# Fourth Presentation of Foundation-Assisted Research Results in Japan (1996)

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Theme: Physical Properties

## Promoting Joint Research Among Industry, Government and Academia

Professor Yasuharu Suematsu
Director General of the National Institute for Advanced Interdisciplinary Research (NAIR)

Major research movements that are gaining currency in Japan include basic research, which has become an international byword; interdisciplinary research, which targets developments in new fields; strategic research, which contributes to society; and creative research, which targets developments in emerging industries. To achieve success in these areas, joint research between industry, government and academia is growing in importance because of its ability to match researchers from a variety of fields with necessary funding. Such joint research, however, requires an environment that enables researchers to participate easily in cooperative research and that facilitates the flow of research funds between industry, government and academia. NAIRŐs efforts to assemble a group of quality researchers by establishing 10-year projects have proven successful. In addition, to promote quality joint research, we must provide opportunities for researchers from around the world to work together and have their research evaluated objectively.

## Scanning Probe Microscopy and Its Application in the Investigation of Surface Magnetic Properties

Professor Kouichi Mukasa, Division of Electronics and Information Engineering, Graduate School of Engineering, Hokkaido University

Magnetic memory materials are used in such applications as computer magnetic disks, and demand for faster magnetic memories with higher capacities continues to grow. To satisfy this demand, two types of research are being conducted at the atomic level. The first method involves the study of magnetic material properties, and the second involves high-density storage, which allows a larger volume of information to be stored in a smaller space. To promote this research, Professor Mukasa has expanded the principles of scanning tunnel-effect microscopy, which uses probes to observe atomic structure on surfaces. Professor Mukasa has developed two new types of scanning probe microscopes to detect various physical quantities relating to the magnetic properties of materials. These microscopes enable researchers to observe the physical phenomena that result from electron spin orientations and make measurements of the magnetization of materials. In the future, these developments are likely to permit performance evaluations of magnetic materials.

## New Photoionization Effects of Semiconductor Nanocrystals Embedded in Glass and Crystals

Professor Yasuaki Masumoto, Institute of Physics, University of Tsukuba

A significant amount of research on ultrahigh-density storage materials for computers involves semiconductor nanocrystal materials, which use light to store information. When materials featuring dispersed microcrystals are irradiated with fixed-wavelength laser light, they become unable to absorb light of this wavelength, creating holes in the absorption spectrum. This process, which is known as spectral hole burning, results in materials with holes into which a large amount of information can be read. Using dispersed semiconductor nanocrystals, which comprise nanometer-sized copper chloride semiconductors in glass, Professor Masumoto identified the photoionization effects of persistent spectral hole burning by laser irradiation. Now he is performing fundamental analysis that involves detailed measurements of the relationship between the influences of temperature and light wavelengths. In this manner, Professor Masumoto expects to clarify the mechanisms and nature of spectral hole burning.

## The Crossover Observed During Magnetic Spin in Superconductons

Professor Yasuo Endoh, Department of Physics, Tohoku University

The theories of statistical physics attribute the superconductivity of superconducting oxide materials to the creation of a charged pair of electrons known as a Cooper pair. However, until recently this phenomenon had not been verified experimentally. Professor Endoh concentrated on observing fluctuations between magnetic spins, which are at present considered the most important force of attraction in creating a Cooper pair. First, he created a large superconducting crystal. Then, he used a new measuring technique known as high-energy neutron spectroscopy to observe magnetic spin fluctuations directly. Through this process, Professor Endoh succeeded in verifying spin waves experimentally. By identifying the exchange interaction between aligned magnetic spins and observing the spin fluctuation characteristics of superconducting materials, this experimentation has helped clarify various aspects of semiconductors and magnetic spins.

## Ferroelectric Domain Inversion Occurring from the Heat Treatment of Piezoelectric Crystals, and Its Application to Elemental Devices

Professor Kiyoshi Nakamura, Department of Electrical Communications, Faculty of Engineering, Tohoku University

Ferroelectric crystals convert electrical signals to mechanical vibrations or light to electrical signals. Alternatively, these crystals can be used as electrical circuits for elemental devices that selectively induce signals of correlated wavelengths. Normally, producing ferroelectric crystals is a complex process. First, a crystal must be heated to polarize it. Then, the crystal is cooled in an electrical field that corresponds to its crystallographic axis orientation. However, Professor Nakamura discovered the domain inversion orientation phenomenon, whereby crystals of lithium metaniobate and lithium metatantalate developed an induced ferroelectromotive force during heat treatment without being submerged in an electrical field. Professor Nakamura explained the mechanism at work by stating that, "Inverse polarization occurred as a result of the electrical field formed near the crystal surface during processing." This method enables the production of new types of elemental devices.