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Preparation of low-melting hybrid glasses through non-aqueous acid-base reaction / Large photorefractivity in Ge-doped silica glasses waveguide / Photocatalysis in advanced TiO2 film electrodes (SOLID STATE CHEMISTRY - Amorphous Materials)

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Visitor
Dr HEO Jong  Pohang University of Science and Technology, Korea, 15 January 2000 – 14 February 2001

Scope of Research

Amorphous and polycrystalline inorganic materials with various optical functions such as photorefractivity, optical nonlinearity, and photo-catalysis are the target materials in this laboratory, which in the forms of thin film and bulk are synthesized mainly by sol-gel, multi-cathode sputtering and sintering methods. The detailed correlation between structure and properties is extensively investigated to obtain highly functional materials by using X-ray diffraction techniques, high-resolution NMR, thermal analyses, various laser spectroscopies and ab initio molecular orbital calculations, and so on.

Research Activities (Year 2001)

Presentations
Photoresonance of doped and undoped silica glasses, Ichii K, Sako A, Takahashi M, Uchino T, Yoko T, Spring meeting, JSAP, 3 March, LPM2001, 17 May, Meeting on Glasses and photonics materials, 2 November, PacRim4, 6 November, BGPPGW, 4 July, ICG, 6 July.
Dispersion of nonlinear absorption coefficients of tellurite glasses by nonlinear transmission spectroscopy, Tokuda Y, Takahashi M, Yoko T, ICG, 3 July, Fall meeting Ceramic Soc. Jpn, 27 September.
Novel pressure-induced polymorphic transition from fumed silica to transparent amorphous SiO₂ at room temperature Uchino T, Sakoh A, Azuma M, et al. AIRAPT-18 & HPCC-11, 24 July

Grants
Yoko T, Photochemical reactivity of glasses, Grant-in-Aid for Scientific Research (A) (2), 1 April 2001 - 31 March 2005.
Uchino T, Mechanism of defect formation and optical functions of silica glasses under irradiation of light, Grant-in-Aid for Scientific Research, Promotive Research (A) (2), 1 April 1999 - 31 March 2001.
Takahashi M, Development of photorefractive low-melting glasses, Grant-in-Aid for Scientific Research (B) (2), 1 April 2001 - 31 March 2005.
Takahashi M, Development of active optical integrated
**Preparation of low-melting hybrid glasses through non-aqueous acid-base reaction**

Organic-inorganic hybrid glasses of new type low-melting glasses with a melting temperature of less than 200°C have been successfully prepared through a non-aqueous acid-base reaction. Such a low-melting hybrid glass has a bright prospect of finding many applications as advanced active photonics devices in addition to conventional low temperature glass-to-metal sealant because of the easy fabrication in the forms of optical fiber and waveguide and the high solubility of optically active organics.

**Large photorefractivity in Ge-doped silica glasses waveguide**

High photorefractive glasses based on silicon dioxide are of great importance as materials for active/passive optical devices in the field of dense and rapid information processing systems. Glasses have long been playing a crucial role in the optical telecommunicating systems as optical fibers. All optical signal processing is, however, strongly required. For this reason, the development of glass materials with large photorefractivity is now the most vigorous field in the photonics community.

Very recently, we have succeeded in the preparation of high Ge-doped SiO$_2$ thin film with a very large photorefractivity of $\Delta n$ > $10^{-3}$ by the p-CVD process, which is one order of magnitude larger than the value reported so far. Based on the precise investigation of defect photochemistry in the Ge-doped silica glass by means of spectroscopy and computer simulations, it is clarified that the photosensitivity of Ge$^{2+}$ species embedded in the glass during preparation process is the origin of photoactivity such as photorefractive and induced nonlinearity.

**Photocatalysis in advanced TiO$_2$ film electrodes**

Since the discovery of water decomposition on the illuminated TiO$_2$, a large number of works on the application and fundamental aspects of photo-catalytic effect of the TiO$_2$ electrode have been reported. They are mainly related to the self-cleaning, chemical energy generation, and photovoltaic devices. In order to realize TiO$_2$-based photocatalytic devices with a visible photo-response, we are trying to apply a new concept of effective carrier separation in the space charge layer to the preparation of TiO$_2$-based film electrode by using the sol-gel process and the multi-cathode helicon sputtering method.

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**Grants (continued)**

- Development of low-melting glasses with large photorefractivity, Nippon Sheet Glass foundation, 1 April 1999 – 31 March 2002.
- Donations from three companies and four private company foundations

**Awards**

- Uchino T, Vittorio Gottardi Prize, Studies on the structure and properties of glasses, International Commission on Glass, 2 July.
- Takahashi M, Award for young scientists, Studies on the optical properties and structure of photonic glasses, Ceramics Society of Japan, 17 May.
- Niida H, A E Owen Student Poster Award First Prize, Preparation, properties and structure of organic-inorganic hybrid low-melting glasses, Society of Glass Technology, 6 July.