SS18B : International Ceramic Society Symposium

SS18B-1 | A Novel Triple-doped Bismuth Oxide for High Performance Reversible Solid Oxide Fuel Cells

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In the realm of reversible solid oxide cell (SOC) applications, singly doped-stabilized Bi_2O_3 (MSB) has emerged as a promising oxide ion conductor. It boasts superior ionic conductivity compared to conventional oxide ion conductors like doped CeO_2 and stabilized ZrO_2, particularly at reduced operating temperatures below 700°C. However, MSB's potential as an electrolyte material for SOCs has been hindered by its time-dependent conductivity degradation, particularly when the operating temperature dips below 650°C. In pursuit of addressing this challenge, our research endeavors led to the development of highly stable stabilized bismuth oxides. This achievement was made possible by the judicious substitution of Bi^{3+} with minute quantities of secondary iso/aliovalent dopants. To comprehensively assess the impact of this multi-doping strategy on enhancing ionic conductivity while mitigating kinetic degradation mechanisms, we conducted a thorough examination of the samples. This included evaluating ionic conductivity and cation diffusivity through electrochemical impedance spectroscopy and density functional theory calculations. Additionally, we delved into the chemical and structural transformations of the samples resulting from extended annealing processes. Furthermore, our innovative double-doped stabilized bismuth oxides found practical application within conventional stabilized zirconia-based SOCs. To gauge their efficacy, we systematically assessed the electrochemical performance and stability of these SOCs in both fuel cell and electrolysis cell modes. This assessment encompassed the analysis of I-V characteristics and impedance spectroscopy, offering valuable insights into the performance-enhancing attributes of our novel bismuth oxides.

SS18B-2 | A New Method to Measure the Diffusion Coefficient of Ions in Solids

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Detection of ion diffusivity in solids is of great importance in the selection of candidate electrolytes applied in energy conversion and storage systems like solid oxide fuel cells and lithium-ion batteries. Here, we present a novel and simple approach to probe the ion diffusivity in solids. In this method, an inhomogeneous distribution of the target ions in a closed system is induced via an external force (electrical field or magnetic field) applied to the specimen. Then the target ions return to a homogenous distribution state in the specimen driven by an internal thermodynamic force when the external effect is removed. The homogenization process is detected by a laser confocal micro Raman spectroscopy and recorded. Then the data of spatial and time dependence of target ion distribution is fitted to a mathematical model, thus the diffusion coefficient could be acquired accordingly. The value obtained was reasonable and acceptable when compared with conventional methods. By altering the external force and detecting means according to different materials, this approach is applicable to the measurement of ion diffusivity of different ion species.

SS18B-3 | A study on Li-M-O (where M: Si, Ti) ceramic breeder as a fuel for nuclear fusion

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Li-M-O ceramics serve as fuel for power generation using nuclear fusion reactions. Liquid Li metal or Li-Pb mixtures are also being studied as fuels for fusion. Nevertheless, the ease of handling and stability of ceramic materials have made them considered as the most promising materials for use as a fuel for nuclear fusion. Nuclear fusion fuel refers to a material that continuously produces tritium by absorbing neutrons during the operation of a nuclear fusion reactor. This material is called Tritium Breeder. Since it is exposed to the high-speed neutron irradiation environment at high temperatures, the material for the Tritium breeder must have excellent thermal conductivity and mechanical properties, as well as be chemically very stable. In addition, a small spherical shape is desirable because the generated tritium must move to the plasma region during the operation of the nuclear fusion reactor. When these conditions are satisfied, it is desirable to have a high Li content per 1 mole as much as possible, but a material with a low Li content (e.g., Ti-based) has better physical properties than a high Li content. This study is about the fabrication of a sphere for a Tritium breeder, that is, a pebble, with excellent physical properties and a high Tritium breeding ratio using a material with high Li content.

SS18B-4 | The RTIC phenomenon and the 28-years history of the AD method

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Research on fine particle collision phenomena is conducted in the fields of space science, high-pressure physics, defense, and aeronautical engineering for the purpose of shielding spacecraft against meteorites and space debris, improving the armor performance of weapon systems, and developing new materials. It has been studied for a long time for the purpose of synthesis. The shock loading or shock compression action discussed therein is the effect of a shock wave propagating through a material based on a purely mechanical process, and is different from the normal mechanical action and thermal action of the material structure. change. Therefore, it is not difficult to imagine that under certain conditions, fine particles that have collided with the substrate adhere firmly to each other, causing a kind of film formation phenomenon.
Since about 28 years ago, coating processes such as the aerosol deposition (AD) method and the cold spray (CS) method, which are thought to be purely based on impact pressure and impact force, have been attracting attention. These accelerate microparticles and ultrafine particles by carry gas to several hundred m / sec or more, make them into a jet stream and collide with the substrate, realize dense coating with good adhesion just by supplying purely mechanical energy. It is thought that fine particles of metals and ceramics are macroscopically bonded at room temperature while remaining in a nearly solid state. In fact, it has been confirmed that, in the aerosol deposition method, it is possible to form a dense ceramic thin film or a thick film having a microcrystal structure of several tens of nanometers or less at room temperature and to obtain excellent electromechanical properties. Then, in the field of semiconductor manufacturing equipment, it has been commercialized as an important coating process. This is called "Room Temperature Impact Consolidation (RTIC)". While investigating the details of this RTIC phenomenon, we discovered that ceramic materials undergo large plastic deformations like metals at room temperature and under high pressure. This is a noteworthy discovery from the viewpoint of ceramics science as well.When viewed as a powder forming process, this phenomenon is fundamentally different from a thermal spray coating and shock compaction in which raw material particles are brought into a molten or semi-molten state to obtain bonding between primary particles. In this presentation, we will first look back on the trigger (reason) for the discovery of the RTIC phenomenon and the history of AD development over the next 28 years, and then will give an overview of the recently focused applied research and issues for practical use. Moreover, the deposition mechanism of the AD process with RTIC phenomenon and the importance of this phenomenon for the future coating technology are explained.

References

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SS18B-5 | Development of Novel Interphase Coating Process for SiC_f/SiC Composites Using Electrophoretic Phenomenon

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Continuous silicon carbide fiber-reinforced silicon carbide (SiC_f/SiC) composites show pseudo-ductile fracture behavior and excellent fracture tolerance in addition to excellent mechanical and thermal properties, and they have been expected as next-generation highly reliable heat resistant materials for aerospace industries, high-temperature gas turbines and future nuclear and fusion applications. To achieve high performance SiC_f/SiC composites with excellent fracture tolerance, the interface between fiber and matrix acts as an important role for toughening and strengthening SiC_f/SiC composites, and optimally controlling the fiber/matrix interface becomes critical to promote interfacial debonding, crack deflection and fiber pullout. At present, carbon or hexagonal-boron nitride (h-BN) has been applied as the interphase between fibers and matrix for SiC_f/SiC composites, and these interphases are formed by chemical vapor deposition (CVD) or chemical vapor infiltration (CVI) method. As an alternative to the conventional interphase formation processes, our research group has proposed the novel interphase formation process on SiC fibers for SiC_f/SiC composites based on electrophoretic deposition (EPD) method, and demonstrated that EPD process was very effective to

form homogeneous interphase on SiC fibers for SiC_f/SiC composites with excellent mechanical properties.
In this symposium, our research activities regarding the interphase formation (carbon, h-BN and nanolayered ternary carbide) on SiC fibers by the process using electrophoretic phenomenon, i.e. electrophoretic deposition (EPD), will be introduced and reviewed.