PG1A : 전자 세라믹스

PG1A-1 | High-photoresponsive photodetector with seamless edge-to-edge connected 2D metal and semiconductor junctions

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Two-dimensional (2D) transition metal dichalcogenides (TMD) have garnered considerable attention owing to their distinctive electrical and optical characteristics. Molybdenum disulfide (MoS_2), one of the most actively studied 2D TMD materials, is widely recognized as an excellent candidate for next-generation electronics. MoS_2 is inherently flexible and transparent, with exceptional light-absorption capabilities that even surpass Si. These remarkable properties make it a key for a wide range of application, but utilizing the potential of 2D TMD materials in practical electronic devices presents unique challenges. Generally, it is unavoidable that metal electrodes deposited through physical vapor deposition (PVD) such as evaporation lead to the formation of non-ohmic contacts between the electrode and semiconductor due to the metal-induced gap state (MIGS) or the pinning effect. Thus, clean and sharp interface contact is essential for application using 2D TMD materials, such as photonic device or field-effect transistor. In particular, optoelectronic devices such as photodiode demand a clean interface to facilitate the rapid transfer of photo-generated carriers. To attain fast-switching and high performance 2D TMD-based optoelectronic devices, 2D-2D based seamless contact could be adopted as it can controls the gap states and form the clear ohmic contact. In this research, we demonstrated $Nb_xMo_{1-x}S_2/MoS_2$/p-Si structure photodiode. MoO_3 and Nb_2O_5 were sputtered sequentially on p-type doped Si substrate and sulfurized at once by chemical vapor deposition (CVD) system. While the upper MoS_2 layer was synthesized at high temperature, Nb atoms diffused forming the $Nb_xMo_{1-x}S_2$ layer, and a few lower-layer MoS_2 remained as activation layer. To analyze the material characteristics, we performed several method, such as high-resolution transmission electron microscopy (HR-TEM), energy dispersive x-ray spectrometry (EDS), x-ray photoelectron spectroscopy (XPS), Raman spectroscopy and ultraviolet/visible/near-infrared spectrophotometer, etc. Optical and electrical properties of seamless contact photodiode were characterized under diverse light wavelength (visible to infrared) and light intensity. It showed reliable photo-response characteristics and a linear correlation between light intensity and photo-current. The photodiode presented a high photo-responsivity up to 2 A/W in the visible wavelength of 530 nm, also showing credible responsivity in the other wavelength of 450 to 850 nm range. The performance significantly improved due to 2D-2D seamless contact heterostructure, presenting a new concept of promising 2D photodiode.

PG1A-2 | Perovskite-Silicon Photodetector for Discriminating Near-Infrared and Visible Light via Bias Variation Without Filter

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In advanced driver assistance systems (ADAS) technology, which assists drivers in achieving effortless driving with minimal input, vision sensors play a crucial role in perceiving elements such as the road, traffic signals, and surrounding obstacles. The key for future ADAS systems to accomplish fully autonomous driving is the development of new hardware capable of operating without additional filters in real-world conditions, including day and night, as well as various weather conditions. Herein, as a purpose to realize an optimized photodetector for the ADAS system, we propose a specialized photodetector, separately sensing both the visible spectrum and NIR light and combining them into a single image. MAPbI3 perovskite and silicon (Si) absorbers are utilized, and an n-type PCBM layer is intercalated to create an optimized back-to-back configuration. Depending on the polarity of the engaged bias, the spectral response of the device can be adjusted. When configured for a specific bias polarity, the device exclusively responds to visible light (in the range of 400-750 nm) while remaining impervious to NIR light. Conversely, when the bias is reversed, the device transitions into a night vision mode, exhibiting peak sensitivity in the NIR range (800~900 nm). The crux of our innovation lies in this device's ability to operate effectively even under conditions of limited visibility, such as foggy days or dark nights. This not only expands the potential for cost-effective and energy-efficient ADAS system development but also hints at its potential application in autonomous driving.

PG1A-3 | High thermal stability of $Ca_2ZrSi_4O_{12}:Yb^{3+}$ NIR phosphor for NIR anti-counterfeiting

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Near-infrared (NIR) emitting luminescence materials with high efficiency and good thermal properties enable potential applications including anti-counterfeiting, secret signals, medical, pharmaceutical, and agricultural industries. In particular, anti-counterfeiting technology needs to be upgraded as counterfeiting technology develops. Accordingly, we synthesized Yb^{3+}doped $Ca_2ZrSi_4O_{12}$ phosphors using a solid-state reaction method to develop a material that emits NIR region by excitation in near-infrared region, breaking away from the existing method using ultraviolet excitation. The $Ca_2ZrSi_4O_{12}$:Yb^{3+} phosphors showed a broad near-infrared emission from 950 to 1050 nm, which was attributed to the $^2F_{5/2} \rightarrow {}^2F_{7/2}$ transition of Yb^{3+} ions above 900 nm and at 280 nm excitation. The excitation spectra, recorded by monitoring the emission at 1020 nm, showed two bands in the ultraviolet and infrared regions. Finally, the relative emission intensity of $Ca_2ZrSi_4O_{12}$:Yb^{3+} phosphor was 91% of the initial emission intensity at 250 °C, indicating its excellent thermal stability. After cooling, the NIR emission intensity recovered to nearly 100% of the initial intensity indicating that the thermal degradation was minimized. These results suggest applicability to advanced anti-counterfeiting applications.

PG1A-4 | Piezoelectricity in Perovskite Halide $MAPbX_3$ (X = I, Br, and Cl) Thin Films

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Compositional dependence on ferroelectric and pieozoelectric characteristics have been rarely reported in perovskite halides. Herein, anion-dependent piezoelectricity and power generation in methylammonium lead halide $MAPbX_3$ (X = I, Br, Cl) were investigated by focusing on the structural origin of the property dependence. In addition, the effect of anisotropic in situ strain was explored for further enhancement in the device performance. The highest piezoelectric energy harvesting performance was achieved for the compressively 0.73%-strained $MAPbI_3$ thin films with a peak voltage/current of ~23.1 V/~1703 nA. In comparison, $MAPbBr_3$ and $MAPbCl_3$ exhibited ~5.6 V/~176 nA and ~3.3 V/~141 nA, respectively, under the same in situ strain condition. Despite the cubic structures of $MAPbBr_3$ and $MAPbCl_3$, apparent piezoelectricity was observed as being associated with the soft polarity modes and defects. In the case of tetragonal ferroelectric $MAPbI_3$, the distortion of PbI_6 octahedra and atomic displacement within each octahedron were quantitatively estimated.

PG1A-5 | Strain-Sensitive, Self-Powered Photoresponse of Fleixble Halide Perovskite Thin Films

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Self-powered halide perovskite-based photodetectors have received increasing attention with efforts of improving photodetction perfromance. Here, we propose the lattice-strain-dependent light-sensing characteristics in self-powered flexible inorganic perovskite $CsPbBr_3$ thin films. A unique method based on two-step depostions was applied to induce lattice strain in the range of −0.83% to +0.83% for the $CsPbBr_3$ thin films. As a result, the highest values were achieved with the responsivity of ~121.5 mA/W and response speed of ~2.5 μs for the maximum tensile strain of +0.81%, corresponding to the improvements of ~100.2% and ~75%, respectively, relative to the unstrained case. The improvement was systematically discussed with chasing the structural origin and teh adjusted band aligments at junctions.

PG1A-6 | Various factors affecting the grain growth of KNN based ceramics

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(K,Na)NbO_3기반 세라믹스는 Pb기반 압전 세라믹을 대체할 소재로 많은 주목을 받고 있다. KNN 기반 세라믹은 주로 소결과정에서 알칼리 원소의 휘발로 인해 조성의 불균일 및 재현성이 떨어지는 등의 문제가 있지만, 여전히 조성제어를 통한 향상된 압전 특성이 꾸준히 보고되고 있다. 또한, 최근 KNN 기반 세라믹에 A-site에 존재하는 K, Na보다 높은 전하수를 갖는 이온이 도핑되었을 때, 수 cm크기의 거대한 단결정으로 성장할 수 있다고 보고되었다. 따라서 본 연구에서는 KNN 기반 세라믹스의 결정립 성장에 영향을 줄 수 있는 다양한 요인들을 파악하고자 분말 입도 분포, 알칼리 원소 함량, 도너 이온 종류를 제어하였으며, 그에 따른 미세구조 변화를 비교하였다. 분말 입도 분포도를 달리하였을 때 단일 분포도를 가지는 경우 일반적 결정립 성장을 가지나, 이중, 삼중, 사중 분포도를 가질 때 비정상 결정립 성장이 관찰되었으며 성장한 비정상 결정립의 크기가 분포도에 따라 달라짐을 확인하였다. 또한 알칼리 원소보다 높은 전하량을 갖는 Ca, Sr, Ba 이온을 첨가하였을 때 순수한 $K_{0.5}Na_{0.5}NbO_3$세라믹과는 달리 결정립 성장이 억제되는 것을 확인하였고, 도핑된 원소에 따른 알칼리 원소의 휘발속도 차이와 그에 따른 결정립 성장 거동이 달라짐을 확인하였다. 또한, 첨가되는 도너 이온을

제어하였을 때, 일반적 결정립 성장부터 cm크기의 단결정으로 성장함을 확인하였다. 이러한 결과를 바탕으로 다양한 요인들이 KNN 기반 세라믹스의 결정립 성장에 미치는 영향에 대해 보고하고자 한다. This work was supported by the National Research Foundation of Korea (NRF) Grant funded by the Korean Government (Ministry of Education) [NRF-2019R1I1A3A01058105] and [NRF-2018R1A6A1A03025761], and the Technology Innovation Program (or Industrial Strategic Technology Development Program-Material Components Technology Development Program) (20024235, Development of Technology for Manufacturing Lithium High Corrosion Resistance Ceramic Parts for Cathode Materials of Li-ion battery) funded By the Ministry of Trade, Industry & Energy (MOTIE, Korea). This work was also supported in part by the International Science & Business Belt support program, through the Korea Innovation Foundation funded by the Ministry of Science and ICT.

PG1A-7 | RF-Sputtering을 이용한 강유전체 세라믹스의 증착 조건에 관한 연구

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압전박막연구는 MEMS 소자, 정밀 소형 의료기기, FE-FETs로서 중요성이 높아지고 있다. 특히 정밀 소형 의료기기에 사용되는 액추에이터의 경우 높은 압전 특성과 생체적합성이 요구된다. 현재 연구되는 무연계 압전 소재중에 $K_{0.5}Na_{0.5}NbO_3$(KNN)계 소재는 상대적으로 높은 큐리온도, 압전특성, 생체적합성 때문에 많은 연구가 진행되고있다. 하지만 KNN계 소재는 A-sites에 K, Na 원소가 존재하기 때문에 고온에서 휘발하기 쉬운 성질을 가지고 있다. 이 때문에 양질의 박막으로 성장시키기 어렵다는 단점이 있다. 이에 본 연구에서는 $K_{0.5}Na_{0.5}NbO_3$ 및 $K_{0.55}Na_{0.55}NbO_3$ 조성의 세라믹 타겟을 제작하고, RF-sputtering을 이용하여 다양한 조건에 따른 박막 및 타겟의 구조적 변화를 분석하고 양질의 박막을 성장시키려 한다. This work was supported by the National Research Foundation of Korea (NRF) Grant funded by the Korean Government (Ministry of Education) [NRF-2019 R1I1A3A01058105] and [NRF-2018R1A6A1A03025761], and the Technology Innovation Program (or Industrial Strategic Technology Development Program-Material Components Technology Development Program) (20024235, Development of Technology for Manufacturing Lithium High Corrosion Resistance Ceramic Parts for Cathode Materials of Li-ion battery) funded By the Ministry of Trade, Industry & Energy (MOTIE, Korea). This work was also supported in part by the International Science & Business Belt support program, through the Korea Innovation Foundation funded by the Ministry of Science and ICT.

PG1A-8 | 초저온 동시 소성(ULTCC)을 위한 $CuMo_{(1+x)}O_4$의 소결 및 유전 특성 연구

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5G/6G 통신 기술을 기반으로 초고속, 대용량 데이터 전송이 요구되면서 고주파 유전체의 연구가 활발히 진행되고 있다. 또한, 700℃ 이하의 온도에서 소결되는 Al 전극과 동시 소성이 가능한 저온 동시 소성 세라믹(ULTCC: Ultra-Low Temperature Co-fired Ceramic)은 공정의 간소화 및 비용 절감을 위해 많은 주목을 받고 있다. 최근, ULTCC 조성 중 $CuMoO_4$는 Al 전극과 반응성없이 약 650℃의 낮은 온도에서 소결이 가능하며, 우수한 마이크로파 유전체 특성으로 보고되었다. 더불어 $CuMoO_4$의 상도표에 따르면 Mo의 비율이 높아지면 녹는점이 낮아지는 것을 확인할 수 있다. 따라서, 본 연구에서는 $CuMo_{(1+x)}O_4$(x=0, 0.1, 0.2, 0.3, 0.4, 0.5)의 소결온도를 낮추기 위해 Mo 제어를 통해 기존 조성보다 낮은 온도에서 얻은 소결체를 얻었으며, 소결 온도에 따른 소결체의 미세구조 및 밀도 분석을 통해 Mo의 함량 증가가 소결성 및 미세구조에 미치는 영향에 대해 연구했다. 또한, Al 전극과 열처리 후 XRD 분석을 통해 Al 전극과의 반응성 여부를 확인하였으며, 미세구조 변화에 따른 고주파 유전 특성 및 품질계수(Q_f)를 보고한다. This work was supported by the National Research Foundation of Korea (NRF) Grant funded by the Korean Government (Ministry of Education) [NRF-2019R1I1A3A01058105] and [NRF-2018R1A6A1A03025761], and the Technology Innovation Program (or Industrial Strategic Technology Development Program-Material Components Technology Development Program) (20024235, Development of Technology for Manufacturing Lithium High Corrosion Resistance Ceramic Parts for Cathode Materials of Li-ion battery) funded By the Ministry of Trade, Industry & Energy (MOTIE, Korea). This work was also supported in part by the International Science & Business Belt support program, through the Korea Innovation Foundation funded by the Ministry of Science and ICT.

PG1A-9 | Au-assisted recrystallization process for large-area single crystal GeS

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Germanium monosulfide(GeS), one of the Type IV monochalcogenides, has layered 2D structure and holds potential for applications in the electronic and optoelectronic fields by its band structure and anisotropic nature. However, conventional methods (CVD, CVT, VLS) can only synthesize single crystal GeS in the shape of nanoribbons, nanofilms, powders and even amorphous films that are not suitable for wide

applications. In this study, we used amorphous GeS films as a source and introduced pressure – controlled recrystallization process assisted by gold, through which we obtained few layers of single crystal GeS larger than 500um. Among the whole process, gold serves as reaction catalyst and passivation layer for GeS, which is susceptible to external corrosion even in ambient condition. We used the characterization tools to verify the presence of GeS. We also observed layer-wise bandgap dependency by the visible light range at wavelengths between 600-800nm. Moreover, we fabricated a back-gate transistor with the synthesized film and conduct I-V characterization. A p-type transfer curve was noted. This method could be helpful for synthesizing 2D crystals which are difficult to produce by conventional methods, containing the other Type IV monochalcogenides.

PG1A-10 | Enhancing Dielectric Stability in $BaTiO_3$-based complex perovskite ceramics through Wrapping Process

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The synthesis of complex perovskite compounds via heterovalent cation substitutions is an effective way to achieve stable dielectric polarizations in BaTiO3 ferroelectric ceramics over a wide temperature range. Solid solutions of (1-x)$BaTiO_3$-x($Bi_{0.5}$, $Na_{0.5}$)TiO_3 and (1-x)$BaTiO_3$-x($Bi_{0.5}$, $Na_{0.5-y}$)($Ti_{1-y}Nb_y$)O3 were manufactured utilizing a unique "wrapping process," which relies on 2-D nanosheets to create a core-shell assembly of $BaTiO_3$ nanoparticles and BNT/BNTN nanosheet mixes. Because the production of solid solutions from these mixes is a diffusion-controlled process, it provides ideal conditions for maximizing contact areas and ensuring a high level of reactivity among the heterogeneous constituents. The core-shell designs were critical in speeding the sintering process while avoiding excessive grain development. The sintered samples demonstrated relaxor properties with strong dielectric permittivity and energy density.

PG1A-11 | ZrO_2 나노복합 Sn/Bi 도금층과 SAC305 솔더볼을 사용한 Hybrid 범프의 제조 및 특성

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Due to the demand for downsizing, high integration of electronic products, and high performance, the importance of electronic packaging technology is increasing. Soldering, which is commonly used for joining electronic components, is a method of bonding materials using a solder with a melting point below 450°C. Sn-3Ag-0.5Cu, commonly used in the electronics industry, has a melting point of 221°C, which is relatively high. This can lead to issues such as warpage caused by the difference in coefficients of thermal expansion (CTE) between the solder and the materials, as well as potential thermal deformation problems in flexible circuit boards. As a result, there is a growing need for research on low-temperature soldering, which offers the advantages of minimizing thermal damage during reflow and energy savings. In this study, nano-composite hybrid bumps were manufactured at a process temperature of 180°C using highly ductile SAC305 solder balls and a Bi layer with added nanoparticles. The optimal conditions for Bi plating were determined by measuring the plating thickness and surface morphology as a function of current density and time using scanning electron microscopy (SEM). ZrO2 nanoparticles were added to the Bi plating solution at concentrations of 0.05wt%, 0.1wt%, 0.2wt%, and 0.3wt%. After plating Bi onto copper pads surface-treated with electroless nickel immersion gold (ENIG), S was sequentially plated to improve the compatibility with SAC305. The nano-composite hybrid bumps were manufactured by reflowing at 180°C for 1 minute. The metallurgical and mechanical properties of the hybrid bumps were compared, and the electrical characteristics were evaluated by mounting 1608 capacitors on flexible printed circuit boards (FPCBs). It was confirmed that the addition of nanoparticles did not significantly affect the electrical properties.

PG1A-12 | 고출력 어플리케이션을 위한 High Tc PIN-PZN-PT 압전세라믹스의 MnO2 도핑효과

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The $Pb(In_{1/2}Nb_{1/2})O_3$-$Pb(Zn_{1/3}Nb_{2/3})O_3$-$PbTiO_3$ (PIN-PZN-PT) has high d_{33} value and Curie temperature (T_C), and the MnO_2 doped PIN-PZN-PT was prepared by traditional ceramic process. In high power applications, temperature stability is crucial due to the heat generated by mechanical loss at high frequency. Therefore, the operating temperature range is limited to $T_C/2$ to prevent performance degradation by heating. In the case of PIN, PZN, and PT, each material exhibits high T_C values of 90ºC, 140ºC, and 490ºC, respectively, allowing them to maintain a T_C exceeding 210ºC even in a ternary system.

Also, to reduce heat generation, a high mechanical quality factor is necessary. Doping MnO_2 induces a domain pinning effect, which restricts domain wall motion and leads to a higher Q_m. When 2 mol% of MnO_2 was doped into the MPB phase composition of 50PIN-21PZN-9PT, we observed a significant increase in mechanical quality factor while maintaining high piezoelectric properties and T_C (d_{33} = 211 pC/N, T_C = 270ºC, Q_m = 1233). Hence, the Mn-doped PIN-PZN-PT exhibits excellent properties suitable for the high-power applications, also it is expected to be applicable to Templated Grain Growth process to achieve even higher performance.

PG1A-13 | 냉간등압법으로 제조된 망간 도핑 안티몬화아연의 열전 특성

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열전재료인 ZnSb의 제조법으로 고온 소결법을 이용하는 것이 일반적이다. 본 연구에서는 공정단순화를 위해 소결공정을 배제하였다. Mn이 도핑된 ZnSb를 냉간등압법만을 이용하여 치밀화하였다. Mn의 도핑량은0 ~ 1 mol %로 하였다. ZnSb의 열전특성은 홀 측정, 열전도도 측정, 제벡계수 시험을 이용하여 다양한 온도 (50 ℃ ~ 200 ℃)에서 실험되었다. P-형 전도성질을 가지는 ZnSb의 전기전도도는 온도에 따라 증가하였고, 열전도도는 온도에 따라 감소하였다. 반면 Mn 함량에 대해서는 전기전도도 및 열전도도 모두 증가하였다. 열전 성능지수인 figure-of-merit (zT)은 Mn 도핑에 따라 증가하였다. 0.5 mol% Mn 도핑에서 최대값을 보였다.

PG1A-14 | Al_2O_3 bonding and transferring technology for integrating epitaxial functional oxides on Si

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This study explores amorphous Al_2O_3 oxide bonding as a technique for transferring epitaxial functional oxides onto silicon (Si) substrates. The integration of functional oxide materials, such as perovskite oxides, with Si is of great interest in advanced electronics, photonics, and energy-related applications. However, the lattice mismatch and thermal expansion coefficient disparities between Si and oxide materials pose significant challenges to their direct integration. Amorphous Al_2O_3 is chosen as the bonding layer due to thermal conductivity, electric resistance, and flatness. Bonding quality is assessed using surface acoustic microscopy (SAM) and atomic force microscopy (AFM), confirming the reliability of this innovative bonding approach. Our objective is to develop piezoelectric-on-insulator (POI) structures, aiming to enhance electro-optic device performance. Successful epitaxial oxide transfer to Si with amorphous Al_2O_3 oxide bonding offers new opportunities for advanced electro-optic systems. In summary, amorphous Al_2O_3 oxide bonding holds promise for improving epitaxial oxide integration onto Si, with potential implications for high-performance electro-optic devices.

PG1A-15 | High-performance transparent piezoceramics for novel electronic applications

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Piezoelectricity is a fascinating phenomenon which facilitates novel electronic applications such as actuators, transducers, and sensors. Among the diverse collection of piezoelectric ceramics, we focused on transparent piezoceramics thanks to its versatile applications, i.e., cinematic sound speakers, smart window, and energy harvesting. However, it is difficult to realize high-end transparent piezoceramics with high piezoelectricity and proper transparency at the same time because general piezoelectric materials used in practical devices are ferroelectrics that exhibit high density and light scattering originating from domain wall effect, thereby imposing them to have low transparency. In this study, we developed transparent high-performance piezoceramics, which manifests high piezoelectricity along with considerable transparency, and expected that this discovery could be the game changer in this society.

PG1A-16 | Effect of Amorphous Boundary Layer on the Properties of Al-doped $Li_7La_3Zr_2O_{12}$ Solid Electrolyte for Lithium Ion Batteries

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$Li_{6.1}Al_{0.3}La_3Zr_2O_{12}$(LALZO) is a promising solid electrolyte material due to its high bulk ionic conductivity and stability against liquid electrolytes. However, conventional ceramic sintering process has the problem of requiring high temperature and time. Cold sintering process (CSP), introduced to solve this problem, enables particle densification at low temperatures below 300 ℃ in a short time. In this study, LALZO was synthesized through solid-state reaction (Ball milling). In order to increase the ionic conductivity of LALZO, an amorphous layer was formed through CSP. The ionic conductivity of the prepared LALZO pellets was compared with LALZO of

conventional high temperature sintering. To identify the LALZO phase, X-ray Diffraction (XRD) was used. The surface morphologies of sintered pellets were observed using Scanning electron microscope (SEM). Furthermore, the relative density of the LALZO also measured as the ratio of theoretical density and measure density.

PG1A-17 | Fabrication of Zn-doped WO_3 nanoparticles and its gas sensing properties for visible-light-activated NO_2 detection

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Metal oxide semiconductors (MOS) are among the most conventional gas-sensing materials; however, high temperatures are essential for the operation, limiting their ubiquitous application. To address this, many efforts have been made in the development of room-temperature gas sensors. One of the most promising approaches involves the activation of sensors using light instead of heat. Among the various types of MOS, WO_3 – an n-type semiconductor with a narrow band gap (~2.8eV) – is widely used for detecting various gases under visible light. Additionally, it has been reported that doping WO_3 with Zn not only creates a large number of oxygen vacancies (OVs) but also prolongs the lifespan of photogenerated electrons, which can contribute to the improvement of gas response and recovery speed. Herein, we report the synthesis of Zn-doped WO_3 nanoparticles using a microwave-assisted hydrothermal method and their gas-sensing characteristics under visible light (e.g., blue). The sensor exhibited a high response (resistance ratio = 6.97) to 1 ppm NO_2 with negligible cross-responses to other gases, even under a relative humidity of 80%. Furthermore, the recovery time also improved by more than 3 times when compared to the pure WO_3 sensor.

PG1A-18 | Developing hybrid composite dielectric materials with low-k and low-loss properties for substrates in microwave/mm-wave system

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For optimal performance in microwave/mm-wave wireless communication devices, it's essential that dielectric materials exhibit a low dielectric constant (ε_r) and a high-quality factor (Q). This combination minimizes time delays and enhances signal selectivity. One promising avenue for meeting these requirements involves exploring potential material solutions, such as ceramics or hybrid dielectric composites that incorporate both inorganic and organic components. These materials offer versatile properties that can address a range of demands in advanced communication systems, ultimately contributing to improved performance and efficiency. Forsterite (Mg_2SiO_4) nanoparticles are opted for as predominant inorganic components owing to their constrained polarization and negligible power dissipation attributes at ultra-high frequencies. Polyimides (PI) are utilized in the ceramic-polymer hybrid materials approach. The dielectric properties of the resulting Composite of forsterite and polyimide (PI) were analyzed at microwave and mm-wave frequencies.

PG1A-19 | $BiFeO_3$-$BaTiO_3$-$BiMO_3$ 3원계 세라믹스의 결정구조 및 압전특성

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압전 소재는 기계적 응력에 의하여 전하가 유도되는 압전 효과가 발생하며, 전기장 인가에 의하여 기계적 변형이 발생하는 역압전 효과도 관찰되며, 이로 인하여 다양한 압전 센서, 엑츄에이터, 초음파 변환기 등에 응용되고 있다. 최근, $BiFeO_3$-$BaTiO_3$ (BF-BT) 세라믹스에서 우수한 압전 특성이 보고되어, $Pb(Zr,Ti)O_3$ (PZT) 계 압전 소재를 대체할 수 있는 친환경 소재로 관심을 받고 있다. 특히, BF-BT 압전 세라믹스는 0.7BF-0.3BT 근처 조성에서 강유전 능면체정에서 완화형 의사 입방정으로 상전이가 존재하며, 이 상경계 조성에서 압전 특성이 최대가 된다고 보고되고 있으나 정확한 상경계 조성 및 결정구조가 아직 규명되지 않았으며, 공정 조건에 따라 결정구조 및 압전 특성의 큰 차이를 보이고 있다. 본 과제에서는 상경계 근처 조성의 BF-BT 에 제 3의 Bi 계 페로브스카이트 화합물을 고용시킨 $BiFeO_3$-$BaTiO_3$-$BiMO_3$ (M = Ga, Al, Zn-Ti, Mg-Nb) 3원계 조성의 결정구조와 압전 특성을 조사하였다. 고용체 조성에 따른 상경계, 결정구조, 미세구조, 강유전 및 압전 특성의 차이를 비교하였다.

PG1A-20 | PMN-PT 단결정에서 열처리 후 압전 특성의 메모리 효과

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압전 재료는 전기에너지와 기계적 에너지를 변환할 수 있는 성질로 인하여 엑츄에이터 초음파 진동자, 압력 센서 등 다양한 분야에 응용되고 있다. $Pb(Mg,Nb)O_3$-$PbTiO_3$ (PMN-PT), $Pb(Zn,Ti)O_3$-$PbTiO_3$ (PMN-PT)와 같은 $PbTiO_3$-완화형 강유전체(relaxor ferroelectric) 압전 단결정 재료는 현재 압전 소재로 널리 사용되고 있는 $Pb(Zr,Ti)O_3$ (PZT) 계 압전 다결정 세라믹스보다 훨씬 우수한 압전 특성으로 인하여 의료용 초음파 진단자

등 고정밀 압전 소자로의 응용이 확대되고 있다. 압전 단결정 소재는 고온에서 열처리한 후 상온으로 냉각하면 다양한 방향으로 배향된 강유전 분역들을 가지기 때문에 압전 특성이 나타나지 않는다. 외부 전기장을 인가하여 전기쌍극자의 방향을 특정한 결정방향으로 배열하는 분극 (poling) 공정을 거친 후에 큰 압전 특성을 나타내며, 이를 큐리온도(TC) 이상으로 열처리하면 각 분역의 분극(polarization) 방향이 무질서하게 되므로 압전 특성이 사라진다. 최근 $Pb(Mg,Nb)O_3$-$PbSnO_3$-$PbTiO_3$ (PMN-PS-PT) 3원계 압전 단결정을 큐리온도 이상의 온도에서 열처리한 후에도 압전 특성이 거의 그대로 남아 있는 압전 메모리 효과가 보고된 바 있다. 이러한 압전 메모리 효과를 가진 단결정 소재는 분극 공정이 필요없으며, 고온의 환경에서도 압전 특성이 유지되는 장점이 있기 때문에 다양한 응용 분야에 적용될 수 있을 것으로 기대된다. 하지만, 이러한 압전 메모리 효과의 원인은 아직 설명되지 않고 있으며, 재현성 있는 후속 실험 결과들이 보고되지 않고 있다. 본 연구에서는 란타늄(La)과 망간(Mn)이 첨가된 PMN-PT 단결정을 큐리온도 이상으로 열처리한 후 강유전 이력 특성, 압전 상수(d33), 전기기계 결합계수 등의 변화를 측정하였으며, 유전 및 압전 특성의 온도 의존성을 조사하여 첨가제에 따른 압전 메모리 효과와 상전이 거동의 차이를 비교하였다.

PG1A-21 | Effect of Compostion ratio for lead free $0.67BiFeO_3$-$0.33BaTiO_3$ PiezoCeramics

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Pb-based ceramics have good high piezoelectric, ferroelectric, and electrical properties. However, Pb-based ceramics contain 60~70 wt% lead, raising environmental concerns. Recently, a $BiFeO_3$-$BaTiO_3$ (BF-BT) solid solution bulk ceramic system is presented as a potential lead-free piezoelectric ceramic system with morphotropic phase boundary at $0.67BiFeO_3$-$0.33BaTiO_3$. However, poor ferroelectric and piezoelectric properties with high leakage currents are often shown. Because of non-stoichiometric compounds as Bi-rich ($Bi_{20}FeO_{40}$) and Fe-rich phases ($Bi_2Fe_4O_9$) formed with oxygen vacancies.

In this study, $0.67Bi_{(1+x)}Fe_{(1+y)}O_3$-$0.33BaTiO_3$ (x = 0-0.05 and y = 0-0.07) piezoceramics fabricated by a solid-state reaction method followed by a water-quenching process. And the process for controlling the rich phase of Fe and Bi were investigated. This resulted in improvement in d_{33}, d_{33}^* and dielectric properties. The experimental process with structural and electrical properties of BF-BT ceramic will be presented in detail.

PG1A-22 | Li-intercalation and Chemical exfoliation of MoS_2

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MoS_2, an outstanding member of the Transition Metal Dichalcogenide (TMDC) materials, has garnered significant attention in research. Alongside graphene, TMDC materials share the trait of thinness and exhibit remarkable semiconductor properties. For instance, MoS_2 can transition its bandgap from an indirect bandgap (~1.3 eV) in bulk structure to a direct bandgap (~1.8 eV) in monolayers, rendering it a crucial material in the electronics industry. In this study, we synthesized single-crystal bulk MoS_2 using the molten salt flux method. This served as a precursor for Li-intercalation through n-Butyllithium, followed by chemical exfoliation under ultrasonic conditions. X-ray Diffraction (XRD) analysis of the bulk MoS_2 indicated a preference for single crystal planes to grow in the (00l) direction. Raman spectroscopy revealed the presence of the phonon modes E^1_{2g} and A_{1g} at wavenumbers of 383 cm^{-1} and 410 cm^{-1}, respectively. Additionally, X-ray Photoelectron Spectroscopy (XPS) data provided insights into the binding energies of Mo 3d and S 2p. The exfoliated MoS_2 was characterized using Field Emission Scanning Electron Microscopy (FESEM) and Transmission Electron Microscopy (TEM). The results demonstrated the successful harvest of several layers of exfoliated MoS_2.

PG1A-23 | 용융염법을 이용한 TiX2 (X = S, Se) 이차원 단결정 소재의 합성과 물성 및 성능 평가

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차세대 반도체 물질로 주목받고 있는 물질군인 전이금속 디칼코게나이드 (Transition Metal Dichalcogenides)는 전이금속(M)을 중심으로 칼코겐 원소(X)가 X-M-X 형태로 결합되어 있는 물질로서 그래핀과 유사한 2차원 형태의 구조를 가지고 있으며, 크기나 두께에 따라 반도체적 성질과 특정한 밴드갭 조절이 가능하여 다양한 분야에의 적용 연구가 활발히 진행 중이다. 본 연구에서는 혼합 용융염을 사용하여 TiX_2 (X = S, Se) 단결정을 합성하였으며, 합성된 단결정의 결정구조, 원자간 결합에너지 등, 내재적 물성을 평가하였다. 또한, 선별된 단결정을 미분화 하여 Na 및 Li 이온 배터리의 음극재로서의 성능을 테스트하였다. 그 결과, TiS_2-Li^+ 의 초기방전용량은 171 $mAhg^{-1}$, $TiSe_2$-Li^+ 는 202 $mAhg^{-1}$였고 TiS_2-Na^+ 에서는 136 $mAhg^{-1}$, $TiSe_2$-Na^+ 는

235 $mAhg^{-1}$으로, 기존 TiS_2, $TiSe_2$ 분말 적용 성능 결과에 비견될만한 용량을 가짐을 확인하였다.

PG1A-24 | The effect of composite TiO_2 powder control on BZT powder synthesis via solid state reaction

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Barium Zirconate Titanate ($Ba(Zr,Ti)O_3$, BZT) has garnered significant attention due to its wide temperature stability, and frequency stability. It has been of great interest for many years in the field. BZT has demonstrated stable operation at high temperatures and frequencies, and high reliability in the manufacturing of multilayer ceramic capacitors (MLCCs), satisfying EIS Class2 X5R. BZT is synthesized via various methods, including solid-state reaction, through diffusion of Ba^{2+} into Ti^{4+} at the interface of $BaCO_3$ and TiO_2, as well as lattice substitution between Zr^{4+} and Ti^{4+}. In this study, changes in the physical and electrical properties of BZT were observed during solid-state reaction. The process used the representative phases of TiO_2: anatase and rutile, as well as the composite phase TiO_2 formed through heat treatment of anatase TiO_2 and the composite phase TiO_2 formed through physical mixing.

PG1A-25 | 열처리된 상변이 버퍼층을 이용한 Sn 도핑 산화갈륨 박막 특성 연구

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Corundum 구조(α-상)인 산화갈륨은 열역학적으로 준안정성이며, 넓은 bandgap(약 5.3 eV)을 가지고 있다.1) 또한 corundum 구조를 갖는 다양한 금속산화물(α-Me2O3)과 a축 및 c축의 격자상수, 격자비율, 이온 반경이 중간값을 갖기 때문에 합금 연구가 가능하다.2) 산화갈륨은 높은 저항률 (〉1×105 Ωcm)로 인해 반절연 특성을 보이며, 또한 외부 도핑된 산화갈륨은 여러가지 산란 메커니즘(불순물, 전위, 표면거칠기)으로 인해 전기적 특성이 감소된다.3) 본 연구에서는 mist-CVD를 이용해 α-Ga2O3 버퍼층을 성장하고 Ga와 Al의 합금을 통해 고온 안정성 특성을 갖는 삼성분계 산화갈륨 이중 버퍼층(α-(AlxGa1-x)2O3)을 성장시켰다. 그 후 700-800℃에서 열처리하여 산화갈륨 버퍼층을 상변이 유도하여 기판에서부터 성장되는 전위결함을 억제하였다. 그리고 버퍼층 위에 Sn이 도핑된 산화갈륨 박막을 성장시켜 n형 산화갈륨 반도체의 전자이동도를 향상시키는 연구를 진행했다. 성장한 산화갈륨 박막의 결정구조를 확인하기 위해 XRD $\theta/2\theta$ 스캔과 FE-SEM 측정을 통해 산화갈륨 박막의 두께와 표면 형상을 확인하였다. UV-Vis을 이용한 투과도 측정과 Hall 측정으로 캐리어 농도와 전자이동도를 확인했다. 상변이 특성을 확인하기 위해 TEM을 이용하여 박막의 레이어별 결정구조를 확인하였다. 본 실험을 통해 열처리를 이용한 박막의 상변이를 이용하여 전위을 억제하고 Sn 도핑 산화갈륨 박막의 전기적 특성을 개선시키는 연구로 n형 반도체 전기적 특성 개선이 기대된다.
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PG1A-26 | 미스트화학기상증착법으로 성장된 산화니켈 박막의 도핑농도 및 열처리온도에 따른 특성 분석

공민성[1,2], 조성호[1], 김경호[1,3], *박민수[3], *배시영[1]
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산화니켈은 P-type 와이드 밴드갭 물질로 투명하고 환경 친화적이며 경제적으로 증착이 가능한 물질으로 태양전지, 광센서 등의 소자에 응용이 가능하여 주목받고 있다. 산화니켈 박막은 스퍼터링, 스핀코팅, PLD 등의 증착 공법이 있는 것으로 알려져 있고, 도핑이 쉬우며 경제적으로 고품질 박막을 에피택셜 성장 할 수 있는 미스트화학기상증착법[1]으로 성장했다. 도핑이 되지 않은 산화니켈은 절연체에 가깝기 때문에 리튬을 5, 10, 15% 도핑하여 도핑 농도 별 물성 분석을 진행하였다. 또한 도핑이 안된 샘플과 도핑 된 샘플들을 열처리하여 열처리 온도 별로 특성 변화를 관찰하였다. FE-SEM, AFM으로 표면 형상과 거칠기를 측정했고 XRD 측정으로 111(NiO), 222(NiO) peak가 37.39, 79.69°에 나타나는 것으로 산화니켈 박막이 성공적인 성장이 됨을 확인하였고 박막의 FWHM, Crystallite size를 계산하고 peak의 intensity와 비교하여 열처리와 도핑이 산화니켈 박막의 품질에 미치는 영향을 관찰했다. UV-Vis으로 투과도 측정 후 밴드갭을 계산하였고 도핑농도와 열처리온도에 의한 변화를 확인했다. 홀 측정으로 캐리어 농도, 이동도 등 전기적 특성을 관찰했으며 양수로 측정된 캐리어 농도로 P-type 도핑이 됨을 확인했다. 전기적 특성 변화를 분석하기 위한 XPS 측정을 했고, Ni^{2+}, Ni^{3+} 이온들로 인한 oxygen vacancy의 증가 또는 감소에 인한 것으로 확인됐다[3]. 이 연구로 미스트화학기상증착법을 이용하여 다양한 특성을 가진 산화니켈 박막을 얻었고 소자에 응용을 할 수 있을 것으로 기대한다.
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PG1A-27 | 사파이어 기판 오리엔테이션 변화에 따른 이종성장 합성 다이아몬드 박막 연구

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다이아몬드는 5.5 eV의 넓은 밴드갭을 갖는 반도체 소재로 열적 특성이 우수한 것으로 알려져 있다[1]. 합성 다이아몬드의 크기와 결함 밀도를 제어하는 것은 광학, 전자 소자와 같은 응용 분야에서 필요한 연구 분야이다. 이를 달성하기 위해 다양한 기판에서의 다이아몬드 이종성장 연구가 수행되고 있다[2], [3] 다이아몬드 성장은 MPCVD를 이용하였고 BEN을 통해 핵생성을 해주었다. 본 연구에서는 α-Al_2O_3를 기판으로 사용하고 수평형 미스트 CVD를 이용하여 α-Ga_2O_3를 성장시켜 버퍼레이어로 활용하였다. 기판뿐 아니라 다양한 면방향에서의 다이아몬드 이종성장을 관찰하기 위해 사파이어 c-, a-, m-, r-plane의 면방향을 사용하였다. 사파이어와 산화갈륨은 같은 롬보헤드랄 결정 구조를 가지고 있어 산화갈륨 에피 성장이 가능하다. 이때 산화갈륨에 추가로 Al을 고용시켜 줌으로써 격자불일치 제어가 가능해지고 열 안정성이 향상되어 다이아몬드 성장에 필요한 고온을 버티게 해준다. 또한 수소 플라즈마에 의한 에칭을 막아주기 위해 Rf sputtering 장비를 이용하여 산화갈륨 위에 이리듐을 증착하였다. 다양한 사파이어 면방향에서 성장한 Diamond/Iridium/AlGO/Al_2O_3 층은 XRD 2theta, rocking curve 측정을 통해 성장한 박막의 결정 방향과 품질을 확인하였다. 다이아몬드의 성장특성을 관찰하기 위해 라만 스펙트럼 분석을 진행하였고 D피과 G피의 비율을 확인하였다. 성장시킨 각 층의 표면형상과 박막 두께는 FE-SEM을 통해 관찰하였다. 합성 다이아몬드의 대면적화를 위해 다양한 이종 기판과 버퍼레이어에 대한 연구가 필요하다.

Keywords: Alluminium gallium oxide, Iridium, Microwave plasma Chemical Vapor Deposition, Hetero-epitaxial Diamond

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PG1A-28 | 아연-공기 전지용 이중 기능성 (산소 환원/발생 반응) 촉매로서 다중 음이온 전이 금속 화합물 설계 및 합성

김민[1], 김주형[1], *강윤찬[1]
[1]고려대학교

전자 이동에 유리한 전자 구조를 갖는 다중 음이온 전이 금속 화합물은 유망한 산소 전극 촉매 소재중 하나이다. 본 연구는, 높은 성능의 아연-공기 전지 구현을 위해 수증기 열처리 및 음이온 교환 전략을 사용하여 코발트 수산화 셀렌화물(Co(OH)Se)과 질소 도핑 탄소 (C)의 구조체 (C@Co(OH)Se)를 합성하여 산소 전극에 적용하였다. 상온 및 상압 조건에서 합성된 C@Co(OH)Se는 조성적 특성과 구조적 특성의 시너지 효과에 의해 산소 환원 반응과 산소 발생 반응에 대한 우수한 전기 촉매 활성을 나타내었다. 나아가 C@Co(OH)Se 기반 아연-공기 전지는 약 7,000분의 사이클 구동 후에도 높은 사이클 안정성에 따른 좁은 충•방전 전위차 (1.01 V)를 나타냈으며, 우수한 속도 특성 (전류밀도 15 mA cm-2에서 1.25 V)을 보였다. 산소 환원 및 발생 반응에 대한 이중 기능성 전기 촉매로서의 코발트 수산화 셀렌화물의 사용 가능성을 입증하고, 전이 금속 화합물과 탄소 매트릭스를 복합화 하는 기술을 제시함으로써 본 연구는 전기 촉매 설계 및 합성의 범위를 확장하는 데 도움이 될 것으로 기대된다.

PG1A-29 | 독특한 이중층 에틸렌 가스 센서의 촉매용 요크-쉘 구조의 Pd-V_2O_5-TiO_2 합성 및 평가

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식물 호르몬 기체인 에틸렌을 정밀하게 검출하는 것은 식물의 건강과 상태를 점검하는 데 필수적입니다. 하지만 에틸렌의 간단한 화학 구조와 낮은 반응성 때문에 민감하고 독점적인 검출은 높은 수요에도 불구하고 큰 과제입니다. 본 연구에서는 요크쉘 구조의 Pd 도핑 V_2O_5-TiO_2 촉매 상층과 할로우 구조의 In_2O_3 감지 하층으로 구성된 혁신적인 에틸렌 가스 센서를 제안합니다. 해당 에틸렌 가스 센서는 요크쉘 구조의 Pd-V_2O_5-TiO_2 촉매층이 에틸렌을 더 나은 반응성을 갖는 아세트알데하이드로 개질하고, 간섭 가스를 비반응성 형태로 필터링하는 효과를 통해 광범위한 작동 온도 범위 (300–400 °C)에서 현저하게 향상된 선택적 감지 능력을 보였습니다. 본 연구에서 제안한 독특한 구조의 이중층 가스 센서가 실제 과일의 숙성 정도를 모니터링하는 데 사용될 수 있음을 확인했습니다.

PG1A-30 | 백투백 다이오드 광 소자를 이용한 다중 광전 논리게이트

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The explosive increase for vast data processing has sparked interest towards a novel logic gate as conventional electronic logic gates face limitations in accurate and fast computing. Accordingly, optoelectronic logic gates (OELGs) based on photodiodes are of significant interest due to their broad bandwidth and fast transmission speed, but complex structure, power consumption, and low accuracy issues are still inherent in these systems. Herein, we present a universal OELG based on the bipolar spectral photo-response characteristics of a back-to-back perovskite photodiode (BPD) having a back-to-back diode structure. Five basic logic gates (“AND”, “OR”, “NAND”, “NOR”, and “NOT”) are demonstrated with only a single BPD by current polarity control. For practical applications, we propose a single chip-level OELG of integrated 64 BPD pixels, demonstrating the 100% accuracy in five logic gate operations.

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PG1A-31 | V_2O_5 첨가가 $(1-x)Li_{2.08}TiO_3$-$xLi_2ZnTi_3O_8$ (x=0.4~0.6) 유전체의 소결 및 마이크로파 유전특성에 미치는 영향

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저온동시소성세라믹(LTCC)용 마이크로파 유전체 제조를 위해 모 조성으로 양(+)의 공진주파수온도계수(τ_f) 값을 갖는 $Li_{2.08}TiO_3$와 음(-)의 τ_f 값을 갖는 $Li_2ZnTi_3O_8$의 복합체 조성물 $(1-x)Li_{2.08}TiO_3$-$xLi_2ZnTi_3O_8$ (x=0.4~0.6) 조성을 제조하였다. 전 조성 범위에서 소결 조건은 1300 °C 2 시간이었으며 이 때 얻어진 유전체의 소결밀도는 이론밀도의 98%였다. $Li_2ZnTi_3O_8$의 함량이 x=0.4에서 0.6으로 증가함에 따라 유전체의 τ_f 값은 +6.44에서 -3.34ppm/°C로 감소하였으며 유전율(ε_r)은 25.24에서 26.42로 증가하였고 품질 계수(Q×f) 값은 58,641GHz에서 71,778GHz로 증가하는 경향을 나타냈다. 특히 $0.5Li_{2.08}TiO_3$–$0.5Li_2ZnTi_3O_8$ 조성의 복합체에서는 ε_r=25.52, Q×f=68,298GHz, τ_f=+1.13ppm/°C 값의 우수한 마이크로파 유전 특성을 나타내었다. 본 연구에서는 우수한 마이크로파 유전특성을 보이나 소결 온도가 1300 °C로 높아 LTCC 적용이 불가능한 $0.5Li_{2.08}TiO_3$–$0.5Li_2ZnTi_3O_8$ 유전체에 소결 조제로 V_2O_5를 사용하여 V_2O_5의 첨가량에 따른 $0.5Li_{2.08}TiO_3$–$0.5Li_2ZnTi_3O_8$ 유전체의 소결특성 및 마이크로파 유전특성의 변화 및 Ag 전극과의 반응성을 분석하여 통신용 마이크로파 LTCC 유전체로의 적용 가능성을 타진하였다.

PG1A-32 | 소결 온도에 따른 MLCC용 KNN ($K_{0.5}Na_{0.5}NbO_3$)계 유전체의 유전특성 확인

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4차 산업 발달에 따라 전자기기에 쓰이는 MLCC (Multilayer Ceramic Capacitor)의 적용 영역이 함께 넓어지면서 더 많은 정전용량과 더 높은 파괴전압을 가지는 고 신뢰성 MLCC를 필요로 하고 있다. 이것을 목표로 비납계 Perovskite구조 KNN($(K_{0.5}Na_{0.5})NbO_3$)계 유전체를 사용하여 후막(thick film, green sheet)을 제조하였고 이를 사용하여 샘플을 제작하였다. 본 연구에서는 KNN계 유전체를 사용하여 테이프 캐스팅(tape-casting)으로 후막을 제조하였고 muti layer 유전체 층을 쌓아 유전체 sheet sample을 제작하였다. 샘플 제작 과정에서 각 샘플의 소결 분위기를 다양하게 조절하여 유전체의 산화 환원 거동을 확인하였다. 소결 분위기별 각 샘플의 유전 파괴 전압을 측정한 결과 BNT계 유전체 대비 향상된 유전특성을 확인할 수 있었다

PG1A-33 | BNT계와 BT-BNT계 MLCC의 유전 특성 및 산화환원 거동

하송아[1], 황경미[1], 박홍우[1], 이주현[2], 조욱[2], 조경수[3], 조용수[3], 이성철[4], *이순일[1]
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최근 자동차 전장화로 인해 MLCC(Multilayer Ceramic Capacitor)의 수요가 늘어나고 있으며, 항복 강도가 높고 고온 및 고전압에서 사용될 수 있는 MLCC 개발이 요구되고 있다. 이를 해결하기 위하여 상전이 온도가 높은 비납계 BNT계 및 BT-BNT계 유전체와 첨가제를 이용해 조성을 제어한 전극을 사용하여 고온 및 고전압 환경에서 사용될 수 있는 전장용 MLCC를 제조하였고, 동시소성을 위해 분위기를 조절하여 산화환원 거동을 확인하였다. 본 연구에서는 BNT 및 BT-BNT 기반의 green sheet 의 최적화를 위해 조성을 제어하였고, 스크린 프린팅을 통하여 Ni 전극을 인쇄하였다. 또한 산화환원 거동을 확인하기 위해 유전체와 전극의 분위기에 따른 소결 및 열처리를 진행하여 다양한 샘플을 제조하였다. 본 연구를 통해 BNT계 및 BT-BNT계 유전체를 이용한 MLCC의 제조 가능성을 제시하였으며, 유전체 후막의 특성 및 Ni 전극의 산화환원 거동을 확인할 수 있었다.

PG1A-34 | 단일 종류의 도펀트 입계 편석을 통한 고전계 및 고온 환경에서의 안정적인 유전 특성의 세라믹 커패시터

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High permittivity multi-layer ceramic capacitors play a crucial role in numerous electronic devices and systems, providing stable current supply and utilized for

noise filtering, bypassing, and coupling. To fulfill these roles more effectively, ceramic capacitors are required to have high relative-permittivity and low dielectric loss. Furthermore, to ensure practical operability, maintaining stable relative-permittivity even under high DC-bias and temperature environment is imperative. As a result, in order to achieve dielectric functionalities including high stability, relative-permittivity and low dielectric loss, various types of additives are utilized with $BaTiO_3$ dielectric matrix in typical ceramic capacitors. However, in this study, highly sufficient reliability can be achieved utilizing atomic-scale grain-boundary segregation of a proper single-type acceptor only a single-type acceptor, not utilizing the various types of additives. Especially, dielectric oxides mixed with specific acceptor additives that can effectively inhibit grain growth exhibit remarkably low dielectric loss encompassing stable relative-permittivity under high DC-bias and temperature. The grain growth suppression enables the straightforward attainment of polycrystalline dielectric oxides of various grain size to meet specific requirement. Atomic-level imaging and compositional analyses are readily performed on grain-boundary region and the narrow distribution width of dopant with several unit cells at grain boundaries are directly clarified. This study demonstrates that it is feasible to achieve exceptional dielectric properties by using only a single-type of acceptor dopant.

PG1A-35 | 고전력 응용처를 위한 Mn-doped PYN-PMN-PT 압전 세라믹스

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In this study, we present our findings regarding the structural, piezoelectric, and high-power characteristics of Mn-doped ceramics with the composition 0.15Pb(Yb1/2Nb1/2)O3-0.48Pb(Mg1/3Nb2/3)O3-0.37PbTiO3, denoted as 0.15PYN-0.48PMN-0.37PT, which are intended for use in high-power transducer applications. We focused on three key attributes: a high mechanical quality factor (Qm), a high piezoelectric strain coefficient (dij), and a high Curie phase transition temperature (Tc). Through Mn doping, we observed an increase in the tetragonal phase proportion within the 0.15PYN-0.48PMN-0.37PT ceramics. This doping process also led to the formation of oxygen vacancies, which had a significant positive impact on the Qm due to their combined influence. Despite the inherent stiffening effect associated with this modification, we maintained a high value of the piezoelectric coefficient (d33). This was achieved by promoting an enlargement in grain size. Remarkably, the sample doped with 3 mol% of Mn showcased impressive piezoelectric properties, specifically d33 measuring 345 pC/N, Qm reaching 1159, and Tc of 207℃. Furthermore, this specimen demonstrated a substantial vibration velocity of 0.6 m/s under conditions where the equilibrium temperature rise (ΔT) was kept below 20℃. This observation substantiates its considerable potential for applications in high-power transducers, where efficient conversion of energy is vital.

PG1A-36 | Microwave Dielectric Properties of $(Mg_{1-x}Zn_x)(Ti_{0.95}(Mg_{1/3}Nb_{2/3})_{0.05})O_3$ ceramics

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Effects of Zn^{2+} substitution for Mg^{2+}- site on the microwave dielectric properties of $(Mg_{1-x}Zn_x)(Ti_{0.95}(Mg_{1/3}Nb_{2/3})_{0.05})O_3$ ($0.00 \leq x \leq 0.05$) ceramics were investigated. $(Mg_{1-x}Zn_x)(Ti_{0.95}(Mg_{1/3}Nb_{2/3})_{0.05})O_3$ (MZTMN) ceramics were prepared by conventional solid-state reaction and sintered at 1400°C for 4h. All of the specimens showed higher relative density than 95% and no secondary phase was detected with the change of the molar ratio of MgO/TiO_2. With the increase of Zn^{2+} contents, the dielectric constant(K) increased slightly due to the higher dielectric polarizability of Zn^{2+}(2.04Å^3) than that of Mg^{2+}(1.32Å^3). The quality factor(Qf) of the sintered specimens with Zn^{2+} substitution (x) for Mg^{2+}-site was improved up to x = 0.01, and then decreased. These results could be attributed to the change of degree of covalency of the sintered specimens. Temperature coefficients of the resonant frequency (TCF) of MZTMN ceramics were dependent on the degree of average oxygen octahedral distortion of ilmenite structure.

PG1A-37 | 투명전극용 $NiTe_2$ 박막의 액상 박리 공정에서의 혼합용매 비율 최적화

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투명전극 소재로써 유망한 $NiTe_2$ 박막은 2차원 적층 구조를 갖고 있으면서 전기전도도가 높고, 광 투과성을 극대화하기 위해서는 박막의 전기 저항의 증가를 최소화하면서 박막의 두께를 낮출 수 있는 박리과정이 필요하다. 본 연구에서는 투명전극용 $NiTe_2$ 박막의 액상 박리 공정에 대하여 혼합 용매로 에탄올, 아세톤, 탈 이온수의 비율을 최적화하였다. 혼합 용매 부피 비율은 2:4:4, 3:3:4, 그리고 4:2:4(에탄올:아세톤:탈 이온수)로, 다음과 같은 세가지 비율의 혼합 용매에 대해 유리 기판 위에 증착한 $NiTe_2$ 박막을 8시간 동안 초음파 박리하였다. 세가지 혼합 용매에

서 $NiTe_2$ 박막은 두가지 메커니즘으로 박리 되었으며, 액상 박리 공정 초기에는 기판-박막 입자 간 박리가, 6시간 이상 공정을 진행할수록 층별 박리가 우세함을 2시간 단위로 투과율의 차이를 분석하여 확인하였다. 세가지 혼합용매 조건 중 3:3:4 혼합 부피 비율이 타 조건에 비하여 효과적으로 전기저항을 억제하였고, 8시간 액상 박리 공정 후 NiTe2 박막의 투과율을 59.6%에서 68.4%로 향상시켰다.

PG1A-38 | Microwave dielectric properties of $Mg_{2-x}(Li_{1/2}Al_{1/2})_xSiO_4$ ceramics

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Effects of $(Li_{1/2}Al_{1/2})^{2+}$ substitution for Mg^{2+}-site on microstructure and microwave dielectric properties of $Mg_{2-x}(Li_{1/2}Al_{1/2})_xSiO_4$ ($0 \le x \le 0.1$) ceramics were investigated. For the $Mg_{2-x}(Li_{1/2}Al_{1/2})_xSiO_4$ specimens sintered at 1525°C for 3h, a single phase with forsterite structure was detected through the entire range of compositions. The dielectric constant (K) of the specimens decreased with $(Li_{1/2}Al_{1/2})^{2+}$ substitution (x) due to the lower dielectric polarizability of $(Li_{1/2}Al_{1/2})^{2+}$ (0.995Å^3) than that of Mg^{2+} (1.32Å^3). Quality factor (Qf) of the specimens are strongly depended on microstructural characteristics. With the increase of $(Li_{1/2}Al_{1/2})^{2+}$ substitution (x), the Qf of the specimens sintered at 1525°C for 3h was increased up to x=0.05 and then decreased due to the decrease of grain size. With the increase of $(Li_{1/2}Al_{1/2})^{2+}$ substitution (x), the temperature coefficient of resonant frequency (TCF) of the specimens was not changed remarkably. Effects of crystal structural on the microwave dielectric properties were also discussed.

PG1A-39 | Optimizing Black Tio_2 Synthesis Process for Safe and Mass Production

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TiO_2 is one of the most widely used materials for photocatalysts. It is Black TiO_2 that improves photocatalytic properties by reducing the surface of TiO_2 to form a defect and inducing color changes. However, In these day many methods use H_2 gas and therefore have disadvantages in terms of mass production and stability. To solve this problem, we synthesized black TiO_2 without using H_2 gas using solid state method. Through this method, we mass-produced black TiO_2 that can be applied to various applications.

PG1A-40 | THz-TDS analysis of metallic composite film on electric field-enhanced resonance structure

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Metamaterials have been explored with various type of materials including metals, semiconductors, dielectrics, and their different combinations for terahertz (THz) research area [1], with an advantage of enhancing the THz field amplitude at certain frequency. In this study, for such purpose, we investigated metallic composite films with a variation in total weight-percentage of Ag micro-particles in polymer matrix [2], which were deposited on gold split ring resonator (SRR) structures. Optical properties of metallic composite films with various weight-percentage of conductive fillers, refractive index n and extinction coefficient k in this study, were extracted by THz-TDS transmittance measurement. We also compared the transmittance difference of the four different ring resonator structure with/without the deposition of metallic composite film to detect effect of the increased absorption cross-section induced by electric field-enhancement in the split gap of the ring pattern.

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PG1A-41 | Dielectric properties of $BaTiO_3$ with various oxide additives

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Effects of transition metal oxides (Mn_3O_4, V_2O_5) and dysprosium oxide on the structural and dielectric properties of $BaTiO_3$ were investigated. For the specimens sintered at 1300-1350°C for 1h in air, a single phase of $BaTiO_3$ (BT) with perovskite structure was detected for the specimens doped-with Mn_3O_4 and Mn_3O_4-Dy_2O_3 (MnDy), however, a secondary phase of $BaVO_3$ along with main phase of BT was detected for the specimens doped-with V_2O_5 and V_2O_5-Dy_2O_3 (VDy). From the results of the larger tetragonality and unit cell volume of the specimens doped-with MnDy and VDy than those of the specimens doped-with Mn_3O_4 and V_2O_5, Dy^{3+} ion was substituted for Ti-site. The specimens

doped-with MnDy and VDy showed higher dielectric loss than that of the specimens doped-with Mn_3O_4 and V_2O_5 due to the formation of positively charged oxygen vacancy compensating for Dy'_{Ti}. Resistivity and breakdown voltage were dependent on their microstructure of the sintered specimens.

PG1A-42 | Application of NbS_2 Synthesized via Molten Salt Method in Gas Sensing Devices

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Gas sensing technology plays a pivotal role in various industries, enabling real-time monitoring and detection of hazardous gases. Transition metal dichalcogenides (TMDs) have garnered significant attention as promising materials for gas sensing applications due to their unique electronic properties. In this study, we explore the application of niobium disulfide (NbS_2) synthesized using the molten salt method as a sensing material for gas detection devices. The molten salt synthesis approach offers a facile and scalable method to produce high-quality NbS_2 layered materials. Gas sensing devices were fabricated using the synthesized NbS_2, and their performance was evaluated for various target gases. This study sheds light on the promising applicability of NbS_2 synthesized via the molten salt method in gas sensing devices. Given its layered structure, the increased presence of edge sites in NbS_2 is poised to further enhance its gas sensing capabilities. Through optimization of sensor parameters and the exploration of potential composite materials, the heightened edge-site density could potentially lead to even greater sensitivity and selectivity in NbS_2-based gas sensors. This advancement paves the way for the development of advanced gas monitoring systems characterized by heightened accuracy and reliability, thus addressing critical needs in various industrial and safety applications.

PG1A-43 | All-solid-state electrochromic lithium ion battery with $L_4T_5O_{12}$ and NiO films fabricated by the magnetron sputtering method

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Electrochromic energy storage devices (EESDs) can be used for a variety of electronic applications such as static displays and smart windows. All-solid-state thin film Li-ion batteries would be the most ideal energy storage devices for electrochromic microelectromechanical systems (MEMS) integrated with energy harvesters. However, it is difficult to develop EESD with both the high performance of electrochromic and stable battery characteristics. Therefore, in order to manufacture an optimal electrochromic device, $Li_4Ti_5O_{12}$ (LTO), NiO electrodes, and a LiPON solid electrolyte were deposited using a reactive frequency magnetron sputtering method. It was found that the LTO thin film showed high capacity and cycling stability as battery performance and excellent electrochromic performance in the visible region. Thanks to its complementary electrochromic behavior with the NiO anodes, the fabricated all-solid-state EESD exhibits excellent electrochromic performance, including a wide range of optical modulation, high coloration efficiency, and cycling stability during the coloring and bleaching process. This all-solid-state EESD is expected to significantly reduce energy consumption with the application of electrochromic electronic devices.

PG1A-44 | The Role of Intensive Pulsed Light (IPL) on Gas-sensing Properties of Titanate nanosheets to HCHO at Room Temperature

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In recent years, the precise detection of Volatile Organic Compounds (VOCs) has gained increasing significance due to their impact on both the environmental and human health. Among various VOCs, formaldehyde (HCHO) is recognized as a pollutant in indoor air and has been classified as a human carcinogen. Conventional gas sensor technologies have faced limitations in terms of their response speed, sensitivity, and ability to distinguish between difference gases. Consequently, the development of high-performance gas sensors with excellent selectivity, low operating temperature, fast response, and short recovery time has become imperative for effective detection and analysis of HCHO gas. The advancement of nanotechnology has opened up opportunities to modify the surface structure and properties using low-dimensional materials. Among them, 2D materials have gained significant interest due to their unique physical and chemical properties, attributed to quantum size effects and distinctive surface

chemistry. In this study, we investigated the surface structural changes of 2D $Ti_{0.87}O_2$ nanosheets and the photocuring effect using Intense Pulsed Light (IPL). We developed a room temperature chemical sensor that effectively utilizes these characteristics for gas detection. To achieve this, we conducted experiments targeting formaldehyde gas and studied the correlation between surface changes induced by IPL on $Ti_{0.87}O_2$ nanosheets and the detection of HCHO gas. As a result, we observed the formation of Ti metal particles and nanopores on the surface of $Ti_{0.87}O_2$ nanosheets after IPL treatment. We also confirmed the accelerated response and recovery rate to HCHO gas at room temperature. This research provides new insights into surface structure control and gas detection using nanotechnology and the photocuring effect, contributing to the development of efficient gas sensors based on $Ti_{0.87}O_2$ nanosheets.

PG1A-45 | Enhanced homogeneous p-n junction performance in oxygen vacancy passivation with H_2O_2 oxidant/N doped ZnO

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Producing p-type ZnO faces challenges due to abundant donor defects, mainly oxygen vacancies (V_O), prevalent in ZnO, which counteract p-type doping effects, causing low hole concentrations. Thus, neutralizing V_O in ZnO films is crucial for p-type ZnO creation. This study employed thermal atomic layer deposition (ALD) to generate N-doped ZnO, passivating V_O with H_2O_2. H_2O_2-50% was identified as the most effective approach for V_O neutralization in N-doped ZnO film synthesis. Electron concentration in N-doped ZnO reduced from 2.27×10^{16} to 1.02×10^{12} cm^{-3}, enhancing p-type ZnO fabrication potential. Introducing nitrogen (direct H_2O_2 dosing after $NH_3 \cdot H_2O$) and F co-doping yielded high-quality p-type ZnO with a hole concentration of 9.28×10^{17} cm^{-3}. Furthermore, a uniform ZnO p-n junction was constructed, utilizing H_2O_2-treated N and F co-doped ZnO as p-type and pristine ZnO as n-type, demonstrating enhanced rectification properties. Acknowledgement: This work was supported by the National Research Foundation of Korea(NRF) grant funded by the Korea government. (MSIT) (RS-2023-00208801).

PG1A-46 | Filamentary and interface-type memristors for energy-efficient neuromorphic hardware based on tantalum oxide

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This research experimentally demonstrated the filamentary and interface-type resistive switching (RS) behaviors of tantalum oxide (Ta_2O_5 and TaO_2)-based on devices grown by atomic layer deposition. Ta_2O_5 is one of the attractive candidates for non-volatile resistive random-access memory (RRAM), but the filament-type RS behavior of Ta_2O_5 significantly affects the reliability of RRAM. Therefore, this study redesigned a TaO_2-based interface-type RRAM device, and compared it with a Ta_2O_5-based device, which exhibits localized conducting filament formation. The TaO_2-based interface-type RS device exhibited gradual RS characteristics and area-dependency in both high and low resistance states. In addition, compared to the filamentary RS device, the RS behaviors of the TaO_2-based interface-type device exhibited higher suitability for neuromorphic, symmetric, and linear long-term potentiation and long-term depression. The results of this study will contribute to the understanding of Ta–O system-based RRAM by exploring both filamentary and interface resistive-switching mechanisms. Acknowledgement: This work was supported by the National Research Foundation of Korea(NRF) grant funded by the Korea government. (MSIT) (RS-2023-00208801).

PG1A-47 | Aerogel thin films with ultralow dielectric constant for interlayer dielectric

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In the process of shrinking integrated circuits, one of the most significant challenges has been an increase in the resistance and capacitance delay. The introduction of porosity may lead to a reduction in permittivity but at the expense of a fall in strength. It has been proposed that nanodevice connection technology might benefit from a thin film composed of highly porous cross-linked silica aerogel. This film would have an ultralow-κ value of 1.7. In order to achieve a high elastic modulus ($\rangle$ 5.1 GPa), cross-linking with an epoxide ring-opening reaction was used. The films were stable enough to withstand the chemical mechanical polishing process as well as the plasma dry etching process. Films made of aerogel have a thickness

of roughly 700 nm and a surface that is hydrophobic. The proposed aerogel films are a next-generation ultralow dielectric constant candidate material to be applied to interlayer dielectric materials.
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PG1A-48 | 콜로이드 발광 나노 물질의 직접 광촉매 패터닝

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Colloidal metal halide perovskite nanocrystals (PeNCs) have been recognized as a promising material class for next-generation realistic displays, owing to their excellent color purity. Precise patterning method should be developed to fabricate red-green-blue full-color pixel arrays with PeNCs. However, the traditional photolithography often results in the degradation of the emissive properties of PeNCs. Direct optical lithography uses the change in solubility due to a chemical reaction upon light source irradiation to pattern PeNCs. However, the photo-induced chemical reaction often affects the passivation of PeNCs. Herein, we present a non-destructive direct photocatalytic patterning method to pattern PeNCs. The strong photocatalytic activity of PeNCs enables the thiol-ene reaction at a low light intensity dose (~30 mJ cm^{-2}). High-resolution patterns (< 1 μm) were achieved without compensating the emissive properties. Our method is widely applicable to other classes of nanomaterials, which provides a non-destructive and simple way to pattern various semiconducting materials for various optoelectronic devices.

PG1A-49 | $(1-x)Pb(In_{1/2}Nb_{1/2})O_3-5Pb(Mg_{1/3}Nb_{2/3})O_3-xPbTiO_3$ 의 MPB 조성의 온도 안정성 향상 전략

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Even though piezoelectric materials possess excellent piezoelectric properties, their low Curie temperature can impede its practical applications. $Pb(In_{1/2}Nb_{1/2})O_3-Pb(Mg_{1/3}Nb_{2/3})O_3-PbTiO_3$ (PIN-PMN-PT) ternary system is considered one of promising candidates for high-power piezoelectric devices due to its good piezoelectric properties, high Curie temperature, and coercive field. Investigating the changes in piezoelectric properties induced by thermal energy is crucial for practical applications. In this study, the depolarization behavior and temperature dependence of piezoelectric properties of (1-x)PIN-5PMN-xPT ceramics was investigated to contribute understanding for the degradation mechanism of piezoelectric properties in the temperature range from room temperature to Curie temperature. To achieve this, we conducted measurements to analyze the temperature dependence of piezoelectric properties.

PG1A-50 | Advancing High Integration in LTCC Technology: Ultra-Thin Electrode Fabrication with 2D Metallic Nanoplates and IPL Sintering

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As the demand for sensors and electronic devices continues to rise across various applications, such as autonomous vehicles and 5G communication, achieving multilayer integration of ceramic dielectrics and inner electrode layers using Low-Temperature Co-fired Ceramic (LTCC) technology has become crucial. To enable high integration, it is necessary to thin down the substrate and electrode layers that comprise these materials. In this study, we propose an innovative approach to fabricate ultra-thin electrodes by combining the techniques of Electrospray Deposition, 2D metallic nanoplates, and intense pulsed light (IPL) sintering. The geometry of high commercial value Ag, Cu, Cu-Ni nanoplates can be precisely controlled through hydrothermal synthesis by adjusting parameters such as synthetic temperature, time, and surfactant. By subjecting the electrode structure to just 240 ms of IPL sintering, we achieved exceptional conductivity ($3.16x10^{-8}$ ohm·m) and a remarkable electrode thickness of 100 nm. This approach offers an economical and high-speed IPL sintering process, coupled with the synthesis of proper 2D metallic nanoplates. Consequently, this economical, high-speed IPL sintering process, combined with the synthesis of precise 2D metallic nanoplates, would be an attractive strategy for advancing LTCC technology to achieve high integration for next-generation electronic devices.

PG1A-51 | Anti-ferroelectric $Hf_{1-x}Zr_xO_2$ by Interface Engineering

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$Hf_{1-x}Zr_xO_2$ ferroelectric memories are one of the most promising candidates for next-generation non-volatile memory due to their CMOS compatibility and high

scalability. According to their different composition ratios of HfO_2 and ZrO_2, which lead to multiple phases such as orthorhombic and tetragonal, resulting in ferroelectric and anti-ferroelectric behavior. Anti-ferroelectric devices cannot be used for non-volatile memory because they don't have remnant polarization. Nevertheless, introducing interface layer can generate built-in bias field via interfacial dipole or fixed charges between the layers, enabling non-volatility of the device. In this research, we fabricated HZO-based anti-ferroelectric capacitors with different interface layer which affects HZO anti-ferroelectricity.

PG1A-52 | 고성능 프러시안 화이트 양극소재 구현을 위한 최적화 합성 공정에 관한 연구

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프러시안 화이트(Prussian white, PW)는 $A_2TM^{II}[Fe^{II}(CN)_6]$의 화학식을 가지는 금속-유기 골격체로, 시안기(CN^-)와 그 양 옆에 TM^{II}과 Fe^{II}이 결합하여 이룬 정육면체 형태의 골격체와 격자 내 A-site가 모두 알칼리 이온으로 점유된 구조이다. TM^{II}와 Fe^{II}는 각각 N과 C에 배위하며, N과 C의 서로 다른 리간드 힘에 의해 N과 결합한 TM^{II}은 하이 스핀(HS), C와 결합한 Fe^{II}는 로우 스핀(LS) 전자 구조를 갖게 된다. PW는 방향으로의 넓은 이온 확산 채널을 가지므로 리튬 이온 이외에도 상대적으로 이온 반경이 큰 알칼리 이온을 삽·탈리할 수 있어 차세대 이차전지의 양극소재로서 큰 주목을 받고 있다. PW는 공침법을 통해 간단하게 합성할 수 있다는 장점이 있으나, 합성 중에 핵 생성과 핵 성장 단계가 거의 동시에 일어나면서 입자들이 무작위적으로 응집하여 필연적으로 결정 내부에 $[Fe(CN)_6]$ 공공이 형성되고, 결정수가 그 자리를 차지하게 되면서 전기화학 성능 저하를 야기한다는 한계가 존재한다. 따라서 고성능 PW소재의 실현을 위해 핵 생성속도와 성장속도를 통제할 수 있는 전략을 도입하여 결함을 제어하는 것이 반드시 필요한 상황이다. 본 연구에서는 PW의 결함 억제와 형상 제어를 위해 합성 온도, 합성 시간, 킬레이트제 첨가 여부, 용존 기체 제어를 통한 합성 분위기 등의 변수를 치밀하게 조절하여 다양한 조건 하에서 PW를 합성했으며, 여러 물성 분석을 통해 결함 제어 여부를 확인했다. 또한 합성 조건에 따른 PW의 전기화학 성능 평가를 통해 결함 정도와 전기화학 성능 간의 상관관계를 분석하고, PW 양극소재 합성의 최적화 공정을 제시했다. 본 연구는 소재의 한계를 극복하고, 재료의 구조 및 물성을 제어할 수 있는 합성법을 확보함으로써 고성능 PW 양극소재 디자인에 관한 후속 연구에 긍정적인 효과를 제공할 것이라 기대한다.

PG1A-53 | Photo assisted ferroelectric synaptic devices for imitating visual learning

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Recently there have been many researches for developing hardware neural network in order to overcome the calculation complexity of software implementation. Ferroelectric memristor is one of the emergent non-volatile memristor as artificial synaptic device, which has analog resistive switching with high stability. We prepared a BFO thin film based ferroelectric memristor for photo-assisted synaptic device by using pulsed laser deposition (PLD). We choose $BiFeO_3$ (BFO) due to its capability to exhibit photovoltaic effect in the visible light, attributed to its smaller bandgap (< 2.5 eV) compared to other perovskite materials. We optimized the thickness of the BFO thin film for light absorption and investigated time dependent photoconductivity. We evaluate the synaptic properties; analogue switching, spike-time dependent plasticity (STDP), and long-term plasticity for non-volatile memory characteristic of FeRAM based on $BiFeO_3$. These results can be novel approach for next generation artificial intelligence devices.

PG1A-54 | Van der Waals Interface Engineering for Enhancement of Semiconductor Device Performance

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In this paper to overcome the major difficulties faced in the semiconductor manufacturing process to make semiconductor devices smaller, this study proposed two solutions that utilize van der Waals interface formation at the dielectric/semiconductor interface and metal/semiconductor interface. Van der Waals interface formation at the dielectric/semiconductor interface was formed by stacking an amorphous hydrocarbon dielectric layer on the TMD channel of the transistor. Using a two-dimensional TMD material with an atomically thin thickness as a channel can overcome the difficulties of existing three-dimensional materials. However, the adsorption of external molecules by van der Waals attraction on the surface of the TMD channel is a new problem that degrades the performance of the TMD transistor. In this study, a large-scale grown amorphous hydrocarbon layer was successfully laminated on the MoSe2 channel to prevent molecular adsorption. As a result, the electrical driving performance and long-term stability of the MoSe2 transistor were demonstrated. Van der Waals interface formation at the metal/semiconductor interface was formed by inserting a WSe2 interface layer into the metal/semiconductor interface. The inserted WSe2 interface layer prevents

atomic diffusion of metal atoms into the semiconductor lattice during the metal deposition process for forming an electrode, alleviates interface defects, and improves charge behavior. As a result, the diode's rectification characteristics and the transistor's driving performance were improved. Such results can overcome difficulties in the metal deposition process in the process of refining semiconductor devices. These research results are expected to contribute to the development and advancement of semiconductor devices in the future.

PG1A-55 | 강상관계물질인 NiWO4에 도핑에 의한 양자역학적 전자 전이

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Strongly correlated electron systems (SCES) show polaronic hopping transport between cations, guiding electron/hole pairs along to cations as d+n+1,d+n-1. In this study, we introduce a quantum-mechanical tunneling (QMT) transport model within the tailored electron correlation NiWO4 SCES insulator. NiWO4 occupyingelectron correlations between Ni-Ni pairs exhibit a charge gap of approximately 3eV, accompanied by an antiparallel spin arrangement. The QMT model derived from the Jonscher-power law analysis of AC conductivity measurements, revealing a frequency-dependent constant denoted by 'n' that remains independent of temperature. To enhance carrier transfer by modifying activation barriers, we perform the different amount of substitutional doping within the NiWO4 matrix using Fe and Co. As a result, Fe-doped NiWO4 reveal increased carrier conductivity, following an altered QMT model stemming from reduced electron correlation. The capability to modulate electron tunneling conductivity through cation correlations in NiWO4 offers intriguing possibilities for advanced semiconductor applications, such as spintronics or neuromorphic computing. This work not only advances our understanding of SCES behavior but also provides valuable inspiration for the development of cutting-edge technologies.

PG1A-56 | $K_{1-x}Li_xNbO_3$ (KLN) synthesis method for reducing secondary phase, and observation of dielectric properties according to changes in composition of $K_{1-x}Li_xNbO_3$ (KLN)

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Due to the development of electronic products, miniaturization and a large capacity of passive devices are required. And to meet such needs, strengthening the performance of the dielectric materials inside the passive device has become an indispensable task. The need for dielectric materials that exceed the performance of BT-based ferroelectric currently used is emerging. Various experiments are conducted to exceed the BT-based ferroelectric. And Chu, S. Y. et al conducted the simulation about the KNN(potassium sodium niobate) which is a kind of lead-free dielectric. According to the simulation by Professor Chu, S. Y. it was predicted that if potassium in the A site could be replaced with Li in the perovskite structure of KNN, then it would show a high dielectric constant. We tried to examine the theoretical results in simulation by experimental research. We synthesized potassium lithium niobate; $K_{1-x}Li_xNbO_3$ x=0.25, 0.5, 0.75; KLN100x, as a function of the lithium ratio by conventional solid-solution. However, the single phase of the perovskite structure did not be formed in the KLN system due to the solubility limit of lithium substitution. For this reason, we used another way to make a single phase suppressing the secondary phase. That way is to mix $KNbO_3$ (KN) and $LiNbO_3$ (LN) as raw materials, not mix potassium carbonate, lithium carbonate, and niobium oxide raw materials at once. We assumed that the secondary phase would decrease in this way because KN and LN already had their perovskite structure. Thereafter, in order to further reduce the secondary phase, we synthesize the KLN by changing the ratio of Nb and K, and accordingly, the dielectric properties were additionally measured to derive KLN with optimal dielectric properties. Through this experiment, an analysis of the microstructure and characteristics of KLN will be conducted to contribute to the subsequent study of lead-free ferroelectric.

PG1A-57 | Effect of ABO_3 materials and $NaNbO_3$ seed addition of $K_{0.5}Na_{0.5}NbO_3$ piezoelectric ceramics

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납(Pb)의 유해성으로 인해 그 사용이 줄어들면서 대표적인 압전 세라믹스의 한 종류인 $Pb(Zr,Ti)O_3$를 대체할 무연계 압전 세라믹스의 연구가 시작되었다. 그 중 $K_{0.5}Na_{0.5}NbO_3$ (KNN)는 대표적인 무연 압전 세라믹스로, 다양한 물질의 도핑을 통해 높은 큐리온도를 갖기 때문에 열적 안정성이 우수하며, 높은 압전 특성 또한 갖는 것으로 알려져 있다. KNN계 압전 세라믹스에서는 압전 특성을 높이기 위해 크게 두 가지 방법을 이용하고 있다. 첫번째로

는 조성의 변화를 통해 상온에서 다상(multi-phase)를 갖도록 유도하는 것이다. 상온에서 여러 종류의 상을 가지면 분극 방향이 다양해지고, 잔류분극량이 많아져 압전 계수가 높아진다는 연구 결과들이 다수 존재한다. 두번째로, grain size를 증가시키는 것이다. 큰 grain은 수많은 nanodomain을 가지면서 높은 압전 계수를 유도할 수 있을 뿐만 아니라, grain 간의 분극을 방해하는 입계의 수를 감소시켜 유전손실을 최소화하여 더욱 압전 특성을 높이는 역할을 한다. 본 연구에서는 이를 바탕으로, 순수한 KNN에 압전 특성을 높이는데 효과가 있는 것으로 알려져 있는 $LiSbO_3$와 $SrZrO_3$를 도핑하고, grain size를 증가시키기 위해 seed를 이용하여 입성장을 유도하여 그 물성을 확인해보고자 한다.

PG1A-58 | BT 시드 토포케미컬 반응 과정에서 생긴 불순물 제거 방법

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The demand of high crystalline templates which seed the anisotropic growth along its crystalline orientation in matrix powder has been rising for templated grain growth to engineer high performance piezoelectric ceramics. Templates are synthesized by molten salt method and topochemical reaction, and then are washed to remove salt and byproducts. Formation mechanism of template have been actively researched, but washing process have not been discussed in detail even though chemical damage on templates and formation of impurity can occur while washing. We propose the primary cause inducing a damage of template by acid and suggest practical strategy to remove BiOCl which is a possible impurity formed during washing.

PG1A-59 | 자가 전원 환경 모니터링 시스템을 위한 고출력 및 장수명을 가지는 와이드형 자기-기계-전기 발전기 개발

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사물 인터넷 (Internet of Things, IoT) 센서 시스템에 지속 가능한 전력을 확보하기 위해 버려지는 표유 자기장을 유용한 전기 에너지로 변환할 수 있는 Magneto-Mechano-Electric (MME) 발전기가 주목받고 있다. 그러나 MME 발전기가 실생활에 실질적으로 적용되기 위해서는 높은 출력 전력과 지속적인 전력 공급이 가능한 신뢰성이 반드시 확보되어야 한다. 이를 위해 본 연구에서는 유한요소해석을 기반으로 Wide & short (WS) 캔틸레버 구조를 설계하여 높은 출력 전력을 생성함과 동시에 장시간의 수명을 가지는 고신뢰성 WS-MME 발전기를 개발하였다. 제작된 WS-MME 발전기는 3 Oe의 입력 자기장에서 10^{12} cycles 이상의 우수한 수명과 7.4 mW (0.58 mW/cm^3.Oe)의 높은 출력 특성을 보였다. WS-MME 발전기의 AC 출력 신호를 DC 출력 신호로 변환하여 주변 환경의 온도, 습도, 빛, 소리, UV, 압력을 감지할 수 있는 다기능 IoT 센서를 60일간 지속적으로 구동하였으며, 이를 통해 주변의 버려지는 자기장 에너지를 활용한 고신뢰성의 자체 전원 환경 모니터링 시스템을 구현하였다.

PG1A-60 | CaF_2 분말 제조 및 UV 렌즈 광학용 단결정 제조

전수종[1], 강준혁[1], 김용준[1], 손원배[1], 김두근[1], 최주현[1], *김선훈[1]
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CaF_2 single crystals demonstrate optical properties characterized by high transmittance, low refractive index, and high chemical resistance. As a result, they have found extensive usage in prisms, windows, and extreme ultraviolet (EUV) lithography systems [1,2]. CaF_2 single crystals can be adversely affected by ambient oxygen and moisture, leading to a degradation in transmittance and solarization. Thus, controlled atmospheric conditions are necessary for the growth process. [2] Before CaF_2 single crystal growth, a pretreatment process is performed to remove impurity gas and moisture adsorbed on the surface of CaF_2 powder. If it is not removed, it contaminates the inside of the furnace and acts as an impurity, reducing optical properties [3]. Therefore, to obtain high-purity CaF_2 single crystals, it is necessary to enhance the purity of the CaF_2 powder raw material through a pre-treatment process. In this study, pretreatment was conducted using pretreatment equipment to create a CF_4 and N_2 atmosphere, followed by a pretreatment process at 1000°C for 3 hours. Scanning Electron Microscope (SEM), Energy Dispersive Spectroscopy (EDS), and Inductively Coupled Plasma-Mass Spectrometry (ICP-MS) were analyzed to confirm impurities.“

PG1A-61 | 시뮬레이션을 통한 $LiTaO_3$ 단결정 성장 조건 최적화

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$LiTaO_3$ 단결정은 뛰어난 광학적 특성과 압전 특성 때문에 탄성 표면파(SAW) 장치에 주로 사용되고 있으며, 이 외에도 변환기, 압전 센서, 디코더 및 공진기와 같은 광전자 응용 분야에 활용되고 있다[1]. $LiTaO_3$ 원소재를 녹이는 과정에서 구리 코일을 통한 유도가열로 열이 전달되기 때문에 상대적으로 바깥 영역이 중앙 영역보다 온도가 높다[2]. 결정 성장이 주로 이루어지는 영역은 중앙 영역에서 시작되기 때문에 $LiTaO_3$ 용융물 내부에 온도 구배가 발생한다. 잉곳 성장 길이가 늘어날수록 용융물의 수평/수직 방향으로 온도 구배가 커져 성장 잉곳 내부 크랙 및 결함을 유발할 수 있다[3]. 그러므로 $LiTaO_3$ 용융물의 온도 구배를 최소화 하는 것이 필수적이다. 따라서 본 연구에서는 $LiTaO_3$ 용융물의 온도 구배를 최소화하기 위해 시드 회전 속도, 인상속도, 방사율 등의 값들을 조절하여 수렴된 시뮬레이션 결과를 나타내었다.

PG1A-62 | Synthesis and electromagnetic wave absorption properties of $M^{2+,\ 3+}$ (M = Mn^{3+}, Zn^{2+}, Ni^{2+}) – substituted Z-type Sr- hexaferrite-epoxy composites

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In this research, Z-type hexaferrites with the chemical formulae $Sr_3Co_2Fe_{24-x}Mn_xO_{41}$ (x = 0, 0.5, 1.0, 1.5, 2.0), $Sr_3Co_{2-y}Zn_yFe_{24}O_{41}$ (y = 0, 0.5, 1.0, 1.5, 2.0), and $Sr_3Co_{1-z}Ni_zZnFe_{24}O_{41}$ (z = 0, 0.5, 1.0) were synthesized using the sol-gel method. XRD analysis revealed that multi-hexaferrites consisting of Z+Y, Z+Y+U, and Z+M+U phases were obtained for samples with x = 0.5, 1.0, y ≥ 0.5 and z ≥ 0.5, respectively. Moreover, in samples with x 〉 1.5, the formation of M+Y phases was observed. The high-frequency properties (ε', ε'', μ', μ'') of the calcined hexaferrite powders-epoxy (10 wt%) composites samples were measured using a vector network analyzer in the frequency range of 100 MHz ≤ f ≤ 18 GHz. Based on the measured high-frequency properties of the composites samples, the absorber thickness (d) and frequency (f), the reflection losses (RLs) indicating the electromagnetic (EM) wave absorption performance were calculated and plotted as 2D maps for the samples, respectively. Although the absorption performance varied with the substitution composition, overall, all samples exhibited high absorption in the L-S band (1-4 GHz) with the lowest reflection loss of 〈 35 dB. Additionally, the sample substituted with Zn (y = 1.0) exhibited broad band (1.5 〈 f 〈 4.3 GHz) EM absorption performance that met of RL 〈 -10 dB. The cations-substituted Z-type Sr- hexaferrite is very promising EM wave absorber in L-S radar frequency band because the EM absorption properties could be tuned actively through selection of substitution cation (M = Mn^{3+}, Zn^{2+}, Ni^{2+}) and its doping level.

PG1A-63 | Mimicking IR visionary system via 0D-2D heterojunction of InAs QD/WSe_2 artificial Synapse

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Emulating visionary and learning/memory function of biological neural system to use 3-terminal transistor is an important technology for effectively controlled in a low power state. In this report, we developed an artificial visionary WSe_2 based 3 Terminal FET with QD to emulate of IR sensitive biological synaptic behavior. Quantum dots (QDs) combined with 2D WSe_2 to mimicking visionary biological synapse and demonstrate neuromorphic functionalities of the human brain via van-der-Waals (vdW) heterostructure. Compared with existing WSe_2, QD/WSe_2 heterojunction FET induced better electrical characteristic and sensitivity under the illumination of visible light and infrared light. For mimicking potentiation and depression characteristic of biological synaptic behavior, Surface morphology and Contact potential of Wse2 and QD/WSe_2 were analysis by Atomic Force Microscope (AFM) and Kelvin probe force microscope (KPFM), respectively. The bonding structure of 0D-2D heterojunction is confirmed by Fourier-transform infrared spectroscopy (FT-IR) and Raman spectroscopy. This 0D-2D heterojunction structure provide a new pathway to emulating IR sensitive visionary neural system to develop IR sensitive visionary neural system, and emerging materials junctions.

PG1A-64 | 수분 감지 및 정보 암호화를 위한 강력한 수변색 광자 업컨버젼 스마트 재료

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Hydrochromic materials that change their luminescence color upon exposure to moisture have attracted considerable attention owing to their applications in sensing and information encryption. However, the existing materials lack high hydrochromic response and color tunability. This study reports the development of a new and bright zero-dimensional (0D) Cs_3GdCl_6 metal halide as the host for hydrochromic photon upconversion in the form of polycrystals (PCs) and nanocrystals (NCs). Lanthanides co-doped cesium gadolinium chloride metal halides exhibit upconversion luminescence (UCL) in the visible–infrared region upon 980 nm laser excitation. In particular, Yb^{3+} and Er^{3+} co-doped PCs exhibit hydrochrmic UCL color change from green to red. These hydrochromic properties are quantitatively confirmed through sensitive detection of water in the tetrahydrofuran solvent via UCL color changes. This water-sensing probe exhibits excellent repeatability and is particularly suitable for real-time and long-term water monitoring. Furthermore, the hydrochromic UCL property is exploited for stimuli-responsive information encryption via cyphertexts. These findings will pave way for the development of new hydrochromic upconverting materials for emerging applications, such as noncontact sensors, anticounterfeit and information encryption.

PG1A-65 | Two-step sintering을 이용한 $BaTiO_3$ 나노분말의 소결거동에 관한 연구

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적층세라믹 커패시터 (MLCC, Multi-Layer Ceramic Capacitor)는 세라믹 유전체층과 전도체로 사용되는 금속층을 교대로 적층시켜 만든 커패시터로, 전자제품의 핵심 부품으로 전자 회로 내에서 각 소자에 필요한 전력의 안정적인 공급을 하는 역할을 한다. 현재 전자제품의 초소형화 및 다기능성화 추세로 인해 마이크로급 크기의 MLCC 제조 기술에 대한 연구 기술개발이 활발히 진행되고 있다. 초소형 MLCC 제조를 위해서 세라믹 유전체로 사용되는 $BaTiO_3$ (BTO)는 주로 나노분말이 이용되고 있지만, 나노 분말은 매우 높은 비표적을 갖고 있어서 소결 공정 중에 입자 조대화 및 불균일 입성장이 일어나기 쉽다. 따라서, 소결 공정 설계 및 최적화에 의해 입성장 및 미세조직 제어하는 것이 매우 중요하다. 입성장 제어 기술로 균일하고 치밀한 미세조직을 구현하면, 기공 등의 결함을 최소화함으로써 제품 물성에 대한 높은 신뢰성을 갖는 MLCC를 제조할 수 있다. 일반적으로 MLCC는 무가압 one-step 소결 공정을 적용하여 제품을 생산하고 있다. 그에 반해 본 연구에서 적용한 two-step 소결공정은 one-step 소결공정에 비해 불균일 입성장이 및 조대화가 억제되는 장점을 갖고 있다, 본 연구에서는 BTO 나노분말을 이용하여, 상압 성형체를 제조하고 다양한 소결 온도에서 one-step과 two-step 소결 공정을 적용하여 소결체를 제조하였다. 소결 공정에 따른 각각의 소결체의 미세조직을 관찰하고, 밀도 및 유전율 측정하여, 비교 분석하여 두 공정에서의 BTO의 소결 거동 특징을 알아보았다.