G1A : 전자 세라믹스

G1A-2 | New Coating Method with the Cationic Particles via Powder Aerosol Deposition Technique

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Aerosol deposition is a technique for creating films by spraying powdered materials in a gas onto a substrate under a vacuum atmosphere. When this technique is applied to ferroelectric ceramic materials, forming small domains of dipole materials into films and multiple-phase coexistence is possible. Therefore, it has attracted attention as the next-generation technology for developing dielectrics with high energy density, such as relaxor-ferroelectric.

Although this technology has many advantages, it is difficult to clearly determine the experimental variables due to the low reliability of the experimental results, and the thickness of the fabricated film is several ㎛, which limits the production of dielectrics with high energy density. In this study, we focused on the process of particle collision with the substrate during the aerosol deposition process. The ceramic particles collating with the substrate in the first collision were found to become positively charged ions. Then a second collision is performed by applying a bias to produce a film. The resulting film has the advantage of forming nanodomains, which is an advantage of AD, but the film can be made thin enough to produce a dielectric with high energy density.

G1A-3 | 보안 통신을 위한 히터가 포함된 빠르고 에너지 효율적인 모트 물질 기반 진성난수발생기 어레이

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A true random number generator (TRNG) generates true random numbers (TRN) by exploiting stochastic phenomena inherent in natural processes, and is being widely used for secure communications and data protection. In the Internet of Things (IoT) era, which is characterized by massive data traffic, a faster and more energy-efficient TRNG is constantly needed. Here, we propose an advanced TRNG incorporating a Mott oscillator as a thermal fluctuation-mediated physical randomness source and a resistive heater as a thermal fluctuation amplifier, enabling it to achieve a TRN generation speed of 100 kbit/s, which is the fastest record over memristive TRNGs. Further, we have successfully integrated a TRNG array for large-scale parallel TRN generation. The TRNG system achieved massive TRN generation feasible by an energy consumption of 0.648 μJ/bit, which is a remarkable achievement over memristive TRNGs.

G1A-4 | Self-rectifying and self-powered ReRAM memristor fabricated using crystalline $NaNbO_3$ film grown on $Sr_2Nb_3O_{10}$ nanosheet at low temperature

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Crystalline $NaNbO_3$ (NN) thin films were deposited on a $Sr_2Nb_3O_{10}$/TiN/SiO_2/Si substrate at 300°C and the $Sr_2Nb_3O_{10}$ (SNO) nanosheets was used as a template to form the crystalline NN films at low temperatures. The NN film grown on one SNO monolayer displayed the bipolar switching curve that is attributed to the construction and destroy of the oxygen vacancy filaments. Additionally, the NN memristor with one SNO monolayer exhibited artificial synaptic properties. However, the NN memristor deposited on two SNO monolayers exhibited self-rectifying bipolar switching properties and two SNO monolayers behaved as a tunneling barrier in the memristor. This memristor showed the large rectification and the ON/OFF ratios of 48 and 15.7, respectively. The tunneling is the current conduction mechanism of this device in low resistance state and the Schottky emission and tunneling are responsible for the conduction mechanism in high resistance state at low and high voltages, respectively. The piezoelectric nanogenerator was produced using crystalline NN film and it generated a large voltage (1.8V) and power (3.2μW). Furthermore, the endurance property of ReRAM and the nonlinear transmission characteristic of the biological synapse were accomplished in the NN memristor powered by the NN nanogenerator. Therefore, the [001]-oriented crystalline NN film formed at 300 °C is able to be utilized for the self-rectifying and self-powered artificial synapse.

G1A-5 | Investigation of Factors Influencing Microwave Dielectric Properties of $(1-x)(MgZr_{0.05}T_{0.95})O_3$-$xSrTiO_3$ Ceramics: The Role of Sintering Conditions and Additives

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In this study, the effects of sintering conditions and additives on the microwave dielectric performance and microstructures of $(1-x)Mg(Zr_{0.05}Ti_{0.95})O_3$–$xSTiO_3$((1-x)

MZT−xST) ceramics for 5G RF filter applications were investigated. Ceramics were synthesized and sintered at various sintering temperatures (T_S) for different equilibrium sintering dwell times (t_d) with and without sintering additives using a solid-state reaction. The phases and microstructures were analyzed using X-ray diffraction and SEM. Increasing t_d and adding 1.5 wt. % ZnO sintering aid significantly enhanced the dielectric performance of MZT−0.04ST ceramics. The addition of ZnO substantially lowered t_d and T_S, activating optimum conditions, and achieving temperature-stable microwave dielectrics (NP0); a lower T_S ~1280 °C and reduced t_d (~8 h), demonstrated improved microwave dielectric properties: ε_r ~20.16, Q_f of ~81377 GHz (at 7.86 GHz), and close to zero τ_f (~0.12 ppm/°C). The enhanced performance can be attributed to improved relative density, homogenous grain size, optimum phase fraction, and chemical ordering.

Keywords: (1-x)$Mg(Zr_{0.05}Ti_{0.95})O_3$−x$SrTiO_3$, Microwave dielectric, Sintering aid, Equilibrium sintering, Quality factor

G1A-6 | 고성능 전기화학적 산소 발생 반응을 위한 전이 금속 기반 층상 이중 수산화물의 국소 물리화학적 특성 연구

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물을 전기분해하여 수소와 산소를 생산하는 반응의 병목 현상인 산소 발생 반응(OER)을 위해 Ir 과 Ru 기반의 촉매를 많이 사용하고 있다. 하지만 이들의 희박한 매장량과 높은 가격으로 인해 전이금속 기반의 층상 이중 수산화물 기반의 촉매들(TM-LDHs)이 대체제로써 상당한 관심을 얻고 있다. 그럼에도 불구하고, OER 반응동안 TM-LDH의 구조적 전기적 특성에 관한 이해는 여전히 부족한 실정이다. 따라서 본 연구진들은 in-situ X-ray absorption fine structure(XAFS) 분석과 density functional theory(DFT) 계산을 이용해 TM-LDHs를 연구했다. 전기화학 실험을 통해 NiFe-LDH가 동일한 양의 NiCo-LDH와 Ni-LDH에 비해 가장 낮은 과전압에서 OER을 개시하며, 매우 높은 OER 활성 및 수명 특성을 가진다는 것을 확인했다. 이러한 성능을 뒷받침하기 위해 추가적인 실험을 진행했다. In-situ XAFS 분석을 통해 OER 도중 TM-LDH들의 국부구조 거동을 밝혀내어 NiFe-LDH가 높은 OER 활성과 수명 특성을 가지는 이유를 제시했다. 또한, DFT 계산을 통해 Ni-LDH와 NiCo-LDH는 basal planes 이 촉매 활성 자리인 반면, NiFe-LDH는 edge planes이 촉매 활성 자리라는 결과가 NiFe-LDH가 OER시 가장 낮은 과전압을 가지는 이유와 관련이 있음을 입증했다. 그러므로 이러한 연구의 결과는 다양한 TM-LDHs의 촉매 활성 자리를 정확히 찾아내고, TM-LDH 촉매의 OER 성능을 최적화하기 위한 전략을 제시하고 있다.

G1A-7 | 나노멤브레인 구조 조절을 통한 마이크로 LED의 새로운 성장 및 기계적 분리-전사 기술

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Building on the burgeoning demand for next-generation display technologies like augmented reality (AR), virtual reality (VR), and head-up displays, micro light-emitting diodes (micro-LEDs) are increasingly recognized as a compelling alternative to traditional LCD and OLED screens. This paper focuses on overcoming the inherent limitations of current micro-LED fabrication and transfer techniques by introducing an innovative approach that utilizes widened sapphire nanomembranes (SNMs) for both the growth and mechanical lift-off transfer of micro-LEDs.

Traditional chip singulation methods, such as plasma etching, are increasingly unsuitable for micro-LEDs due to a host of issues including kerf loss, wafer consumption, and reduced quantum efficiency. Notably, conventional laser lift-off based pick and place transfer methods present challenges, especially in their scalability and potential to damage the GaN layer during the transfer process. In contrast, our work eliminates the need for dry etching by leveraging engineered sapphire nanomembranes as a substrate for micro-LED growth. By widening the SNMs, we've been able to introduce tensile strain, enhancing the mechanical strength of the substrate and mitigating dislocation densities.

Prior to this, our group employed 2-μm-wide SNMs as growth templates. While these narrower SNMs already exhibited low dislocation density, their limited width necessitated the merging of multiple SNMs for larger micro-LED arrays. Our widened, tensile-strained SNMs allow each micro-LED to be grown and mechanically lifted-off from a single, standalone SNM, eliminating the need for merging and further enhancing the system's scalability and efficiency. Structural simulations confirm the advantage of applying tensile strain, showing our SNMs can endure a more extensive range of mechanical forces without harming the GaN layers.

By obviating the need for chip singulation and etching, and addressing the transfer-induced damage and efficiency issues, our widened and tensile-strained SNMs lay the foundation for efficient and scalable micro-LED technology. This work significantly propels the manufacturing and integration potential of micro-LEDs, setting a new benchmark for their application in next-generation high-performance displays.

G1A-8 | 고전력 압전 디바이스로의 응용을 위한 PMS-PZT 압전 세라믹 내 Fe_2O_3도핑 효과

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High-power piezoceramics have been used in various piezoelectric devices. Since a large amount of heat is usually produced from the high-power devices, the piezoceramics used in these devices should have a high Q_m. Furthermore, these high-power piezoceramics need to have a high k_p value because they should change electrical energy to mechanical energy effectively. In this study, $0.05(Pb_{0.98}Sr_{0.02})(Mn_{1/3}Sb_{2/3})O_3$-$0.95(Pb_{0.98}Sr_{0.02})(Zr_{0.48}Ti_{0.47})O_3$ (PMS-PZT) + 0.25 wt% CeO_2 + 0.5 wt% Yb_2O_3 + x wt% Fe_2O_3 piezoceramics were investigated for the application to the high-power devices and the effects of Fe_2O_3 doping on the structural and piezoelectric of the PMS-PZT piezoceramics were systematically studied. Fe_2O_3-added PMS-PZT ceramics were well sintered at 1150 °C for 2 h with a dense microstructure. When the amount of Fe_2O_3 is less than 0.02 wt%, the Q_m value of the PMS-PZT piezoceramic has been improved but it reduced when the amount of Fe_2O_3 exceeded 0.02 wt%, although the k_p value enhanced. As a result, the PMS-PZT piezoceramic with 0.02 wt% of Fe_2O_3 provided the optimized properties of a high Q_m of 1515 and k_p of 0.6 with high T_c of 318 °C. Therefore, the PMS-PZT piezoceramics with 0.02 wt% of Fe_2O_3 is considered to be a good candidate for high-power piezoelectric devices.

G1A-9 | The effect of atmosphere on single crystal growth of $0.685(Na_{0.5}Bi_{0.5})TiO_3$-$0.065BaTiO_3$-$0.25SrTiO_3$ using solid state single crystal growth.

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$(Na_{0.5}Bi_{0.5})TiO_3$-based electroceramics are of interest as a lead-free replacement for $Pb(Mg_{1/3}Nb_{2/3})O_3$ electrostrictive materials for actuator applications. It is expected that their properties can be improved further by using single crystals. In this work, the growth of single crystals of $0.685(Na_{0.5}Bi_{0.5})TiO_3$-$0.065BaTiO_3$-$0.25SrTiO_3$ using the solid-state single crystal growth technique is studied. Ceramic powder is prepared by the mixed oxide method. Seed crystals of $SrTiO_3$ are buried in the powder, pressed into pellets and sintered at temperatures between 1100°C to 1250°C for 1,3,5,10,20 and 30h in air and oxygen atmospheres. Single crystals of $0.685(Na_{0.5}Bi_{0.5})TiO_3$-$0.065BaTiO_3$-$0.25SrTiO_3$ grow onto the seed crystals. Single crystal microstructure was studied by scanning electron microscopy. The effect of different pre-sintering temperatures on crystal growth was also studied. To understand the effect of sintering temperature better, sintering studies were carried out on ceramic samples in air and oxygen atmospheres. The effect of sintering temperature, time and atmosphere on densification and grain growth behaviour was studied.

G1A-10 | Thermal-Evaporated Perovskite Light-Emitting Diode with MoS_2-Based Thin-Film Transistors for Display Applications

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Recently, many researchers have emerged in the application of halide perovskites because of their superior optical properties and electrical properties. Those properties ease to apply perovskites to diverse devices such as light-emitting diodes (LEDs), solar cells. However, the solution process that is disadvantageous to commercialize and integrate with thin-film transistors (TFTs) is essential to fabricate superior perovskite films. On the other hand, the properties of thermal evaporated perovskite LED (PeLED) have been inferior compared with solution-processed PeLED, but the uniform thickness can be achieved by thermal evaporation over large-area. In this study, we synthesized solid-state halide perovskite for fabricating PeLED by single-source thermal evaporation and integrate PeLED with TFT based on MoS_2 for fabricating an active-matrix PeLED display with an 8 × 8 array, which exhibits excellent brightness control capability and high switching speeds. This study demonstrates the probability of PeLEDs as candidates for next-generation displays.

G1A-11 | Highly Flexible and Stretchable Graphene Grown Directly at 100ºC

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The direct synthesis of large-area, defect-free graphene on flexible substrates is a critical technology for the development of soft electronic devices. In this study, we employ in situ plasma-assisted thermal chemical vapor deposition (PATCVD) to synthesize high-quality graphene with a 4-inch diameter directly on 10 nm Ti-buffered substrates at 100°C. The monolayer graphene exhibits exceptional stretchability and flexibility with low sheet resistance. Further enhancements in both

mechanical and electrical performance are achieved by in situ multi-stacking of graphene layers. The resulting 4-layered graphene multi-stack consistently maintains an ultralow resistance of approximately 6 Ω/sq, even under the conditions of harsh repeated stretching tests. This remarkable performance is attributed to self-doping effects under ambient conditions. Graphene-based field-effect transistors, fabricated on polydimethylsiloxane (PDMS) substrates, demonstrate an unprecedented hole mobility of approximately 21,000 cm^2/Vs at a gate voltage of -4V. Remarkably, this exceptional hole mobility is maintained consistently, regardless of the channel length, even during 5,000 cycles of repeated stretching at a 140% parallel strain.

G1A-12 | Optimized piezoelectric properties of [001]-textured (Na, K)NbO_3-based piezoceramics for piezoelectric energy harvesters

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The output power of piezoelectric energy harvesters is influenced by the k_p and $d_{33} \times g_{33}$ of the piezoceramics at resonance and off-resonance frequencies, respectively. The $0.96(Na_{0.5}K_{0.5})(Nb_{1-x}Sb_x)O_3$-$0.01CaZrO_3$-$0.03(Bi_{0.5}Ag_{0.5})ZrO_3$ [$NK(N_{1-x}S_x)$-CZ-BAZ] ceramics exhibited a low k_p and $d_{33} \times g_{33}$ owing to its small d_{33} and large $\varepsilon^T_{33}/\varepsilon_0$. The [001]-textured x = 0.01 composition exhibited an enhanced k_p (0.73) and $d_{33} \times g_{33}$ (32.2×10^{-12} m^2/N) owing to the increased d_{33} and decreased $\varepsilon^T_{33}/\varepsilon_0$. The domain of the textured $NK(N_{1-x}S_x)$-CZ-BAZ changed from microdomains to nanodomains and polar nanoregions with an increasing x, and the altered domain structure affected the piezoelectric properties of the samples. The harvester fabricated using the [001]-textured x = 0.01 composition exhibited a high power (2.7 mW) and a large power density (6.72 mW/cm^3), which is similar to the largest power density obtained from harvesters fabricated using (Na, K)NbO_3 (NKN)-related ceramics. Therefore, the [001]-textured $NK(N_{0.99}S_{0.01})$-CZ-BAZ is a promising material for application in harvesters, and the [001] texturing technique proves to be an efficient method for developing piezoceramics related to NKN, suitable for use in harvesters.

G1A-13 | 도너 이온 첨가를 통한 압전 세라믹의 조성 설계 개발 연구

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압전 소재는 압전 특성을 활용하는 압전 센서, 압전 스피커 등 다양한 분야에서 사용되고 있다. 압전 소재 중 $Pb(Zr,Ti)O_3$ (PZT) 계열 소재는 높은 압전 특성으로 가장 널리 사용되고 있다. 하지만, 환경 오염 물질인 Pb가 함유되어 있어 Pb-free 압전 소재 개발 연구의 필요성이 제기되면서 현재 다양한 연구가 진행되고 있다. 최근 Pb-free 압전 소재 중에서 $(K,Na)NbO_3$ (KNN) 계열 소재는 높은 압전 특성을 나타냄으로써 차세대 친환경 압전 소재로 주목 받고 있다. 본 발표에서는 KNN 계열 소재에 도너 이온을 첨가함으로 나타나는 미세구조 변화와 일반 세라믹스 공정으로 cm 급 크기의 단결정을 성장시키는 연구를 소개하고자 한다. 비정상 입성장을 유도시킨 조성은 간단한 방법으로 단결정 seed 제조 또한 가능하다. KNN 계열 소재에서 나타나는 독특한 특성을 활용하여 미래시장에 대응할 수 있을 것이라 기대한다.

G1A-14 | Structural, Optical, and Magnetic properties of Er doped Yttrium Iron garnet

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$Y_{3-x}Er_xFe_5O_{12}$ garnet samples with $0.0 \leq x \leq 3.0$ were fabricated using traditional solid-state reaction technique. All the samples have a homogeneous cubic phase with I a -3 d space group, and the lattice parameters of the samples slightly decreased with enhancement of x owing to smaller ionic radius of Er^{3+}. The reflection of Er doped $Y_3Fe_5O_{12}$ (YIG) samples at the wavelength of 1450 ~ 1650 nm decreased with more amount of Er^{3+}. Furthermore, the $Y_{3-x}Er_xFe_5O_{12}$ samples showed decrease at certain temperature with addition of Er^{3+}, and this temperature increased with the increase of x. Therefore, the optimum optical and magnetic properties of the $Y_{3-x}Er_xFe_5O_{12}$ samples for the magneto-optical devices can be obtained through the control of Er^{3+} content, indicating that the $Y_{3-x}Er_xFe_5O_{12}$ samples are good potential candidates for the magneto-optical applications.