SS11 : 故이종흔 교수 메모리얼 세션

SS11-1 | Electroinc Nose - A way to Smart Sensing System

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An electronic nose is an instrument which comprises an array of chemical sensors with partial specificity and an appropriate pattern recognition algorithm, capable of recognizing simple or complex odors. Following by definition, the development of a smart sensing system is a multidisciplinary process that requires the development of appropriate chemical sensors for application, as well as the signals received from the sensors and the classification of odors using appropriate recognition algorithms. The main hardware component of smart sensing system, which had been developed by late Prof. Lee's Group, is an array of non-specific chemical gases, which interact with a board range of chemicals with varying strengths. Correspondingly, the analyte stimulates sensors in the array, which elicits a characteristic response called "fingerprint". The main software component of smart sensing system, which has been carrying out by our group, is its feature extraction and pattern recognition algorithms processing the sensor characteristics response, extract and selected useful information and realize the pattern recognition. Against the background of the research experience of both groups, late Prof. Lee's Group and our research group have been conducting collaborative research for several times and have been working on practical use of smart sensing system in the industrial field. In the talk, we would like to introduce our collaborative works, which have been done before, to memorize late Prof. Lee.

SS11-2 | 가스센서 연구의 혁신가

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반도체식 가스센서 분야의 세계적인 권위자이신 고 이종흔 교수님께서 국내 가스 센서 연구 발전에 얼마나 크게 이바지하였으며 그것이 가지는 의의에 대해 개인적인 경험과 객관적인 지표를 가지고 발표하고자 합니다. 고인이 남기신 유산을 어떻게 하면 더욱 발전시키고 계승할 수 있을런지에 관하여 함께 고민하는 시간을 가지고자 합니다.

SS11-3 | Vapor phase transformation of 1-dimensional metal oxide nanostructures and their functional applications

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Various one-dimensional (1-D) homo- and hetero-nanostructures consisting of p-type CoO, Co_3O_4, NiO, and Mn_3O_4 and n-type ZnO have been prepared by complete and partial vapor phase transformation of ZnO nanowires (NWs) and their functional applications such as gas sensors and diluted magnetic semiconductors have been investigated. Highly crystalline p-type CoO, Co_3O_4, and Mn_3O_4 NWs, that are known to be difficult to grow via conventional vapor phase route, have been successfully synthesized by the complete vapor phase transformation of ZnO NWs. The CoO NWs covered with ZnO nanorods with diluted magnetic semiconducting behavior have been prepared by the two-step vapor phase reaction. The partial transformation reaction led to the formation of various hetero-nanostructures such as n-type ZnO NWs decorated with discrete configuration of p-type Co_3O_4, NiO or Mn_3O_4 nanoclusters as well as ZnO(n-type)-$ZnCo_2O_4$(p-type) core-shell nanocables (NCs) and ZnO-$ZnMn_2O_4$ core-shell NCs. The main focuses of the thesis is directed at the elucidation of vapor phase transformation reactions and the design of high performance gas sensors and diluted magnetic semiconductors using 1-D homo- and hetero-nanostructures through the control of morphology, catalyst loading, p-n junction.

SS11-4 | Research on Rational Design of Nanostructures for Gas Sensors with Prof. Jong-Heun Lee

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In March 2016, I embarked on a transformative journey when I joined the Functional Nano-Material Laboratory (FNML), a research group helmed by Professor Jong-Heun Lee. As a postdoctoral researcher, I immersed myself in the realm of the Rational Design of Nanostructures for Gas Sensors. Over the course of two and a half years, our collaborative efforts yielded nice results in the realm of nanomaterial-based gas sensors. Our endeavors encompassed a diverse array of nanomaterials, each contributing to the advancement of gas-sensing technology. Notable projects included the development of MoO_3 nanopaper for dual sensing of TMA and H_2S, the utilization of CdS nanoflakes to enable NO_2 sensing under visible light, the application of CuBr nanoparticles for NH_3 sensing at room temperature, and the utilization of $PbTiO_3$ nanoparticles for ethanol sensing in the presence of humidity fluctuations. Throughout this period, the principle of rational nanostructure design emerged as a cornerstone in augmenting the performance of gas sensors, thereby illuminating a pathway towards the creation of high-performance gas sensing devices.

Beyond his role as a distinguished materials science professor, Prof. Jong-Heun Lee exhibited a profound commitment to his roles as both a researcher and a father in his daily life. The privilege of collaborating with him was a profound honor. As we bid farewell, may Jong-Heun's legacy endure, serving as a testament to his indelible contributions.

SS11-5 | 이종흔 교수님과 함께한 새로운 가스 감응 소재 설계

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Recently, the utilization of oxide semiconductor gas sensors has undergone rapid expansion across diverse sectors, including medical, environmental, and mobile communication technologies. Nevertheless, three of the greatest obstacles remain for their real applications: low sensitivity, poor selectivity, and humidity-dependent gas-sensing properties. This highlights the need to pioneer innovative gas-sensing materials. Benefiting from the novel concepts suggested by Prof. Jong-Heun Lee, we have made considerable strides in inventing a range of high-performance gas-sensing materials. The materials have been prepared based on strategies such as utilizing p-type oxides, modulating oxidation reactions, tuning multi-modal porosity, and implementing regenerative sensing surfaces. Recently, our research has extended to the development of novel sensing materials, finally aimed at the realization of room-temperature and transparent gas sensors. Herein, I briefly introduce the results of research performed with Prof. Jong-Heun Lee. This presentation is designed to expose the exceptional insights contributed by Prof. Jong-Heun Lee in gas sensor research. I would like to deeply show my profound respect and admiration for his exemplary contributions. May the souls of the departed rest in peace.

SS11-6 | Bilayer oxide semiconductor gas sensors with functional overlayer for highly sensitive, selective, and humidity-independent gas sensing

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Oxide semiconductor gas sensors have been widely used because of distinctive advantages such as high response. Recently, with rapid progress in sensor networks and computing power, sensor applications are rapidly expanding to various fields. However, three of the greatest obstacles for real applications still remain, which include low response, poor selectivity, and humidity dependent sensing. To address corresponding issues, we suggested novel bilayer gas sensors consisting of sensing films and catalytic overlayers. Unlike conventional sensors, the bilayer sensors can separate the sensing and catalytic reactions into independent processes, enabling the sensitive, selective, and humidity independent gas-sensing. Three novel functionalities of bilayer sensors with overlayer are 1) the suppression of cross-responses to interferants through filtering, 2) the enhancement of responses to target gases through gas reforming, and 3) the reliable gas-sensing through moisture-blocking. These bilayer sensors with high selectivity, sensitivity, and moisture endurance can open new pathways toward high-performance gas sensors.

SS11-7 | 전도성 금속 유기 골격체 기반 상온 동작 가스센서 개발

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최근 금속-리간드 간의 전도 원리 규명을 통해 전도성 금속 유기 골격체 (Metal organic frameworks, MOFs) 가 제안되고 있고, 에너지 저장, 센싱을 위한 전자재료로써 주목 받고 있다. 특히 전도성 MOFs는 높은 전도도와 더불어 넓은 비표면적, 풍부한 기공, 그리고 금속 클러스터 및 리간드 기능기로 이루어진 촉매 반응부위를 가지고 있어 저항변화형 가스센서로 응용을 가능하게 한다. 2차원 구조의 전도성 MOFs가 제안된 이후, 가스 감지 성능 향상을 위해서 금속 및 리간드의 기능기를 치환하거나, 가스 감응막의 두께 조절, 촉매 담지 등의 기능화 방법이 제안되어 왔으나, 여전히 낮은 감도, 낮은 선택성, 및 비가역성은 MOFs 센서의 실사용을 방해한다. 광활성화는 감응물질 내부의 전하를 여기시켜 가스 반응성을 향상시키거나 가스 탈착 반응을 가속화 시켜 가역적인 반응을 기대할 수 있다. 본 연구에서는 대표적인 2차원 전도성 MOFs인 $Cu_3(HHTP)_2$ (HHTP = 2,3,6,7,10,11-hexahydroxytriphenylene)의 성능을 향상시키기 위해서, $Cu_3(HHTP)_2$ 나노 구조체에 Fe_2O_3를 혼합하여 가시광의 도움을 받은 상온 가스센서를 준비하였다. $Cu_3(HHTP)_2$ 나노 구조체의 체계적인 크기 조절을 통해 감도 및 선택성이 크게 증가하였고, Fe_2O_3 나노 입자와의 물리적 혼합은 type II 전자 밴드 구조를 형성해 광활성에 의한 전하분리 효율을 향상 시키고 전하의 수명을 증가시켜 NO_2의 회복을 가속화 한다. 이 전도성 MOFs-산화물 혼합체는 고성능 상온 동작 가스센서를 제작하는 새로운 전략을 제공한다. 또한 새로운 전도성 MOFs를 탐구하고 가스감응물질로 사용하는 것은 MOFs기반 가스센서의 라이브러리를 확장시키는 가장 중요한 단계이므로, triphenylene기반이 아닌 다른 전도성 MOFs의 가스센서 적용가능성을 고찰한다.

SS11-8 | 이종흔 교수님의 제자로서, 그분을 기리며

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This session is dedicated to the career and memory of Prof. Jong-Heun Lee. It celebrates his life! Prof. J.-H. Lee passed away on January 14, 2022. During his active career, he made significant contributions to the progress of oxide semiconductor gas sensor technology. His achievements have pointed towards new directions for future research and development in this field. Prof. J.-H. Lee was not only an active researcher in his field, but also a dedicated teacher to his students, and a kind father to his lab. As Professor Jong-heun Lee's last graduate student, I would like to take this opportunity to express my deep respect and longing for him.

SS11-9 | Facile Fabrication of Carcinogenic Benzene Sensor using Raisin Bread-Structured Film with Catalytic Pd-Co_3O_4 and Gas-Sensing SnO_2 Hollow Spheres

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The facile fabrication of benzene sensors has remained a long-standing challenge, as sophisticated nano-structures and/or sensing films are crucial to attain benzene selectivity. Herein, we report a raisin bread-structured film fabricated by simple mixing of two oxide spheres. The film comprises catalytic Pd-Co_3O_4 (i.e., raisins) and gas-sensing SnO_2 hollow spheres (i.e., bread). In contrast to films of SnO_2 or Pd-Co_3O_4 hollow spheres, raisin bread films are highly selective to less reactive benzene. Thus, an array of the SnO_2, Pd-Co_3O_4, and raisin bread sensors enables exclusive benzene identification with principal component analysis. The superior benzene-sensing properties of raisin bread sensors are attributed to the oxidative consumption of interfering gases by Pd-Co_3O_4, whereas less-consumed benzene sensitively reacts with the SnO_2. This is supported by proton transfer reaction-quadrupole mass spectrometry analysis. This work provides a simple strategy to attain benzene selectivity and is expected to trigger the development of portable devices to monitor benzene.