5-Year Project

Nano-structured magneto-optical devices

Project Leader

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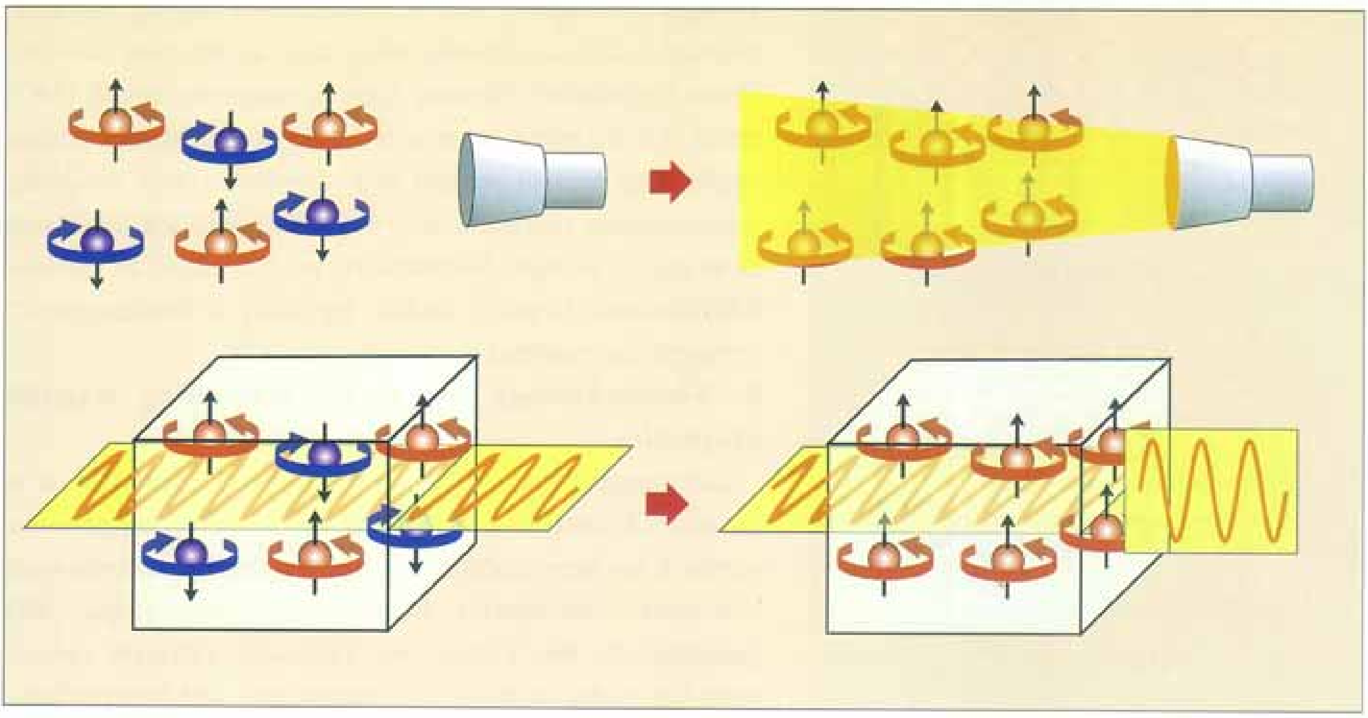

magneto-optical effects

Electronics are essential to present-day life, and it is no exaggeration that its progress determines the future of our country. Nowadays, electronics must not only promote downsizing and integration, but also simultaneously perform multiple functions which are difficult to accomplish using conventional techno-logies. We are therefore interested in the materials used in devices, because historically the discovery of new materials has led to breakthroughs in electronics-related technologies.

Recently, new phenomena that appear on nanometer or mesoscopic scales, such as phase separation and self-organization, have been attracting much attention. Most of these phenomena are the consequence of competition between different interactions. Therefore, if these interactions can be controlled as desired, with the aid of thin film technologies, large new effects or functionalities that are needed in practical devices maybe attained.

In this project, we propose a new strategy for the development of electronic devices, i.e., material engineering by controlling nano-scale interactions. In particular, we focus on new magneto-optical materials in opto-electronics, which will finally be incorporated into prototype devices. Specifically, in the project we will develop:

i) optical isolators using materials with large magneto-optical effects.

ii) optical switches using ferromagnetic-ferroelectric materials,and.

iii) optical memories using materials that indicate photo-induced magnetic transitions.

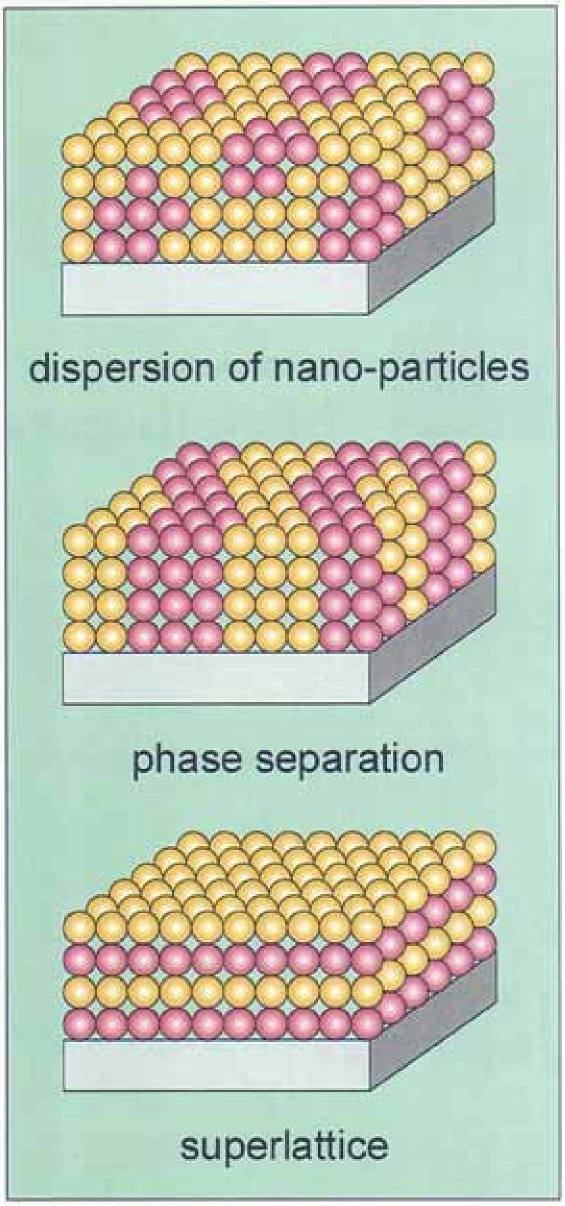

Fig. 1 Examples of nano-scale structures

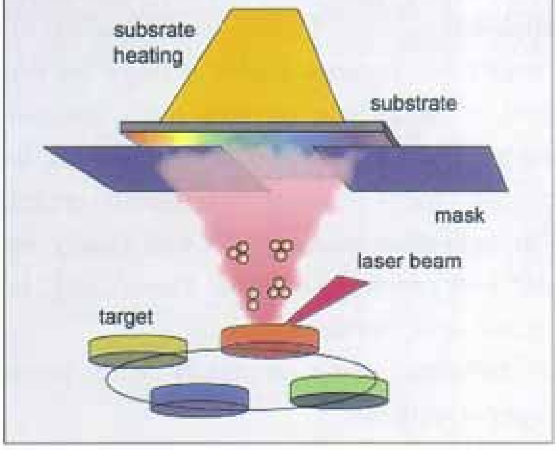

Fig. 2 Schematics of laser MBE system

●Contents of Research

1. Fabrication of new magneto-optical devices

In some oxide materials, such as Mn-based perovskite-type oxides, various interactions compete with each other, resulting in the formation of quasi-stable states. Irradiation of UV or visible light on these materials causes ordering of spins. Here, the amount of applied beam, or numbers of photons, can be memorized as the strength of magnetic field. We are using this phenomenon to fabricate optical memories.

It is also possible to control photons by magnetism. Transparent magnets can be obtained by doping magnetic impurities into semiconductors, such as titanium dioxide. These transparent magnets show a magneto-optical (MO) effect that the plane of polarized light is rotated by a certain angle. The present project will develop a new magnetic semiconductor yielding a large MO effect, which is applicable as an optical isolator. Furthermore, we will create an electric-field-controlled optical switch by using a ferromagnetic-ferroelectric material.

2. Nanotechnology several for controlling material properties

For practical use of the above-mentioned materials, it is necessary to maximize the MO effects. Based on our previous works, it has been clarified that the introduction of nano-scale structures considerably modifies the macroscopic MO properties. In this project, we artificially fabricate various nano-structures, such as fine precipitates and superlattices, by using the laser MBE technique, which allows us to arrange atoms on a substrate in a sophisticated manner.

3. Evolution of magneto-optical electronics

Most of the conventional opto-electronic devices work on the basis of interactions between photons and electron charges, and magneto-optical phenomena have attracted little attention. Therefore, the development of new devices based on photon-magnetism interactions will have a major impact on the field of opto-electronics. For instance, laser source peripheral equipment will be made much smaller, and communication using sub micron light beam will be realized. The materials themselves have functionalities such as memory effect, so related devices are expected to become smaller.

●Organization of Research

Term: October 2003 to September 2008

Structure: Project leader, several regular researchers, and several collaborating research members from Tokyo Institute of Technology & University of Tokyo

Location: Kanagawa Science Park(KSP) East Building 5th and 6th floor