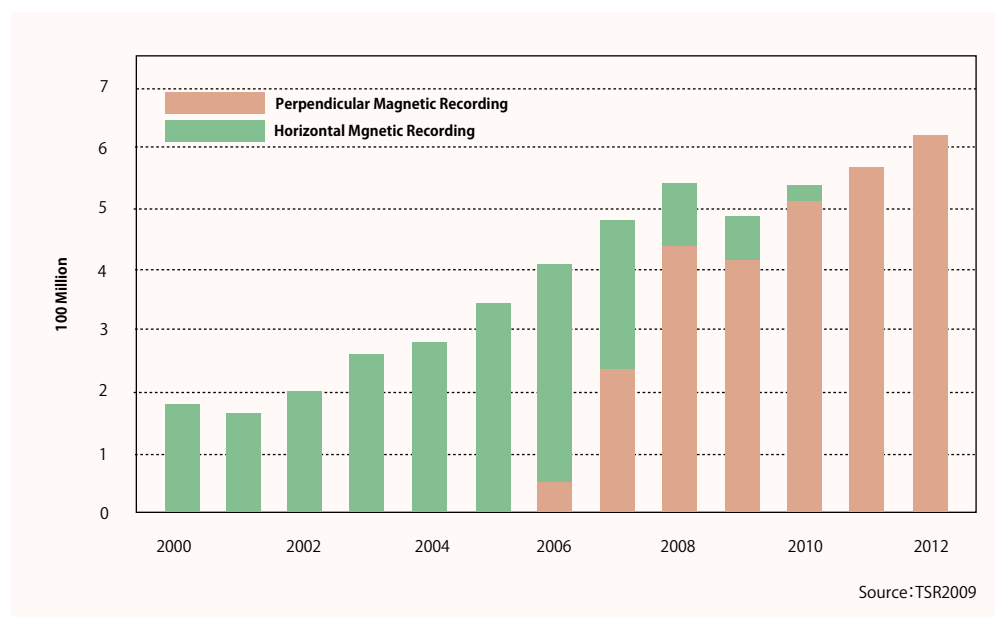


Figure 1. Shift to perpendicular magnetic recording HDD in the World

HDDs produced in 2010 will be of the perpendicular magnetic recording type. The technological innovation from the horizontal to the perpendicular type is progressing at an unprecedented speed, and it is truly gratifying for an inventor such as myself to observe first-hand its mass production and its pre-eminence in the marketplace.

In retrospect, I began my research of magnetic recording in 1950 with the objective of improving data recording density. It started with the invention of metal tapes and establishment of the theory of high density recording. I realized around 1975 that magnetizing perpendicular to the plane of the recording media was extremely effective in improving the recording density. Within 3 years, I developed several key technologies, namely a single pole-type magnetic head, cobalt and chrome alloy film with uniaxial perpendicular magnetic anisotropy and a composite media combining perpendicular and horizontal magnetic films, all of which still remain the basic structure of perpendicular magnetic recording to this day. Thus, it was verified that perpendicular magnetic recording was basically possible.

Thereafter, the goal was to achieve practical application of the technology, so with the concerted efforts of the laboratory personnel, our research expanded with a focus on the development of new magnetic heads, recording media as well as the evaluation of recording and playback properties. At the same time, due to the scope of this research theme, the Committee 144 on Magnetic Recording was established and organized by the

Japan Society for the Promotion of Science. In addition, to date, the research has been furthered at well over 200 research committee meetings with the Universities-Industries collaboration in an open-minded manner. Also the Perpendicular Magnetic Recording Conference (PMRC) has been held 8 times. Moreover, in May of this year, the 9th PMRC conference is scheduled to be held.

In this way, through the many years of research and cooperation by a wide range of people, the objective of this invention has been fulfilled. This is due to our firm pioneering policy held from the start of the research. I believe this example is unprecedented.

2. Research philosophy - Complementarity

The most difficult element in carrying out new research was to determine which subject among the many issues to take up first, such as magnetic head, recording media, recording behavior, etc. This was because from our data, perpendicular recording came to be recognized, and the manner of its spreading to the world was about to change as well. In the early stages, focus was placed on the problem of demagnetization and increasing the recording density. However, as the study progressed, we realized that the perpendicular magnetic recording and the conventional horizontal magnetic recording can complement each other (Figure 2). This is derived from the basic relationship in which the force operating between the recorded bits (magnetization) becomes a repulsive force in horizontal magnetization thus resulting in demagnetization, whereas this same force becomes an attractive force resulting

in an increase of magnetization in the cause of perpendicular magnetization.

There are two types of recording methods for magnetic recording, namely horizontal and perpendicular. I have decided to call the relationship between these two complementarity. The expression “dual” was a possibility, but the word “complementarity” means not only “double” but “to fill in the gap and make complete.” This concept of “complementarity” provided an extremely important impetus in actually making the perpendicular magnetic recording a reality. Making a clear distinction between the conventional horizontal recording as analog and the perpendicular recording as digital was an audacious suggestion in those days, but looking back, I believe it was the correct decision. The transition from horizontal to perpendicular means more than merely improving the recording

density. We understand that the transition in the recording limitation from structure to property is in harmony with the direction of engineering development.

3. Road to practical application

As mentioned above, the initial research proceeded smoothly, but getting into the 1990's, the focal technology for magnetic recording shifted to high density playback technology. Thus, we experienced a period which might be called “the valley of death.” However, in the 2000's, the recording density reached 100 Gbit/in² and the recording limitations due to thermal demagnetization became apparent. Once again, the shift towards perpendicular magnetic recording began. In overcoming the period of “the valley of death,” the research system, comprised of the collaboration of both industrial and

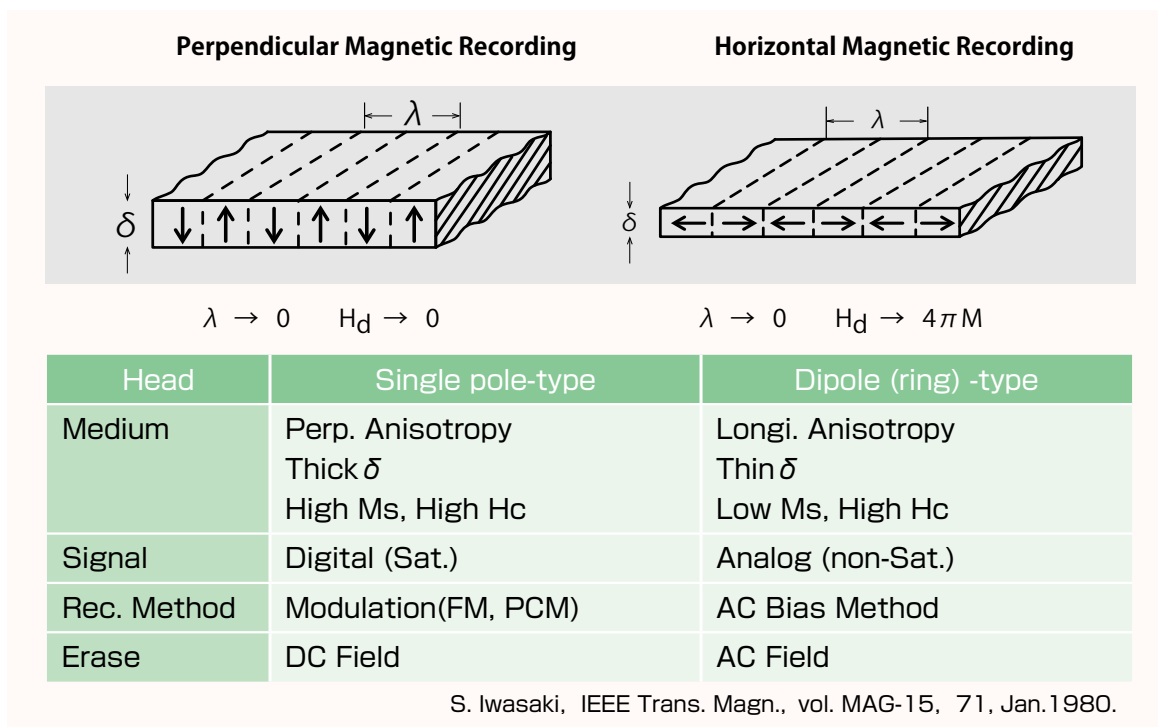
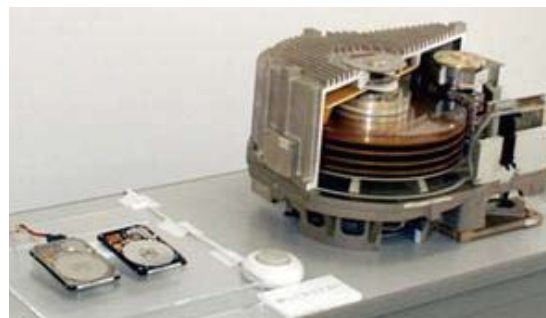


Figure 2. Complementarity relation between perpendicular and horizontal recordings

academic communities as aforementioned, was a source of much strength.

My initial forecast regarding the time frame of practical application of the perpendicular magnetic disk was the 1990's, but it was deferred until 2005. However, the recording density achieved in 2005 was in accord with the recording density trend initially anticipated. Comparing the trend for both perpendicular and horizontal recording methods, if the transition to the perpendicular type would have been seriously considered in the early 1990's, HDD would have occupied an even more superior position than at present. This should serve as an example for future research strategies.

From 2005, many manufacturers have marketed their perpendicular recording type HDDs, and in a few years all products are expected to switch to the perpendicular type. This can truly be called an innovation in the field of hard disks. Comparing the present perpendicular recording type HDD to the horizontal recording type HDD of 25 years ago (Figure 3), while the weight and power consumption were reduced considerably, the capacity has increased 1000 times. This innovation is not only an epoch-making improvement in performance, but also has a great effect in the conservation of resources and energy. The idea which was conceived in one laboratory at the Research Institute of Electrical Communications of Tohoku University has taken root all around the world. I am truly happy as a researcher that the first steps to the realization of my motto "integration into society" is taking place.



Current (Left)		In 1980s (Right)
Perpendicular	Recording Method	Horizontal
135g	Weight	35kg
300GB	Memory Capacity	0.3GB
0.4W	Power Consumption	600W

Figure 3. Comparison of past and present hard disk drive (HDD)

4. Significance of perpendicular recording

It can be said that the production scale (more than 500 million units annually) and the speed of conversion to the perpendicular HDD far exceeds the norm of conventional industrial production. Even the industrialization speed of the transistor was not as fast as this. The realization of this fact is attributable to the superiority of the principle of perpendicular magnetic recording and the fact that organizational research has been conducted for over 25 years and persevering efforts were made to maintain social interest through academic conferences, etc. Of course, the fact that the conventional recording reached its limit in performance is another contributing factor.

Perpendicular magnetic recording is based on the extremely obvious principle that the interaction of the bits creates magnetic suction power which contributes to achieving high density, and this is the best answer to the achieving of high

density in magnetic recording. This confidence did not waver even during the period of the so called “valley of death” during the 1990’s.

Looking back over the 110-year history of magnetic recording development, magnetic recording started from the early piano curve recording, namely a one-dimensional, only length-wise recording method, to magnetic tapes, which is a two-dimensional, planar recording method. Finally, we have arrived at the ultimate three-dimensional recording method using perpendicular magnetization. This is the final method in achieving high density. Thus, although improvements may be made in the recording media in the future, the principle of perpendicular recording is thought to be unshakeable.

If perpendicular recording had not been invented 30 years ago, magnetic recording might have disappeared altogether with

the emergence of Solid State Device (SSD) and optical disk in recent times, or at least it would have lost its present major position in the field of memory. Presently, magnetic hard disk drives (HDD) are supporting the advanced information society in which information in enormous quantity, namely several hundred exabytes (10^{20} bytes), is circulating. At the same time, these serve the role of a “Rosetta Stone,” passing on enormous quantities of information to the next generation. We have come to an era where brain data and one’s entire personal history can be stored in a HDD which can be purchased for several 10,000 yen. We are on the verge of a new generation where personal knowledge, namely value, is increasing dramatically. That is in effect, called “IT civilization.”

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The Science and Technology Foundation of Japan

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The Foundation holds a series of seminars on advanced technologies used widely in everyday-life. In the seminars designed for students and general public, experts in the related fields explain in plain terms the technologies that are also the focus of interest at that time.



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The Foundation provides research grants to scientists and researchers under 35 years of age. Every year, the Foundation selects projects in the same fields as the Japan Prize of that year and gives one million Japanese yen for a project.



Stockholm International Youth Science Seminar (SIYSS)

Under the auspices of the Swedish Federation of Young Scientists and with the support of the Nobel Foundation, The Science and Technology Foundation of Japan sends two Japanese students to the annual Stockholm International Youth Science Seminar.

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