SS6 : 제 4회 미국세라믹학회 한국 챕터 특별 심포지엄: 대학원생 및 박사 후 연구원

SS6-1 | A biomimetic-inspired novel alumina microfiltration membrane for the treatment of oil-in-water emulsion

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The development of efficient materials and technique for oil/water separation can help to overcome the challenge of water reuse and resource preservation. Ceramic membranes are the key reliable technology for the effective separation process in the modern world. However, membrane fouling is an inevitable phenomenon that limits the separation efficiency of ceramic membranes. Different chemical surface modification techniques have been demonstrated to overcome the challenge of membrane fouling. However, the potential influence of biomimetic approach to developing ceramic membranes for O/W separation has rarely been investigated. In this work, colloidal sol-gel method was adapted to engineer the surface structure of an alumina (Al_2O_3) microfiltration (MF) membrane in resemblance to the nepenthes pitcher plant-like microstructure. Interestingly, the oleophobicity of the novel Al_2O_3 MF membrane was highly improved leading to the low adhesion of oil droplets on the membrane surface. Membrane performance such as permeate flux, and rejection/recovery rate were also evaluated. The flux recovery ratio of the Al_2O_3 MF membrane was three folds higher compared to conventional Al_2O_3 MF membrane, after a four-cycle filtration operation. This work provides an effective route to investigate biomimetic ceramic membranes to improve the separation performance of O/W emulsions.

SS6-2 | Ternary eutectic reactions in Yb/Y-co-doped SiAlON ceramics

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Yb ions doped into SiAlON ceramics could be converted to a divalent state in a reducing atmosphere by the CO generated in a graphite heater. Regarding the relationship between color and reduction of Yb ions from Yb^{3+} to Yb^{2+} in Yb–Si–Al–O–N glass, the color of Yb-SiAlON ceramics was dependent on the intermediate phase. In particular, the devitrification of the vitrified $Yb_3Al_5O_{12}$ progressed as the Al content increased. In addition, the color of the ceramics changed from brown/yellow to blue/green. Therefore, this color is also related to the densification process, as it arises during the diffusion process of the Yb-doped transient liquid phase. Based on this background, Yb/Y-doped SiAlON ceramics are heat-treated at a temperature range of 1500-1650°C, which is the temperature range of ternary eutectic reaction for Yb_2O_3-Al_2O_3-SiO_2. Then, the relationship between color changes and ternary eutectic reactions is characterized.

SS6-3 | Tailoring barium titanate ceramic suspension for digital light processing 3D printing

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Lead-free piezoelectric ceramics, such as barium titanate ($BaTiO_3$, BTO), are promising as eco-friendly alternatives to lead-containing materials like lead zirconate titanate. Therefore, the demand for lead-free piezoelectric ceramics is widespread, as they are needed to replace lead-based piezoelectric ceramics. On the other hand, many application fields have recently placed higher requirements on complex-structured piezoelectric ceramics. Digital Light Processing (DLP), a 3D printing and additive manufacturing technology based on vat photopolymerization, can produce complex-shaped ceramic structures with high precision and relatively faster printing speed. Proper ceramic suspension should be formulated in the process of DLP for producing lead-free piezoelectric 3D-printed BTO ceramics. The suspension, which consists of BTO ceramic powders, photocurable resin, dispersants, and sometimes additives, is exposed to ultraviolet light to form ceramic green parts layer-by-layer during DLP 3D printing. Subsequent thermal processing, including de-binding and sintering, achieves high-density BTO ceramic. In this study, we controlled BTO particle sizes and selected proper additives to formulate proper BTO suspension that can minimize light scattering during the photopolymerization and further enhance the layer-by-layer adhesion of the 3D-printed structures. As a result, the 3D-printed BTO ceramics exhibit improved dielectric and ferroelectric properties, expanding possibilities for self-powered sensing, energy harvesting, and energy storage applications.

SS6-4 | 화학기상 증착으로 제조한 균일한 입자 크기를 가진 탄소 프리폼을 이용한 용융 규소 침투된 탄화규소 복합체의 제조

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Recent decades have witnessed significant technological advancements that have greatly improved the quality of life for humanity. However, the excessive use of fossil fuels has led to problems such as natural disasters and global warming, posing threats to humanity. To address this issue, research is underway to explore the use of various materials for enhancing the durability of components employed in the gas turbine and nuclear power fields. SiCf/SiC composites are being considered as an attractive alternative material due to their outstanding mechanical properties, including high specific strength, sufficient fracture toughness, enhanced thermal stability, and high corrosion resistance. Molten silicon-infiltrated SiCf/SiC composites offer advantages in terms of simplicity and cost-effectiveness compared to other processes. However, during the carbonization process of molten silicon-infiltrated SiCf/SiC composites, shrinkage and closed pores form in the carbon preform. Shrinkage and closed pore form unreacted silicon and carbon in the SiC matrix, which reduces the density of SiC_f/SiC composites and degrades mechanical properties and oxidation resistance at high temperatures. In this study, carbon particle preform having a uniform size without shrinkage in the SiC fabric were fabricated by chemical vapor deposition using acetylene gas as the raw material. The size and amount of carbon particles in the fiber preform could be controlled by adjusting the deposition conditions. The mechanical properties were improved by minimizing the unreacted silicon and carbon of molten silicon-infiltrated SiC_f/SiC composites.

SS6-5 | Thermal, electrical and mechanical properties of pressureless solid-state sintered silicon carbide ceramics prepared with different boron sources

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The influence of boron source (B, BN, and B_4C) on the thermal, electrical, and mechanical properties of pressureless solid-state sintered silicon carbide ceramics were investigated. In all specimens, a high relative density of 99.9% was achieved using appropriate additive composition and sintering under optimal conditions. The results of this study indicated that the boron source greatly influenced the properties of SiC ceramics. For the same density level of SiC ceramics sintered with B and B_4C additives, the thermal conductivity, electrical conductivity, and flexural strength are higher than those sintered with BN additives. The presence of intrinsically weak BN grains in the grain boundaries decreased the thermal and electrical conductivity of ceramics while marginally increased fracture toughness. Depending on the boron source, the thermal conductivity, electrical conductivity, and flexural strength of prepared SiC ceramics varied in the ranges of 72.4-147.5 $W \cdot m^{-1}K^{-1}$, 6.3×10^{-7}-3.1×10^{-5} $\Omega^{-1} \cdot cm^{-1}$, and 386-545 MPa, respectively.

SS6-6 | A Nonempirical Approach for Correlating Infrared Transmission Edge and Chemical Composition of Ge-Based Chalcogenide Glasses

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Optical transmission window of a conventional dielectric material is normally formed by absorptions caused by electronic bandgap transition and vibrational transition via multi-phonon processes. In the case of infrared-transmitting inorganic glasses, the longer-wavelength side transmission edge is one of the key parameters that need to be thoroughly assessed. Specifically, for use as imaging optics components in the long-wavelength infrared (LWIR; 8~12 μm) region, the cutoff wavelength of infrared transmission should be positioned at 〉12 μm, and the refractive index dispersion over the LWIR region should be verified to minimize optical aberrations of the resulting imaging lens assembly. It is not difficult to conjecture that actual measurement of those parameters of each glass specimen is costly and time-consuming. This reasoning has stimulated us to derive a nonempirical method capable of correlating those parameters and chemical composition of any given chalcogenide glasses. Mainly due to the inherent complexity in the vibrational structures, it is not a simple task to ab-initio calculate vibrational absorption spectrum of chalcogenide glasses to numerically estimate the infrared transmission edge. In an effort to devise a facile approach, we came up with that the infrared transmission edge of Ge-based sulfide and selenide glasses can be quantitatively estimated in the framework of the single average harmonic oscillator (SAHO) model. Here, chalcogenide glass is postulated to acts as a SAHO in terms of infrared transmission edge, and then its SAHO parameter expressed with a combination of the average bond energy and molar mass of a given chalcogenide glass can be nonempirically correlated with its infrared transmission edge in a quantitative manner. Since the already commercialized chalcogenide glasses are limited to lower refractive indexes and higher refractive index dispersion across the LWIR region, compositional search for better chalcogenide glasses is highly desirable. Recently, we have introduced Te-containing chalcogenide glasses in an attempt to increase refractive index and to lower its dispersion at the same time. In this presentation, we deliver optical/thermal/ mechanical properties of our telluride glasses, and interpret their infrared transmission edge in connection with the SAHO model.

SS6-7 | Ultrasonic infiltrated ceria nano-catalyst for high performing solid oxide electrochemical cells

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As a sophisticated way to enhance catalytic activity of electrodes in solid oxide electrochemical cells (SOCs), surface modification with nanoparticles has been widely studied. Nevertheless, achieving consistency and scalability of the nanoparticles remains challenging. In this study, we have developed a highly conductive Sm^{3+} and Nd^{3+} double-doped ceria decorated $La_{0.6}Sr_{0.4}Co_{0.2}Fe_{0.8}O_{3-\delta}$ -$Gd_{0.1}Ce_{0.9}O_{2-\delta}$(SNDC@LSCF-GDC), using an ultrasonic spray infiltration technique. The incorporation of uniform SNDC infiltrates has led to enhanced oxygen catalytic activity by increasing oxygen vacancies and reaction sites on the electrode's surface. The solid oxide cell (SOC) with the SNDC@LSCF-GDC oxygen electrode demonstrates high performance in both fuel cell mode (1.97 W/cm^2 at 750°C) and electrolysis cell mode (1.72 A/cm^2 at 750°C). Furthermore, we have successfully implemented the ultrasonic infiltration- based SNDC nanoparticles in a large-sized commercial cell (10cm x 10cm effective area), resulting in increased power output and remarkable stability over a period of 960 hours.

SS6-8 | Ta-Stabilized $BaCoO_{3-\delta}$ as a Highly Active Oxygen Electrodes of Reversible Protonic Ceramic Electrochemical Cells

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Protonic ceramic electrochemical cells (PCECs) are drawing significant interest due to their capacity to efficiently and reversibly converse chemical fuels into electricity at temperatures below 600°C. Unfortunately, the slow reaction kinetics at the oxygen electrode result in insufficient reaction activity and compromised cell stability. Hence, the development of a notably active oxygen electrode is essential to achieve the high performance PCECs. Recently, introducing high-valence cations (e.g, V^{5+}, Nb^{5+}, and Ta^{5+}) into the $SrCoO_{3-\delta}$ lattice has reported as a potential strategy to improve the electrocatalytic activity and stability. However, Sr-based oxygen electrodes have durability issues related to Sr segregation during PCEC operation. In response to this, $BaCoO_{3-\delta}$ based materials are gaining attention as Sr-free oxygen electrodes due to several advantages of Ba cation: low electronegativity, large ionic radius, and cost-effectiveness. Drawing inspiration from prior studies, we designed Ta-doped $BaCoO_{3-\delta}$ perovskites oxides with exceptional activity and durability for bifunctional oxygen electrodes. Through this work, we showcase the effectiveness of Ta doping in the $BaCoO_{3-\delta}$ lattice, promoting the formation of cubic perovskite structure and enhancing the electrocatalytic activity for high-performance PCECs.

SS6-9 | Highly-scaled three-dimensional ferroelectric transistor array with 10 nm gate length for next-generation computing systems

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Ferroelectric transistors based on hafnia-based ferroelectrics are promising candidates for next- generation computing-in-memory (CIM) applications due to their high scalability, fast operation speed, and low power consumption. However, in two-dimensional arrays, the area and energy efficiency of the ferroelectric transistor-based CIM are limited because different tasks should be performed at different memory elements and arrays. Here, we propose a three-dimensional (3D) ferroelectric transistor array for the area-efficient next-generation computing system. We show that ferroelectric transistors can be scaled down to a 10-nm dimension using the vertical structure. With the fabricated device, vector-matrix multiplication is successfully demonstrated, and excellent pattern recognition accuracy was achieved. Finally, we show that area-efficient computation can be achieved by allocating each array of vertical layers in a 3D ferroelectric transistor array for different tasks. This work provides a practical strategy to realize high-performance and highly efficient CIM systems by stacking computation components vertically.

SS6-10 | $NiO_x@Fe_3O_4$ Anchored on Carbon Support for Enhanced Oxygen Evolution Reaction

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Noble metal based electrocatalysts (e.g. RuO_2 and IrO_2) are widely utilized for oxygen evolution reaction (OER), however, high cost and scarcity obstruct their large-scale industrial application. Instead, inexpensive transition metal-based electrocatalysts have been attracted. But, their sluggish kinetics still remains a challenge. Herein, we report the $NiO_x@Fe_3O_4$ on carbon nanotubes (CNTs) as an efficient electrocatalyst for OER. The $NiO_x@Fe_3O_4$ core-shell structure on CNTs were simply prepared by pulsed laser ablation (PLA) in liquid media. $NiO_x@Fe_3O_4$ decorated on MWCNT's surface shows enhanced OER performance. Optimized electrocatalysts exhibit enhanced OER activity, which shows the overpotential of 286 mV at the current density of 10 mA/cm^2 and the tafel slope of 32 mV/dec. Based on the experimental results, we believe that materials strategy for the formation of heterogeneous nanostructure proposed in this study can provide a scientific basis to further improve the OER performance of the relevant electrocatalysts.

SS6-11 | 차세대 전자기기를 위한 투명 압전 PLZT 세라믹 기반의 투명 스피커 개발

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압전스피커는 기존의 전자기 유도 코일 방식의 스피커에 비해 소형화 및 높은 전력효율을 제공하여 차세대 전자기기의 주요 부품으로 개발되고 있다. 그 중에서도 투명 압전스피커는 Smart window, Transparent display와 같은 투명 장치에 가시성을 해치지 않고 적용할 수 있어 큰 관심을 받고 있다. 이전 연구에서는 Polyvinylidene fluoride(PVDF)와 같은 투명 압전 고분자 소재를 사용한 유연하고 투명한 스피커가 개발되었으나, 고분자의 낮은 압전 특성(d_{33}=15pC/N)으로 인해 고전압에서만 작동하며 출력 음압이 낮은 한계가 있었다. 본 연구에서는 높은 압전 특성(d_{33}=180pC/N)과 투과도 65% (at 550nm, ITO 전극 코팅 시)의 투명 lead lanthanum zirconate titanate (PLZT) 세라믹을 제작하고, 이를 투명 polyethylene terephthalate (PET) 진동판과 결합하여 전체적으로 투명한 스피커를 개발하였다. 제작된 PLZT 스피커는 음성주파수 범위 500 Hz – 8 kHz에서 주파수 응답특성을 측정한 결과, $10V_{peak\text{-}to\text{-}peak}$에서 30 – 68dB sound pressure level (SPL)의 우수한 출력 특성을 보였다. 또한 PLZT 스피커를 실제 노트북과 연결하여 음악을 재생하고, 모니터 화면 위에 설치하여 투명 스피커로서 차세대 디스플레이와 통합 가능성을 제시하였다.

SS6-12 | Aqueous Zn-ion battery based on AVNF cathode and Al_2O_3 coated anode with improved cycle performance

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Rechargeable aqueous zinc ion batteries (AZIBs) have gained significant attention as a promising alternative to Lithium-ion batteries due to water-based electrolytes, high energy density per volume, and cost-effectiveness. However, parasitic reactions such as hydrogen evolution reaction, corrosion, and dendrite growth in the Zn anode can result in the degradation of the electrochemical performance of AZIBs. Herein, we report the effect of ammonium vanadate nanofiber (AVNF) cathode and Al_2O_3-coated Zn anode on enhanced cycle performance of the AZIBs. The optimized AVNF//Al_2O_3@Zn batteries showed ultra-high cycle stability with a capacity retention of 94 % even after 5000 cycles at a current density of 10 A g^{-1}. This work gives a scientific and technical understanding of developed cathode and anode materials for enhanced battery performance in AZIBs.

SS6-13 | Site Occupancy Effect on Electromechanical Properties of Lead-free BF-BT Ceramics

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$BiFeO_3$-$BaTiO_3$ (BF-BT) is a promising candidate in lead-free ceramics with high electromechanical properties and high Curie temperature (T_c). In this study, the static piezoelectric constant (d_{33}) and dynamic piezoelectric coefficient (d^*_{33}) of 1- x ($BiFeO_3$)- x($BaTiO_3$) with x= 0.33, 0.34 and 0.35 were studied at room temperature. To determine the impact of Ba and Ti substitution on crystal structure and electromechanical properties of BF-BT ceramics, all the compositions under study were synthesized through conventional solid state reaction method with air quenching process. XRD patterns revealed a single phase perovskite structure with an MPB (morphotropic phase boundary) between Rhombohedral

and tetragonal phases. All the compositions had high relative density (>95%) and the average grain size decreased as the BT concentration increased. The highest d_{33}(192 pC/N) was attained at BF-0.33BT, and negative strain decreased with BT contents, which may be due to softening effect of BF-BT ceramics. Maximum unipolar strain of (0.20%) with corresponding dynamic piezoelectric coefficients (d^*_{33} = 406 pm/V) was achieved at BF-0.35BT under an applied electric field of 5.0 kV/mm. In order to further enhance the piezoelectric properties via composition engineering, our study demonstrated the link between chemical composition and piezoelectric properties. Keywords: BF-BT, MPB, Piezoelectrics, site occupancy, chemical tuning
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SS6-14 | Effective surface passivation of photocatalytic TiO_2 via improved TiO_2-SiO_2 core-shell structure

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The widespread utilization of TiO_2 in various industries is hindered by its intrinsic photocatalytic activity. Conventionally, researchers have sought to mitigate this limitation by creating core-shell structures with a silica layer encapsulating the TiO_2 core. In this study, we propose a novel approach using perhydropolysilazane (PHPS) as an inorganic silica precursor to coat TiO_2, capitalizing on its inherent photocatalytic activity. This technique enables the fabrication of thinner and denser silica shells, offering superior surface passivation compared to the commonly employed tetraethylorthosilicate (TEOS) precursor. Comprehensive photocatalytic evaluations reveal that PHPS-coated TiO_2@SiO_2 core-shell particles and thin films exhibit exceptional control over TiO_2 photocatalytic activity. Furthermore, these structures maintain high whiteness and refractive index, suggesting their potential in applications requiring TiO_2's high refractance properties, such as white paint production and cosmetics. This study demonstrates the effectiveness of PHPS as a silica precursor, providing a straightforward method to create a thin SiO_2 shell over the TiO_2 core while achieving superior surface passivation and suppressed photocatalytic activity, positioning PHPS-coated TiO_2@SiO_2 core-shell as a promising alternative to conventional TiO_2@SiO_2 structures.

SS6-15 | Epitaxial Piezoelectric Thin Film for Finger Vein Recognition

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Finger vein recognition is considered a highly secure biometric authentication method due to its reliance on a unique pattern that is difficult to acquire and replicate. To implement finger vein recognition, particularly in portable devices like smartphones, we used piezoelectric ultrasonic transducers (PMUTs) utilizing MEMS technology. In order to ensure effective ultrasonic sensing without the need for gel-based impedance matching, high output intensity and thermal stability was required. This was achieved by selecting PMN-PZT, a type of relaxor-ferroelectric material renowned for its exceptional piezoelectric properties and stable thermal performance, as the piezoelectric layer and growing it epitaxially. In the fabrication process, we deposited epitaxial LSMO/CeO_2/YSZ layers to function as buffer films on an SOI substrate using pulsed laser deposition (PLD). Epitaxial growth of PMN-PZT was achieved through RF-magnetron sputtering. Both x-ray phi scan analysis and transmission electron microscopy (TEM) confirmed the successful hetero-epitaxial growth of deposited films. To determine the output pressure of the PMUT array, we conducted pulse-echo measurements by using hydrophone. Fingerprint and finger vein images were obtained with the assistance of beam foaming and color doppler imaging techniques.

SS6-16 | Investigating the Oxidation Behavior of 2H-$MoTe_2$ at the Atomic Level

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Defects during 2D TMD crystal growth lead to oxidation upon exposure to air and harsh conditions. Understanding this is crucial for electronics, optoelectronics, and catalysis. Notably, 2H-$MoTe_2$, a 2D semiconductor, has the potential for controlled p- to n-type conversion due to heightened air susceptibility. Despite macroscopic research, atomic-level oxidation is unclear. Our study explores 2H-$MoTe_2$ oxidation across environments.

Exposing it to air for 17 months caused hexagonal/ triangular etching from defects and gradual MoO_2 hillock formation. Monitoring oxidation showed the impact of active species and substrate. Under O_2, MoO_2 formed on 2H-$MoTe_2$ surface, while H_2O preserved most but induced basal plane defect etching. Theoretical computations explored defective 2H-$MoTe_2$ surface reactions with O_2 and H_2O, yielding volatile TeO_2 and H_2Te, creating Te vacancies in the basal plane. O_2 favored Te vacancy via preferred dissociation over H_2O. Dominant Te vacancy formation involved H reactions. During TeO_2 volatilization, extra O atoms hindered lattice reconstruction, increasing the kinetic barrier. TEM aligned with oxide film formation in O_2. Our findings deepen atomic-level 2H-$MoTe_2$ oxidation insights, inspiring enhanced TMD-based 2D device durability.

SS6-17 | Non-$BaTiO_3$ 유전체 세라믹에서의 열적 안정성 및 신뢰성 향상을 위한 전략

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The increasing demand for high-end automotive multilayer ceramic capacitors (MLCCs) has prompted the electronics industry to seek out high-temperature dielectrics that surpass the capabilities of the extant MLCC 'X8R', which maintains dielectric permittivity within 15% between -55°C and 150°C. Despite the fact that $BaTiO_3$ (BT) has been the MLCC base material due to its capacity, tunability, and compatibility, its Curie temperature (T_c) of approximately 120°C restricts its use in high-temperature applications. $Bi_{1/2}Na_{1/2}TiO_3$ (BNT) (T_m: 330°C), $Bi_{0.5}K_{0.5}TiO_3$ (BKT) (T_m: 380°C), and $K_{0.5}Na_{0.5}NbO_3$ (KNN) (T_c: 400°C) are non-BT systems with higher Curie temperatures. Defect chemistry and the formation of ternary systems have improved their temperature stability. However, alternative X9R-dielectric compositions are dominated by complex ternary systems, posing management and reproducibility challenges. This research seeks to develop uncomplicated X9R-dielectric compositions with enhanced temperature stability, minimal dielectric loss (tan $<$ 0.03), and high breakdown voltage. Recently, we developed a promising composition in BNT systems possessing enhanced properties and having potential as an MLCC material for automotive applications. The specific strategy for enhancing thermal stability and reliability in the BNT-based dielectrics will be dealt with.

SS6-18 | Overcoming Scattering Issues in 3D Ceramic Printing Technology through a Novel Flashing Technique

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Digital light processing (DLP) is a commonly used 3D printing technique for fabricating ceramic structures layer by layer by using ultraviolet (UV) light to cure the photopolymerizable slurry containing ceramic powder. The DLP technique along with its several processing benefits has a common problem of excessive curing (overcuring) arising due to the scattering of light when it strikes the ceramic particles in the solution. The overcuring deteriorates the mechanical characteristics as well as aesthetical features of the printed part. This study addressed scattering issue with novelty where photopolymerizable slurry of zirconia and titania was not cured at once for a certain exposure time but the UV light was supplied in multiple flashes instead to cure the slurry. The flashing technique proved to be an effective alternative to conventional DLP printing to achieve high shape fidelity as well as structural integrity necessary for aesthetical and mechanical prospects of the printed parts

SS6-19 | Suppressing depolarization at the phase transformation in PMN-PT single crystals via high-temperature alternating current poling

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Among relaxor ferroelectric materials, PMN-PT single crystals stand out for their exceptional performance. However, their application in high-temperature environments is hindered by depolarization during the rhombohedral to tetragonal phase transformation (T_{rt}). In this study, we employed Alternating Current Poling at High Temperature (ACP(HT)) on (001)-oriented PMN-29PT single crystals, suppressing depolarization compared to ACP at ambient temperature (ACP(AT)). At AT, both ACP(AT) and ACP(HT) single crystals exhibited piezoelectric charge coefficients (d_{33}) of 1800 pC/N and 1675 pC/N, respectively. After annealing at 120 °C above T_{rt} (93 °C), the d_{33} values for ACP(RT) and ACP(HT) were measured at 278 pC/N and 1526 pC/N, respectively. Following thermal cycling, the d_{33} of ACP(HT) slightly dropped to 1450 pC/N. In-situ X-ray diffraction and Raman spectroscopy analyses confirmed that structural changes in ACP(HT) single crystals occur at a local or short-range scale, indicating that the phase transformation at T_{rt} induces minimal disruption to domain orientation and subsequent depolarization.

SS6-20 | DLP 3D 프린팅을 이용한 유연 $BaTiO_3$ 복합체 정전용량식 압력 센서 제작 및 특성 평가

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Barium Titanate ($BaTiO_3$, BTO) is a lead-free ferroelectric ceramic material known for its high dielectric and piezoelectric properties, and has been applied in various fields such as multilayer ceramic capacitors, ferroelectric memories, piezoelectric sensors, actuators, and energy harvesters. On the other hand, with the increasing need for devices with complex shaped structures, additive manufacturing (AM) has recently attracted attention. Digital light processing (DLP) 3D printing is one of the vat photopolymerization- based AM technologies, capable of producing high-precision and complex ceramic and ceramic composite structures. In the ceramic DLP process, suspension containing ceramic powder, photocurable resin, dispersant, and photoinitiator are exposed to ultraviolet light of a specific wavelength, and ceramic green parts, which is ceramic composites, are manufactured using a layer-by-layer photocuring process. Flexible pressure sensors are pressure sensors that can be altered based on pressure sensitive materials such as dielectrics (e.g. BTO) and have been researched for various applications such as artificial skin and smart healthcare. The application of flexible and biocompatible materials is essential for wearable devices. High sensitivity of the pressure sensor is required to enable monitoring of external reactions and small movements. To improve the sensitivity of capacitive flexible pressure sensors, it is advantageous to use an insulating layer with a high dielectric constant, and the amount of thickness variation with pressure determines the sensitivity. In this study, we fabricated and compared various structures of flexible capacitive sensors using DLP 3D printing process to achieve high sensitivity in a limited volume. First, rheological and photocuring properties of BTO suspensions consisting of BTO nanoparticles and photocurable resin were thoroughly investigated and used to fabricate 3D printed BTO composite flexible capacitors. Carbon nanotubes (CNTs) were also introduced as conductive fillers to increase the effective dielectric properties of capacitive pressure sensors. With the optimal suspension conditions, we fabricated various structured flexible capacitive sensors and compared their sensing performance. Finite element method was also performed to analyze the pressure distribution depending on the structures. The results suggest the promising possibility of complex shaped flexible pressure sensors fabricated via DLP 3D printing for various future applications.

SS6-21 | Improving Catalytic Activity and Stability of Ir using a High-Entropy Alloy Platform for Hydrogen Evolution Reaction in Acidic Medium

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In the pursuit of efficient electrocatalysts for the hydrogen evolution reaction (HER) in proton-exchange membrane water electrolysis conditions, noble metals, such as Ir, are commonly utilized as catalysts due to moderate corrosion resistance and activity towards HER in acidic medium. Nevertheless, the scarcity and high costs of noble metals have led researchers to focus on developing catalysts which reduce the use of noble metals while increasing catalytic activity and stability. Herein, we present FeCoNiCuIr catalysts engineered using a high-entropy platform to enhance both activity and stability. Characterized by a unique single-phase and homogeneously distributed atomic structure, high-entropy alloy (HEA) demonstrates enhanced corrosion resistance compared to Ir mono-element catalyst. Also, the electronic structure of Ir was modified by introducing transition metals (TMs) to optimize the hydrogen binding energy through charge transfer from TM to Ir. This research presents a design principle for HEA catalysts which enhances both activity and durability simultaneously.

SS6-22 | Enhancing thermal properties through the synthesis of high-entropy stabilized $A_2Zr_2O_7$ structures

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Thermal barrier coatings (TBCs) are systems designed to protect components of gas turbines or aviation engines operating at temperatures exceeding 1200 °C. Ceramic materials with low thermal conductivity and exceptional thermal durability have traditionally been utilized as TBC materials. However, there is a growing demand for thermal insulating materials capable of withstanding even higher operating temperatures above 1200 °C to enhance thermal conversion efficiency. This study proposes the promising characteristics of high-entropy zirconate ceramics, which offer superior thermal insulating performance as a next-generation TBC material. High-entropy oxides (HEOs) of $A_2Zr_2O_7$ zirconate were synthesized by incorporating five cations with similar ionic radii into the A^{3+} cation site. High-entropy materials can lead to lattice distortion and increased lattice scattering, ultimately resulting in a reduction in thermal conductivity. The HEOs material exhibits enhanced thermal barrier performance compared to conventional YSZ, suggesting its potential as a next-generation TBC material.