## High-Temperature Materials Science   Prof. **Kazumasa Togano** (2003.4~2005.3)

**【Staff Members】**

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**【Research Activities】**

We have developed both the superconducting materials and the materials related to hydrogen energy, and also have searched their fundamentals.

On the superconducting materials, we remarked two types of materials. $MgB_2$ superconductor with critical temperature of 39 K has been examined for applications with cooling by not only cryostat but also liquid hydrogen (20 K) in future hydrogen society. Although $MgB_2$ is recently manufactured as cables, it still has the problem that the critical current density is attenuated drastically in applied magnetic fields. In order to solve this problem, it is needed to introduce effective pinning centers. Therefore, we have tried to reduce the crystallite sizes in nanometer orders by addition of different phases and introduction of non-equilibrium processes (such as mechanical milling or film-forming techniques), and finally succeeded in developing the critical current density in applied magnetic fields. We have also studied boride- and borocarbide-systems including light-weight metals such as lithium and magnesium, and found out Li2Pd3B superconductor with the critical temperature of 8 K (thesis ***1***). It is the first example of boride-superconductor composed of the alkaline-metal and distorted octahedron of $Pd_6B$ (thesis ***2***).

On the materials related to hydrogen energy, we have studied complex hydrides whose main phases are light-weight metals and non-metals. The "metallurgical" synthesis technique on the basis of gas-solid reactions has been extensively applied, for the first time, to the complex hydrides. Consequently, we could succeed in synthesizing various types of the advanced complex hydrides, and then clarify their atomistic and electronic structures precisely (thesis ***3***). Based on the researches, we have developed valence-control technique (thesis ***4***) and composite-forming technique (thesis ***5***) for the synthesis and functionization of the complex hydrides (e.g.; synthesis of the lithium-magnesium-based complex hydrides storing a large quantity of hydrogen reversibly, and their convenient production from the mixtures of nitrides which are suitable for industrial usage). The systematic researches concerning the advanced complex hydrides are regarded as a new research program in an activity of International Energy Agency (IEA), and requested to be presented at 7 international conferences as invitation or keynote lectures in 2004.

***1.*** K. Togano, P. Badica, Y. Nakamori, S. Orimo, H. Takeya and H. Hirata,
"Superconductivity in the Metal Rich Li-Pd-B Ternary Boride"
Phys. Rev. Lett., 93 (2004), 247004.

***2.*** P. Badica, T. Kondo, T. Kudo, Y. Nakamori, S. Orimo and K. Togano,
"Magnetization measurements on Li2Pd3B superconductor",
Appl. Phys. Lett., 85(2004), 4433-4435.

**3.** S. Orimo, Y. Nakamori and A. Zuttel,
"Material properties of MBH4 (M = Li, Na, and K)",
Mater. Sci. Eng. B, 108 (2004), 51-53.

**4.** Y. Nakamori and S. Orimo,
"Destabilization of Li-based complex hydrides",
J. Alloys. Compd., 370 (2004), 271-275.

**5.** Y. Nakamori, G. Kitahara and S. Orimo,
"Synthesis and dehydriding studies of Mg-N-H systems"
J. Power Sources, 137 (2004), 309-312

**【Plan】**

We would like to set "developments and searching of fundamentals on various light-weight hydrides as environmental and energy-related materials" for our future research plans. Particularly, new hydrides composed of alkali (alkaline-earth) metals and non-metallic elements such as boron, carbon and nitrogen, will be focused for the purpose of extracting their potential functions, mainly on hydrogen storage. The following researches are to be carried out collaborated with the other related departments and institutions;

a) Syntheses of new complex and alloy hydrides: We will synthesize complex and alloy hydrides possessing specific atomistic and electronic structures, using high-pressure gas-phase reaction, atmosphere-controlled mechanical milling, and film-forming techniques such as reactive evaporation and CVD.

b) Developments of hydrogen storage materials suitable for individual applications: Some types of complex and alloy hydrides are expected to be developed as advanced hydrogen storage materials. The hydrides suitable for the individual applications, such as vehicles, mobile and stationary equipments, will be developed using the various synthesis techniques mentioned above.

c) Experimental analyses of atomistic structures and their applications: We will experimentally analyze atomistic structures of the complex and alloy hydrides newly synthesized, using, i.e., synchrotron radiation X-ray diffraction and neutron diffraction measurements. On the hydrides expected as neutron-shielding materials, we will develop their applications.

d) Experimental and theoretical analyses of electronic structures and their applications: We will experimentally analyze electronic structures of the complex and alloy hydrides newly synthesized using *in-situ* measurements of magnetization, electric resistibility, Raman spectrum, and so on. Possibilities of the functions for superconducting or catalytic materials will be examined assisted by computed materials science.

Our research fields on the light-weight hydrides as environmental and energy-related materials shall be widely expanded to inside, interface, and surface of the hydrides composed of metallic, inorganic and their composite systems.