G1B : 전자 세라믹스

G1B-1 | 다층세라믹콘덴서(MLCC)의 DC-bias aging 현상과 포화용량 예측방안

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Aging in dielectrics is the decrease of their capacitance as a history of applied electric field. In this work, we revisit the mechanism of aging phenomena in ceramic capacitors which are Multi-Layer Ceramic Capacitors (MLCCs) in the respect of DC-bias voltage, temperatures and it is shown that aging phenomena can be accelerated via DC-bias voltages (electric field strength) and increase of temperatures. From the results of a poling-depoling ・experiment, it is confirmed that the saturation capacitance can be evaluated within a short time. Consequently, we proposed the simple method by electric field manipulation to evaluate the saturated capacitance of MLCCs quantitatively under the aging condition. The estimated capacitance correspond to measured capacitance after 2,000hr within error rate of 4%.

G1B-2 | Development of continuous thickness measurement system for the HTS CCs

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To ensure the high-temperature superconducting (HTS) magnet aligns with its intended design, it is crucial to accurately verify the thickness of the HTS CCs before incorporating it into the magnets. However, despite the growing significance of this measurement, there is currently no device capable of measuring this thickness continuously. Furthermore, the HTS CCs employed in HTS applications often exhibit non-uniform thickness, not only along their length but also across their width. Hence, it is imperative to develop a continuous measuring apparatus that can precisely ascertain both the thickness and shape of long-length HTS CCs. This study presents a development in the field of continuous thickness measurement technology for HTS CCs. A reel-to-reel transfer device is combined with a confocal laser sensor to measure continuously thickness during transferring long HTS CCs. The results will be presented for the discussion including (1) the applicable measurement method, (2) the system's design, and (3) the specifications related to the measurement process.

Keywords: HTS CCs, Thickness measurement system, Reel-to-reel, Confocal laser sensor Acknowledgement: This research was supported by National R&D Program through the National Research Foundation of Korea(NRF) funded by Ministry of Science and ICT (2022M3I9A1076881)

G1B-4 |Effect of crystal structure on the piezoelectricity of [001]-textured PZT- PNN ceramics

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The $(0.53-x)PbZrO_3-xPbTiO_3-0.47Pb(Ni_{1/3}Nb_{2/3})O_3$ (PZ-PT-PNN) ($0.29 \leq x \leq 0.38$) piezoelectric ceramics were prepared by conventional solid-state reaction method. The CuO has been used to reduce the sintering temperature of the Pb-based ceramics through the generation of the liquid phase and they can be densified at 950 ℃. The 1.0 mol% CuO-added PZ-PT-PNN ceramic with a rhombohedral structure exhibited the d_{33}, k_p and $\varepsilon^T_{33}/\varepsilon_0$ values of 370 pC/N, 0.49 and 1884, respectively. Furthermore, the 1.0 mol% CuO-added PZ-PT-PNN thick film was textured along the [001] direction using $BaTiO_3$ (BT) templates to improve its piezoelectric properties. The [001]-textured 1.0 mol% CuO-added PZ-PT-PNN + y vol% BT thick film ($1.0 \leq y \leq 5.0$) was well textured along the [001] direction with a high Lotgering factor (≥ 90 %). Moreover, the textured sample ($y = 3.0$) showed the increased d_{33} and k_p values of 920 pC/N and 0.65, respectively, indicating that they are promising materials for the piezoelectric devices such as piezoelectric speakers and actuators. Finally, the relation between the piezoelectric properties and crystal structure of the [001]-textured samples have been also discussed.

G1B-5 | 마이크로파 유도가열 기반 MLCC 1분 초고속 동시소성의 복합물리 시뮬레이션 연구

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마이크로파 유도가열 기술에 의한 MLCC(multi-layer ceramic capacitor)의 초고속 동시소성 과정과 이를 3차원 복합물리 모델링으로 시뮬레이션 한 연구에 대해 발표하고자 한다. 전도성 박막을 비접촉 방식으로 가열할 수 있는 마이크로파 유도가열 기술에 의해 저진공 산화 분위기에서 1분 이내에 MLCC 소성을 완료하였으며, 용량 및 dissipation factor, 절연저항, 전극 연결도 등의 성능 또한 크게 개선하여 고품질의 MLCC를 얻을 수 있었다. 마이크로파 유도가열에 의한 균일하고 빠른 MLCC 동시소성을 연구하기 위해 마이크로파 대역의 자기장 속의 MLCC를 모델링하고 전자기장 및 열 해석 시뮬레이션을 수행하였다. 균일한 자기장 내에서 니켈 전극층에 의한 자기장 벡터 분포 변화 및 유도 전류량 계산으로 MLCC를 균일하게 가열할 수 있는 메커니즘을 구현할 수 있었으며, 열의 전도 및 대류, 방사 해석을

통하여 시간에 따른 MLCC와 가열용기의 온도 분포, 전도 및 방사에 의한 열 손실 비율을 확인할 수 있었다. 또한 MLCC 표면을 경계로 하는 입력 및 손실 에너지 변화를 기반으로 가열에 필요한 에너지를 분석하여 가열효율을 높이기 위한 연구를 수행하였다.

G1B-6 | Two-terminal Lithium-mediated Artificial Synapses with Enhanced Weight Modulation for Feasible Hardware Neural Networks

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Recently, artificial synapses involving an electrochemical reaction of Li-ion have been attributed to have remarkable synaptic properties. Three-terminal synaptic transistors utilizing Li-ion intercalation exhibits reliable synaptic characteristics by exploiting the advantage of non-distributed weight updates owing to stable ion migrations. However, the three-terminal configurations with large and complex structures impede the crossbar array implementation required for hardware neuromorphic systems. Meanwhile, achieving adequate synaptic performances through effective Li-ion intercalation in vertical two-terminal synaptic devices for array integration remains challenging. Here, two-terminal Au/Li_xCoO_2/Pt artificial synapses are proposed with the potential for practical implementation of hardware neural networks. The Au/Li_xCoO_2/Pt devices demonstrated extraordinary neuromorphic behaviors based on a progressive dearth of Li in Li_xCoO_2 films. The intercalation and deintercalation of Li-ion inside the films are precisely controlled over the weight control spike, resulting in improved weight control functionality. Various types of synaptic plasticity were imitated and assessed in terms of key factors such as nonlinearity, symmetricity, and dynamic range. Notably, the Li_xCoO_2-based neuromorphic system outperformed three-terminal synaptic transistors in simulations of convolutional neural networks and multilayer perceptrons due to the high linearity and low programming error. These impressive performances suggest the vertical two-terminal Au/Li_xCoO_2/Pt artificial synapses as promising candidates for hardware neural networks.

G1B-7 | Enhancement of hard and soft piezoelectric properties of the PZT-PZN ceramics for the application to high power device

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High-power piezoceramics have been utilized in different piezoelectric devices, such as piezoelectric transformers, motors, and ultrasonic transducers. As a large amount of heat is usually generated from high-power devices, the piezoceramics used in these devices need to have a high mechanical quality factor (Q_m) and a high coercive electric field (E_C). These high-power piezoceramics should also have a large piezoelectric charge constant (d_{ij}) because they should possess a high vibration velocity, which is expressed as $Q_m \times d_{ij}$. Therefore, the high-power piezoceramics must have the soft and hard piezoelectric properties. Additionally, a high T_C is crucial for maintaining their piezoelectric traits at higher temperatures. In this study, we fabricated $(Pb_{0.94}Sr_{0.06})[(Zr_{1-x}Ti_x)_{0.75}(Zn_{1/3}Nb_{2/3})_{0.25}]O_3$ (PS-ZT-ZN) piezoceramics at a relatively low temperature of 950°C. The piezoceramic with x = 0.5 displayed the outstanding hard and soft piezoelectric properties d_{33} = 352, k_p = 0.53, and Q_m = 1543, with a high T_C around 250°C, making it an excellent candidate for high-power devices. We also fabricated and evaluated the piezoelectric properties of the PS-ZT-ZN thick film fabricated at 950°C to measure their suitability for application in high-power multilayer devices.

G1B-8 | Investigating the phase transitions of $KNbO_3$ and $NaNbO_3$ single crystals by impedance spectroscopy and Raman scattering

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$KNbO_3$ and $NaNbO_3$ are the end-members of the pseudo-binary $(K_{1-x}Na_x)NbO_3$ system, which is of increasing importance in the fields of piezoelectric and energy storage materials. KNbO is a ferroelectric material whose single crystals find applications in electrooptical and surface acoustic wave devices. $NaNbO_3$ is an antiferroelectric material which is receiving attention as an energy storage material. Materials based on $(K_{0.5}Na_{0.5})NbO_3$ are promising candidates to replace $Pb(Zr,Ti)O_3$ piezoelectric materials. In these materials, control of the room temperature phase and phase transition behaviour is increasingly used to optimize the electrical properties. As a result, it is necessary to determine the phase transition temperatures of these materials. This is often

carried out by using impedance spectroscopy to measure the variation in relative permittivity and loss tangent with temperature, but it is not always possible to unambiguously determine the phase transitions with this technique. In the present work, impedance spectroscopy is combined with temperature-controlled Raman scattering to study the phase transitions in single crystals of $KNbO_3$ and $NaNbO_3$. Single crystals of $KNbO_3$ and $NaNbO_3$ are grown by the flux growth method. Starting powders of $KNbO_3$ and $NaNbO_3$ are prepared by the mixed oxide method and their phase purity checked using X-ray diffraction (XRD). Appropriate amounts of KBO_2 and $Na_2B_4O_7$ flux are added to the $KNbO_3$ and $NaNbO_3$ powders respectively. Batches are placed in a Pt crucible with lid, which is then placed in an alumina crucible with lid. The alumina crucible and lid are sealed with alumina cement to reduce volatilization losses. The batches are melted and homogenized at high temperature (1060°C and 1200°C respectively) then slowly cooled. Single crystals of $KNbO_3$ and $NaNbO_3$ nucleate on the Pt crucible walls or in the flux and grow. After cooling to room temperature, the crystals are removed from the solidified flux and cleaned. The structure of the single crystals is analysed using X-ray diffraction. The chemical composition of the single crystals is analysed using electron probe microanalysis. The phase transitions and electrical properties of the single crystals are analysed using temperature-controlled Raman spectroscopy and impedance spectroscopy. Keywords: $NaNbO_3$, $KNbO_3$, perovskite materials, flux growth method, single crystals.

G1B-9 | 100 °C에서 성장한 무전사, 고품질, 대면적 그래핀의 전기적 응용

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The direct synthesis of inherently defect-free, large-area graphene on various substrates is a key technology for electronic devices. In the present work, in situ plasma-assisted thermal chemical vapor deposition (PATCVD) was implemented to synthesize high-quality graphene directly on 10-nm-thick Ti-buffered substrates with a diameter of 4 inches at 100 °C. The in situ synthesized monolayer graphene, which displays no defects, exhibits an outstandingly low sheet resistance as low as ~80 Ω/□. For applications in OLED encapsulation, the transfer-free and defect-free nature of monolayer graphene was indirectly demonstrated by observing lithium diffusion through the graphene into the copper collector. Furthermore, enhanced thermal dissipation in electronic devices is required for the safe operation of electronic components. In this study, the thermal dissipation effect of monolayer graphene was compared with that of copper and gold metals. As a result, the thermal dissipation property of monolayer graphene showed a superior effect compared to that of noble metals. Based on the various predominant electrical properties of monolayer graphene, its applications in electronic devices are limitless.

G1B-10 | Pb-based perovskite template synthesis and templated grain growth

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A doner was added to the $0.4(Na_{0.5}Bi_{0.5})TiO_3$-$0.6PbTiO_3$ seed used for Pb-based piezoelectric ceramics template grain growth (TGG) to synthesize a larger, uniform, angular seed than the existing seed. The synthesized seed is large in size and melts quickly at low temperature (950°C) to form a liquid phase, showing a high sintered density (Relative density 〉 95%). And it enables oriented growth in $[001]_{PC}$ direction at low temperature (950°C). In addition, since it does Reactive Template Grain Growth (RTGG), it does not remain inside after sintering, so it has the advantage of not reducing the polarization. As a result, the $0.705Pb(Mg_{1/3}Nb_{2/3})O$-$0.295PbTiO_3$ + 5NBT-PT ceramics textured in the $[001]_{PC}$ direction have high density (relative density = 97%) and excellent piezoelectric properties (d_{33}^* = 872 pm/V) shows.

G1B-11 | Dense microstructure formation of the [001]-textured KNN-BAZ piezoceramics through low temperature sintering

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CuO-added $0.96(Na_{0.5}K_{0.5})(Nb_{1-x}Sb_x)O_3$-$0.04(Bi_{0.5}Ag_{0.5})ZrO_3$ (NKNS-BAZ) piezoceramic has been textured along the [001] direction using 3.0 mol% $NaNbO_3$ (NN) templates at low temperature of 970 °C. All NKNS-BAZ piezoceramics were well textured along the [001] direction with the high Lotgering factors (〉 96%). The CuO was used to decrease the sintering temperature

of the NKNS-BAZ piezoceramics, which prevents the formation of pores caused by the melting and decomposition of NN templates. Particularly, the reduction in sintering temperature below 970°C is expected to form a dense pore-free microstructure. The Sb^{5+} content of the [001]-oriented NKNS-BAZ piezoceramics has been modified to find the best piezoelectricity through the control of the crystal structure. Furthermore, the [001]-textured NKNS-BAZ piezoceramics are to be employed in the production of multilayer actuators, with a subsequent investigation into their actuating capabilities.

G1B-12 | Microwave dielectric properties of $Mg_2Ti_{1-x}(Al_{1/2}Sb_{1/2})_xO_4$ ceramics

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Microwave dielectric properties of $Mg_2Ti_{1-x}(Al_{1/2}Sb_{1/2})_xO_4$ ($0.00 \leq x \leq 0.1$) ceramics were investigated. For the specimens sintered at 1450°C for 4h, a single phase of Mg_2TiO_4 with an inverse cubic structure was obtained for the entire range of compositions. To investigate the effect of $(Al_{1/2}Sb_{1/2})^{4+}$ on the structural characteristics of $Mg_2Ti_{1-x}(Al_{1/2}Sb_{1/2})_xO_4$ ceramics, Rietveld refinement was performed on XRD patterns of the sintered specimens. The quality factor (Qf) value of the specimens increased up to x=0.05 mol owing to the increase of average bond valence which is a function of bond length and strength in A_2BO_4 structure. The dielectric constant (K) of the specimens was dependent on the ionic polarizability of the composing ions. Temperature coefficients of the resonant frequency (TCF) of the specimens was proportional to the K. The relationships between microstructure and microwave dielectric properties of the specimens are also discussed.

G1B-13 | Transfer Technology for Integrating High-Quality Single Crystal Relaxor-Ferroelectric Oxide on Flexible Si

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Integration of high-quality functional single crystal oxides on Si has received extensive attention for the multifunctional devices. Research on the direct growth of single crystal oxides using buffer layers such as YSZ, CeO_2, and LSMO has been conducted for integrating functional single crystal oxides on Si substrates. However, this approach faces issues including thermal stress, relatively low crystallinity and difficulties in controlling the crystal orientation of the thin films. Here, we suggest a transfer process to integrate high-quality, fatigue-free $Pb(Mg,Nb)O_3$-$Pb(Zr,Ti)O_3$ (PMN-PZT) single crystals on 5 μm-thick flexible Si. A high quality PMN-PZT single crystal was grown on an STO single crystal substrate with $LaSrMnO_3$ (LSMO) as a sacrificial layer using RF-magnetron sputtering. After the CMP process, the epitaxial PMN-PZT layers were bonded on silicon-on-oxide (SOI) with metal as a bonding layer. By selectively etching off the sacrificial layer of LSMO, the PMN-PZT/metal/SOI structure was obtained. Furthermore, we successfully fabricated a 5 μm-thick flexible Si transferred with a PMN-PZT epitaxial thin film by etching the handling layer of an SOI substrate. To investigate the influence caused by this fabrication process, P-E curves and XRD were measured both before and after the process. This work paves the way for further exploration of oxide-semiconductor hybrid systems for a wide range of applications in electronics, photonics, and sensing.

G1B-14 | Self-rectifying and artificial synaptic characteristics of amorphous Ta_2O_5 thin films grown on $Sr_2Nb_3O_{10}$ nanosheets

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Amorphous Ta_2O_5 (ATa_2O_5) films were grown on $Sr_2Nb_3O_{10}$/TiN/SiO/Si (SN-TSS) at room temperature. $Sr_2Nb_3O_{10}$ (SN) metal-oxide nanosheets were used as a tunneling barrier to induce self-rectifying properties in ATa_2O_5 memristors. An ATa_2O_5 thin film grown on one SN monolayer exhibited a typical bipolar switching curve without any self-rectifying property, indicating that one SN monolayer cannot function as a tunneling barrier. This ATa_2O_5 thin film showed switching behavior owing to the formation and breakage of oxygen vacancy (OV) filaments. Self-rectifying characteristics were observed in an ATa_2O_5 thin film grown on two SN monolayers, which behaved as a tunneling barrier in the Pt/ATa_2O_5/SN-TSS memristor. The current conduction of this ATa_2O_5 memristor in the high-resistance state (HRS) is explained by Schottky emission, direct tunneling, and Fowler–Nordheim (FN) tunneling. In the low-resistance state (LRS), this ATa_2O_5 memristor shows insulating behavior, indicating that OV filaments were not formed. The current conduction of this ATa_2O_5 thin film in the LRS was attributed to direct tunneling and FN tunneling.

Moreover, ATa_2O_5 thin films grown on two SN monolayers exhibited artificial synaptic properties. Therefore, the ATa_2O_5 memristor can be used as an artificial synapse with a cross-sectional array structure.