【Grant-in-Aid for Scientific Research(S)】
Science and Engineering (Engineering Ⅱ)

Title of Project : Cultivation of Inorganic Electrides as a New Functional Materials

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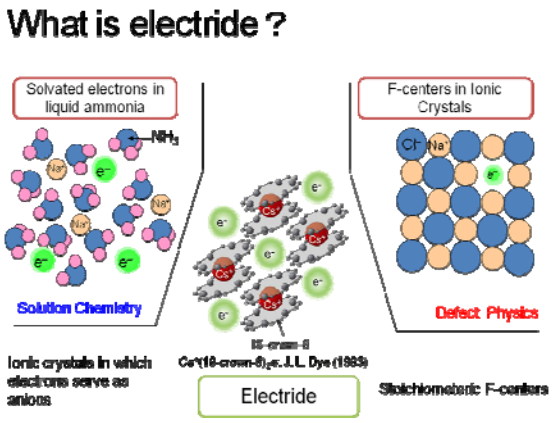
Research Area : Material Science Inorganic Materials Physical properties
Keyword : electride, functional ceramics

【Purpose and Background of the Research】

Electride is an ionic crystal in which electrons serve as anions. In 1983 this new class of materials was first synthesized by J.Dye (Michigan State University) who was succeeded by use of crown-ether to prevent the recombination of electron and the mother cation. Although various exotic properties have been expected for them, progress in their material research still remains primitive. The primary obstacle was extremely high sensitivity to heat and water/ oxygen. Thus, realization of electrides which are stable at RT and in an ambient atmosphere was the long stranding issue since its discovery.

We reported an inorganic electride by injecting electrons to the sub-nanometer-sized cages in the crystal structure of $12CaO \cdot 7Al_2O_3$(C12A7) in 2003. This material C12A7:e- is a first RT and air stable electride. Since then, several unique electron-active properties have been found in C12A7:e-, i.e.. metal-insulator transition, metal-superconductor transition such as insulator-metal-superconductor transition and extremely low work function.

In this project, we aim at the cultivation of science and technology of inorganic electrides.



【Research Methods】

Materials science on inorganic electrides is cultivated covering fundamental aspect, function exploration, and device application.

The following four subjects are to be focused:

① Elucidation of electronic properties in bulk C12A7:e- and fabrication of electronic devices Metal-insulator, metal-superconductor transition, Resistive memory switching device based on field assisted oxygen-electron exchange in built-in nanostructure
② Exploration of surface electronic and chemical function in C12A7:e- STM observation, application to organic chemical reactions in aqueous media
③ Attempt to fabricate amorphous electride electro-conductive melts and glass
④ Trial for new inorganic electrode materials

【Expected Research Achievements and Scientific Significance】

An approach to realize electro-active functionalities arising from specific nanostructure composed of abundant elements will be established. Concretely, materials science on representative elements, which has not focused as the platform for electro-active function to date, should be cultivated.

【Publications Relevant to the Project】

- S.Matsuishi, Y.Toda, M. Miyakawa, K..Hayashi, T.Kamiya, M. Hirano, I.Tanaka, and H.Hosono, High-density electron anions in a nano-porous single crystal: $[Ca_{24}Al_{28}O_{64}]^{4+}(4e^-)$, *Science* **301**, 626-629 (2003).
- M.Miyakawa, S.W. Kim, M. Hirano, Y. Kohama, H. Kawaji, T. Atake, H. Ikegami, K. Kono, and H. Hosono: Superconductivity in an Inorganic Electride $12CaO \cdot 7Al_2O_3$:e-; *J. Am. Chem. Soc* , **129**, 7270-7271 (2007).
- H.Hosono, Y.Mishima, H.Takezoe, and J.D.K.Mackenzie (ed.), *Nanomaterials*,: from Research to Application, Elsevier(2006).

【Term of Project】 FY2009-2013

【Budget Allocation】 148,700 Thousand Yen

【Homepage Address and Other Contact information】
http:// lucid.msl.titech.ac.jp/~www/