Emerging Materials
Room Event Hall - Session EM-TuP
Emerging Materials Poster Session

EM-TuP-1 A Novel Topological Semi-Metal: MoP Pathfinding for Future Interconnects at Nanoscale*, **Jeong-Seok Na**, Kyle Blakeney, David Mandia, Jeremie Dalton,* LAM Research

Metal interconnect resistance increases as devices continue to shrink, which poses challenges for metallization schemes in future device nodes.

Topological semi-metals (TSMs) were recently introduced and have demonstrated promising resistivity scaling performance at nanoscale. This is due to their unique properties related to topologically protected surface states and suppressed electron backscattering. MoP is considered one of promising candidates due to its high carrier concentration (~10^{23} cm^{-3}) and relatively low bulk resistivity (~9 μΩ·cm) compared to other TSMs.

We describe the fundamental problem of metal resistivity increasing as interconnect dimensions shrink. Recently, some materials have been observed to show an unconventional resistivity decrease with decreasing dimensions. Among these topological semi-metals, MoP is a promising candidate. There have been few reports about MoP synthesis process that is compatible with interconnect applications.

In this study, we investigate the growth behavior and film properties of MoP using thermal ALD process. First, we compared different reducing agents in the ALD of MoP films. Second, comprehensive film characterization was conducted to evaluate resistivity and crystal phase/structure using 4-point probe, XPS depth profile, AR-XPS, GI-XRD and XRR analyses. The selective growth was tested to evaluate bottom-up gapfill in via structures over a wide temp range for both logic and memory applications. Finally, we discuss the need for thermal stability studies and nanoscale device characterization in order to prove the resistivity scaling benefits of MoP films.

EM-TuP-2 Vapor Phase Infiltration of Poly(1-Trimethylsilyl-1-Propyne) with Trimethylaluminium*, Jonathan Jenderny,* Applied Electrodynamics and Plasma Technology, Ruhr-University Bochum, Germany*; Nils Boysen,* Fraunhofer Institute for Microelectronic Circuits and Systems, Duisburg, Germany*; Florian Preischel,* Inorganic Materials Chemistry, Ruhr-University Bochum, Germany*; Teresa de los Arcos,* Technical and Macromolecular Chemistry, Paderborn University, Germany*; Aleksander Kostka,* Center for Interface-Dominated High-Performance Materials, Ruhr-University Bochum, Germany*; Peter Awakowicz,* Applied Electrodynamics and Plasma Technology, Ruhr-University Bochum, Germany*; Jean-Pierre Glauber,* Leibniz Institute for Solid State and Materials Research, Germany*; **Harish Parala**,* Institute for Materials Chemistry, Leibniz Institute for Solid State and Materials Research, IFW Dresden, Germany*; Anjana Devi,* Institute for Materials Chemistry, Leibniz Institute for Solid State and Materials Research, Germany

Inorganic–organic hybrid materials are gaining importance for different applications, combining the advantages of both organic and inorganic materials. Vapor phase infiltration (VPI) has emerged as a promising technology for the synthesis of hybrid materials. In the field of polymeric gas separation membranes, a common problem is long-term stability, as filtered gases can lead to material deterioration or swelling [1]. In addition to increasing the membrane stability, VPI has also been shown to beneficially impact the separation performance, e.g., when infiltrating polymer of intrinsic microporosity 1 (PIM-1) with trimethylaluminium (TMA) [2].

In this study, VPI of poly(1-trimethylsilyl-1-propyne) (PTMSP) with TMA is investigated. PTMSP was chosen due to its exceptionally high free volume and its organic nature, featuring a carbon-carbon double bond as functional group. Saturation of the precursor inside the polymer is attained after already 60 seconds of infiltration time inducing significant densification of the material as observed by transmission electron microscopy (TEM). Water contact angle measurements indicate a shift towards hydrophilic behaviour after infiltration. Depth profiling using time-of-flight secondary ion mass spectrometry (TOF-SIMS) shows accumulation of aluminium (Al) in the PTMSP polymer. The presence of Al was detected along the whole polymer, confirming that the VPI process affects the whole polymer and is not limited to the sub-surface or the gradient layer region. Depending on the infiltration time, a significant densification of the porous structure was observed that directly influences the selectivity of the gas permeation, up to a complete blocking for long infiltration times. These results represent the first VPI process of a polymer featuring only a C-C double bond and outline the versatility of the VPI technique, being applicable for both gas-barrier and membrane applications in the future.

[1]: N. A. Ahmad, et. al., *Sep. Purif. Technol.,*2019, 212, 941

[2]: E. K. McGuinness, et.al., *Chem. Mater.,* 2019**,** ***31***, 5509

[3] J. Jenderny, et.al., *Adv. Mater. Interfaces*, 2024, 11, 2400171

EM-TuP-3 Study of (TaN)1-XCx Electrode to Investigate Its Impact on OTS Selector Devices*, **Minkyu Lee**, Taeyoon Lee,* Yonsei University, Korea

Conventional transition metal nitrides (TMNs) have gained significant attention in the field of memory devices due to their low resistivity and high thermal & chemical stability. In particular, tantalum nitride (TaN) has been widely applied in various memory industries owing to its high melting point, uniform resistivity, and diffusion barrier properties. However, recent research in the direction of reducing the reset current in phase change memory (PCM) faces limitations with TaN due to its low resistivity. Therefore, it is essential to study materials that can control resistivity while having low roughness and good adhesion with the substrate. Carbon, an element with a small atomic size, can be incorporated into TMN materials to modulate their resistivity and control surface roughness through grain size variations. Here, we demonstrate novel $(TaN)_{1-x}C_x$ electrodes that can adjust electrical resistivity depend on the compositions of carbon. X-ray diffraction (XRD) patterns were analyzed to confirm each crystal lattice and peak shift. Applying measured XRD patterns, full width half maximum (FWHM) and grain sizes were extracted using Debey-Scherrer equation. To visualize crystal structure and amorphous state of $(TaN)_{1-x}C_x$ films, transmission electron microscope (TEM) was employed along with the diffraction pattern using fast fourier transform (FFT).

EM-TuP-4 Study for Deposition of CuI onto Indium-Gallium-Zinc-Oxide for Light Detection Application*, **Woosuk Sohn**, Taeyoon Lee,* Yonsei University, Korea

IGZO phototransistors have been recently paid attentions in various fields such as displays, image sensors, and wearable devices, owing to their high charge mobility and photosensitivity. Although the IGZO phototransistors are widely recognized, some improvements are required as they can detect a limited wavelength range of visible light due to the wide bandgap of IGZO (approximately 3.7–3.8 eV). Generally, the bandgap of IGZO can be adjusted by introducing impurities, however, such approaches often lead to performance degradation by decreasing the mobility of transistor and raising the threshold voltage and subthreshold swing. In this study, we developed a CuI/IGZO phototransistor capable of detecting light in the whole visible range by utilizing copper iodide (CuI), a p-type semiconductor material widely used in photodetectors, solar cells, and LEDs. As p-type CuI is spin-coated on the n-type IGZO layer, a pn junction and a type-II bandgap structure can be formed, which leads to an increase in the number of electrons and holes generated by light and enhances the photocurrent. Also, zinc (Zn) was additionally doped to prevent the degradation of performance of CuI TFTs due to the volatility of iodine, and enhance the on-off current ratio of the transistor. For the gate dielectric, spin-coated Al_2O_3 was employed instead of SiO_2, yielding better device stability. While the Al_2O_3 layer was not deposited by atomic layer deposition (ALD), it still provided sufficient insulating properties. Future work could incorporate ALD-based thin-film deposition to achieve improved thickness uniformity, interface control, and large-area process scalability. In fact, ALD has shown promise in uniformly doping IGZO and CuI thin films and controlling defects, suggesting that it can further enhance the responsivity and detectivity of CuI/IGZO phototransistors. The proposed device has great potential for applications in photo-memory and neuromorphic device, presenting innovative advancements in fields such as artificial intelligence, autonomous driving, and smart devices.

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