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2025 Spring Meeting
Hudson Mohawk AVS Chapter
Thursday, April 24, 2025
3:00 – 7:10 PM

University at Albany
ETEC building, Room B011
1220 Washington Avenue, Albany, NY 12226

Meeting Agenda

3:00 - 3:20 Reception *(coffee and cookies served)*

3:20 - 3:30 Welcoming Remarks by Executive Committee

Keynote Presentation

3:30 - 4:10 "*New materials for high-conductivity interconnects*"
Prof. Daniel Gall, Rensselaer Polytechnic Institute

Oral Presentations

4:10 - 4:30 *"Organic-Inorganic Hybrid Photoresist Synthesized by Vapor-Phase Infiltration for Extreme Ultraviolet (EUV) Lithography"*
Prof. Chang-Yong Nam (Brookhaven National Laboratory)

4:30 - 4:45 *"AFM-in-SEM for Precise Endpoint Delayering of SRAMs"*
Greg M. Johnson (ZEISS Microscopy)

4:45 - 5:00 *"Epitaxial Growth of the Topological Semimetal PtAl"*
Oishy Roy (RPI, Graduate Student)

5:00 - 5:15 *"Developments in XPS Surface Analysis: Automated Redox reactions and Femtosecond Laser Ablation Depth Profiling"*
James Lallo (Thermo Fisher)

5:15 - 5:30 *"Epitaxial Growth of $CuAl_2$ Films as Conductor for High Conductivity Interconnects"*
Zahra Ahmadian (RPI, Graduate Student)

5:30 - 6:50 **Poster Presentations** *(pizza and refreshments served)*

6:50 - 7:10 **Student Awards Ceremony**

Poster Presentations

P01. **HEATER DESIGN FOR SPUTTER DEPOSITION SYSTEM TO EXPLORE NEW INTERCONNECT MATERIALS**
Jynene Alfay (Rensselaer Polytechnic Institute, Undergraduate Student)

P02. **METHODS FOR IN-SITU TEM OBSERVATION OF ELECTROMIGRATION FAILURE IN Ru METALLIZATIONS**
Brent Engler (Rensselaer Polytechnic Institute)

P03. **STUDY OF INTERFACIAL PROPERTIES OF Ti/ Ga_2O_3 SCHOTTKY JUNCTIONS PROCESSED WITH SiH_4 PLASMA**
Sahyadri Anil Patil (University at Albany, Graduate Student)

P04. **EFFECT OF DEPOSITION TEMPERATURE ON GROWTH OF EPITAXIAL Mo(011)/ $Al_2O_3(11\bar{2}0)$**
Ethan Hendrix (Rensselaer Polytechnic Institute, Graduate Student)

P05. **OPTIMIZING ANISOTROPIC EMISSION PROPERTIES IN ERBIUM-DOPED THIN FILMS AND NANOSTRUCTURES FOR INTEGRATED QUANTUM APPLICATIONS BY FINITE-DIFFERENCE TIME-DOMAIN MODELING**
Nicholas Winslow (University at Albany, Undergraduate Student)

P06. **IN-SITU ELECTRON MICROSCOPY OF CONDUCTION FILAMENT (CF) DYNAMICS IN ASYMMETRIC METAL-INSULATOR-METAL (MIM) BASED RESISTIVE SWITCHING DEVICES**
Subhangshu Sen (Rensselaer Polytechnic Institute, Graduate Student)

P07. **EFFECT OF DEPOSITION METHOD ON ELECTRON TRANSPORT IN Mo/W THIN FILMS FOR INTERCONNECT APPLICATIONS**
Ethan Han (Rensselaer Polytechnic Institute, Undergraduate Student)

P08. **CORRELATIVE XPS & SEM ANALYSIS FOR NMC AND Na-ION BATTERY CATHODE MATERIAL SURFACE COMPOSITION**
James Lallo (Thermo Fisher)

P09. **MULTIPLEXED BIOSENSING USING GRATING-COUPLED FLUORESCENCE PLASMONICS (GC-FP) FOR NEAR-POINT-OF-CARE DIAGNOSTICS**
Dwiti Krushna Das (University at Albany, Graduate Student)

P10. **NbAs THIN FILM DEPOSITION FOR FUTURE INTERCONNECTS**
Ariful Islam (Rensselaer Polytechnic Institute, Graduate Student)

P11. **ANGLE-RESOLVED PHOTOLUMINESCENCE SPECTROSCOPY OF ERBIUM-IMPLANTED THIN-FILMS AND NANOPHOTONIC STRUCTURES**
Blair Garrett (University at Albany, Undergraduate Student)

Driving Directions

The ETEC building is in the Harriman State Office Complex, which is adjacent to the University at Albany campus. The address of the ETEC building is ETEC, 1220 Washington Avenue, Albany, NY 12226.
It is important that you include "ETEC" in your search if you are using a mapping program; otherwise, the search will send you to the state police barracks.

*From **UAlbany Campus**:*

There is no direct street access to the ETEC building from the UAlbany campus. You must first drive to either Washington Avenue or Western Avenue and go east towards downtown Albany.
Just after passing the UAlbany campus, there will be an entrance to the Harriman State Office Complex (State Office Buildings).

- If entering Campus Access Road from Washington Avenue, you will see the ETEC building on your left. After passing the building, you will take a U-turn to access the side of Campus Access Road that passes in front of the ETEC building. The parking lot is on the north side of the building.
- If entering Campus Access Road from Western Avenue, you will also need to take a U-turn so that you are driving towards the ETEC building, not away from it. Again, the parking lot is on the north side of the ETEC building.

*From the **North**:*

Take the Northway (I-87) south to Exit 1E. Merge onto I-90 east (toward Albany/Boston). Then take Exit 3 (State Office Buildings), which will put you on Campus Access Road. After passing the ETEC building, you will take a U-turn to access the side of Campus Access Road that passes in front of the ETEC building.

*From the **South**:*

Take the Thruway (I-87) north to Exit 24. Merge onto I-90 east (toward Albany/Boston). Then take Exit 3 (State Office Buildings), which will put you on Campus Access Road. After passing the ETEC building, you will take a U-turn to access the side of Campus Access Road that passes in front of the ETEC building.

*From the **West**:*

Take the Thruway (I-87) east to Exit 24. Merge onto I-90 east (toward Albany/Boston). Then take Exit 3 (State Office Buildings), which will put you on Campus Access Road. After passing the ETEC building, you will take a U-turn to access the side of Campus Access Road that passes in front of the ETEC building.

*From the **East**:*

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The address of the ETEC building is:
ETEC, 1220 Washington Avenue, Albany, NY 12226.

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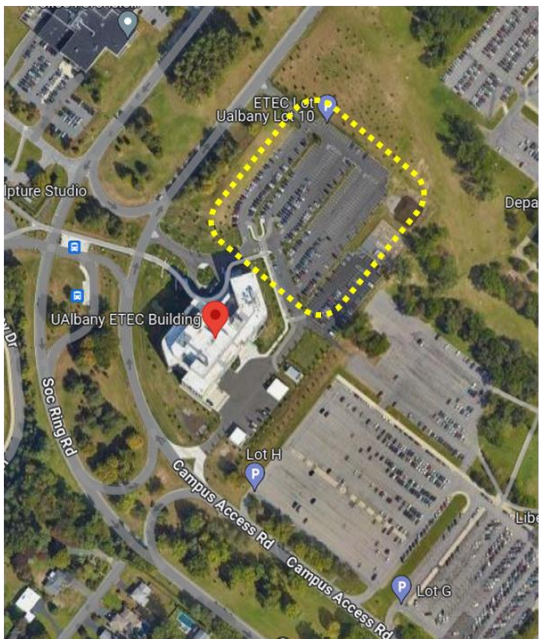
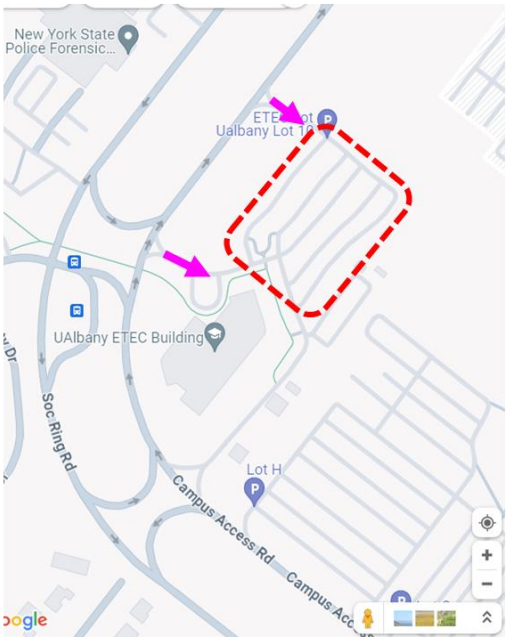
Print the parking permit and display it on your dashboard when parking in the ETEC lot.
Otherwise you will have to pay at a UAlbany parking meter as a visitor.

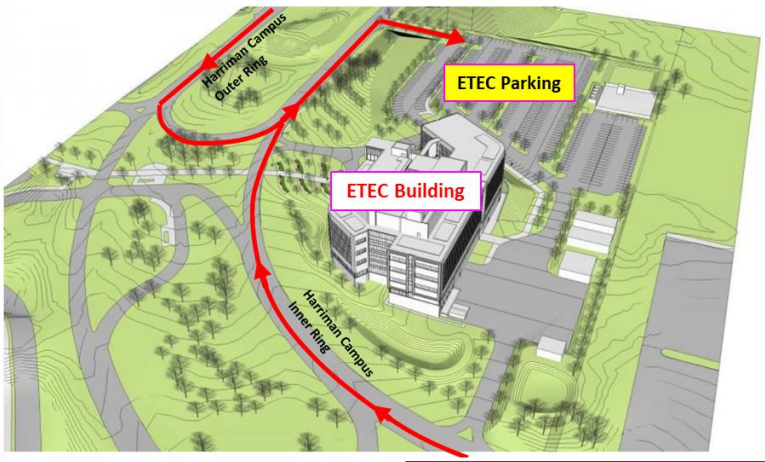
HMAVS meeting location is in ETEC Room B011 (Basement level).

Enter ETEC Lot from Campus Access Road (inner ring road, one-way)
(Purple Arrows)





From Washington Ave (North)



From Western Ave (US-20, South)

NEW MATERIALS FOR HIGH-CONDUCTIVITY INTERCONNECTS

Daniel Gall

Robert W. Hunt Professor of Metallurgical Engineering
Department of Materials Science and Engineering
Rensselaer Polytechnic Institute, Troy, NY 12180

galld@rpi.edu

A major challenge for the continued downscaling of integrated circuits is the resistivity increase of interconnect lines and vias with decreasing dimensions, limiting power efficiency and causing the interconnect delay to exceed the gate delay. This resistivity increase is due to diffuse electron scattering at surfaces and grain boundaries and leads to, for example, a 10-fold resistance increase for 10-nm-wide Cu lines. This talk summarizes our search for alternative interconnect materials that have the potential to outperform Cu. These include metals with a small electron mean free path to render electron scattering at surfaces and grain boundaries negligible, electropositive metals with spherical Fermi surfaces which minimize surface charge transfer and maximize electron transmission at grain boundaries, and anisotropic compounds with preferential transport along the wire direction.

Speaker Biography:

DANIEL GALL is the Robert W. Hunt Professor of Materials Science at the Rensselaer Polytechnic Institute, USA. He received his Diploma from the University of Basel in 1994 and his Ph.D. from the University of Illinois at Urbana-Champaign in 2000. Prof. Gall's research focuses on the development of an atomistic understanding of thin film growth and on the electronic and optical properties of materials. He is particularly renowned for his work on the resistivity size effect and its impact on interconnect lines in integrated circuits. Daniel Gall has served as Assistant Editor and Editorial Board Member for Thin Solid Films and the Journal of Vacuum Science and Technology A, and as Program Chair for the AVS International Symposium. He is a Fellow of the American Vacuum Society and has won numerous awards from NSF, DoE, RPI, ASM, AVS, IBM, and LAM for his work on transition metal nitrides and on high-conductivity interconnects. Professor Gall has authored over 200 peer-reviewed journal articles. His students won over 60 best poster and paper awards. **https://gall-lab.mse.rpi.edu/**

Keynote Presentation

ORGANIC-INORGANIC HYBRID PHOTORESIST SYNTHESIZED BY VAPOR-PHASE INFILTRATION FOR EXTREME ULTRAVIOLET (EUV) LITHOGRAPHY

Chang-Yong Nam

Center for Functional Nanomaterials
Brookhaven National Laboratory, Upton, NY

cynam@bnl.gov

Extreme scaling of semiconductor devices into the Angstrom era over the coming decades critically depends on advances in extreme ultraviolet (EUV) lithography. A key challenge in EUV patterning lies in the limited performance of current photoresist materials and the lack of associated fundamental understanding. In this talk, I will present our recent efforts on utilizing vapor-phase infiltration (VPI)—an organic-inorganic hybridization technique derived from atomic layer deposition (ALD)—for developing novel hybrid EUV photoresist materials, which can feature enhanced EUV sensitivity, high-resolution patterning capability, and improved etch selectivity.

Speaker Biography:

Dr. Chang-Yong Nam is a Senior Scientist and the Group Leader of the Electronic Nanomaterials Group at the Center for Functional Nanomaterials (CFN) of Brookhaven National Laboratory (BNL), and an Adjunct Professor of Materials Science and Engineering at Stony Brook University and University of Texas at Dallas. Dr. Nam received his Ph.D. in Materials Science and Engineering from the University of Pennsylvania (2007), M.S. in Materials Science and Engineering from KAIST (2001). and B.E. in Metallurgical Engineering from Korea University (1999). Dr. Nam's research is focused on two primary areas: (a) Development of atomic layer processing (ALP) methods, including ALD and atomic layer etching (ALE), towards microelectronics and energy applications; (b) Materials processing and device physics in low-dimensional semiconductors and neuromorphic materials. **www.bnl.gov/staff/cynam**

Invited Speaker

AFM-in-SEM FOR PRECISE ENDPOINT DELAYERING OF SRAMs

Greg M. Johnson[1] and Frank Hitzel[2]

[1] ZEISS Microscopy
[2] DoubleFox GmbH

greg.johnson@zeiss.com

Conductive Atomic Force Microscopy Measurements are a well-known technique for the electrical examination of surfaces in semiconductor materials and devices. This talk discusses advances in simultaneous tomographic milling, with kHz-frequency electrical measurements, to provide precise endpoint determination when examining complex structures in real product. A 3 nm technology node finFET SRAM is examined. Despite the relatively rough appearance of some areas of the chip, the milling by the AFM tip was able to create local areas with high planarity. The AFM measurement provided the exact moment certain structures were polished through. Discussion of various electrical modes in the analysis that might provide clearer indications of breakthrough is also undertaken in this paper.

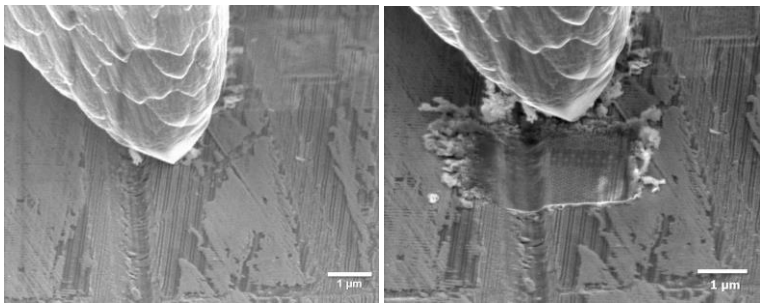


Figure SEM views of the second milling experiment, taken before (top) and after (bottom).

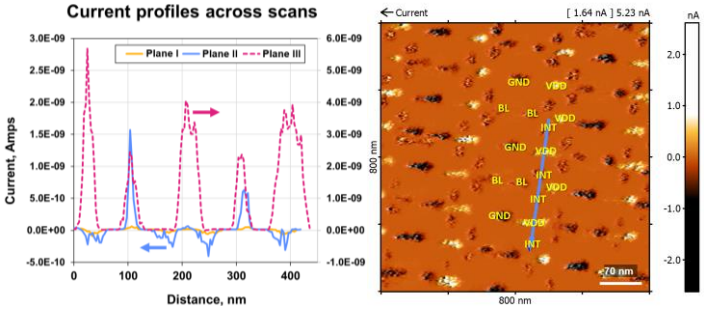


Figure. Comparison of electrical data from various scans.
The profile measures data from a scan that crosses an INT, VDD, INT, INT, and VDD contacts.
Top: graphs of the current data. Bottom: line scan drawn on the data.

Oral Presentation

EPITAXIAL GROWTH OF THE TOPOLOGICAL SEMIMETAL PtAl

Oishy Roy[1], Ching-Tzu Chen[2], Atharv Jog[3], Nargess Arabchi[3], Daniel Gall[1]

[1] Materials Science and Engineering, Rensselaer Polytechnic Institute, Troy, 12180,
[2] Tomas J Watson Research Center, IBM Research, Yorktown Heights, 10598
[3] Advanced Logic Technology, IBM Research, Albany, 12203

royo@rpi.edu

This collaborative research project explores the promise of a new compound conductor PtAl for narrow high conductivity interconnects. PtAl is a topological semimetal with a cubic chiral structure with the $P2_13$ space group. It is theoretically predicted to exhibit topologically protected surface states which lead to scattering-free electron conduction, resulting in an inverted resistivity size effect at small dimensions.

PtAl thin films are deposited by ultra-high vacuum magnetron sputtering onto $Al_2O_3(0001)$, $Al_2O_3(1\bar{1}02)$, $Al_2O_3(11\bar{2}0)$ and MgO(001) substrates at T_s = 400-1000 °C. Growth on $Al_2O_3(1\bar{1}02)$ at T_s = 1000 °C leads to epitaxial PtAl(001) layers with a resistivity ρ that decreases from 115 - 67 μΩ·cm with increasing thickness d = 13 – 109 nm. The resistivity also decreases for deviations from stoichiometry which lead to Pt_5Al_3 and Pt_2Al_3 impurity phases for Pt and Al rich conditions, respectively. PtAl deposition at T_s = 700 °C leads to a thickness-dependent crystalline orientation, with predominantly PtAl 001 layers for $d \geq 26$ nm but PtAl 210 orientation for $d \leq 13$ nm, and a decreasing ρ = 140 – 92 μΩ·cm for d = 13 – 57 nm. *In situ* vacuum annealing at 850 °C of layers deposited at 400 °C causes a transition from 210 to 001 oriented films with a measured ρ = 220 μΩ·cm for d = 3 nm.

Oral Presentation
Graduate Student

DEVELOPMENTS IN XPS SURFACE ANALYSIS: AUTOMATED REDOX REACTIONS AND FEMTOSECOND LASER ABLATION DEPTH PROFILING

James Lallo[1], Stephen Sweeney[2], Steven Hinder[3], Simon Bacon[4], Robin Simpson[4], Paul Mack[4], Adam Bushell[4], Tim Nunney[4], Richard White[4], Mark Baker[5]

[1] Thermo Fisher Scientific
[2] University of Glasgow, UK
[3] University of Surrey, UK
[4] Thermo Fisher Scientific, UK
[5] University of Surrey, UK

James.Lallo@Thermofisher.com

This presentation gives some examples of the latest developments in Surface Analysis being developed by Thermo Fisher Scientific. We investigate the benefits of using automated, in-situ redox reactions for the purpose of producing well controlled oxide growth on the surface of various sample types. The driving force behind using such a procedure is in the potential for generating a sequence of spectra from a progressively chemically-modified surface to remove ambiguities that can lead to misinterpretation, thus aiding in faster understanding of the unmodified surface. Our study presents XPS results from coupled stepwise oxidation/reduction of surfaces, to aid in resolving such ambiguities across a wide array of materials. We use gas-phase oxidation agents to control the redox states of a specimen, leveraging the logarithmic growth of oxide thickness. This oxidation is implemented using vacuum ultraviolet light (VUV) and the generation of ozone and gas-phase hydroxide free radicals close to the surface of the specimens within the entry-lock of the Thermo Scientific Nexsa surface analysis instrument. This work focusses on the benefits of automating this process to ascertain the potential merits of including it into a standard operating procedure for XPS analysis.

XPS depth profiling is a widely employed analytical technique to determine the chemical composition of thin films, coatings and multi-layered structures, due to its ease of quantification, good sensitivity and chemical state information. Since the introduction of XPS as a surface analytical technique more than 50 years ago, depth profiles have been performed using ion beam sputtering. However, many organic and inorganic materials suffer from ion beam damage, resulting in incorrect chemical compositions to be recorded during the depth profile. This problem has been resolved for most polymers by using argon gas cluster ion beams (GCIBs), but the use of GCIBs does not solve the issue for inorganics. A prototype XPS depth profiling instrument has been constructed that employs a femtosecond laser rather than an ion beam for XPS depth profiling purposes. This novel technique has shown the capability of eradicating chemical damage during XPS depth profiling for all initial inorganic, compound semiconductor and organic materials examined. The technique is also capable of profiling to much greater depths (several 10s microns) and is much faster than traditional ion beam sputter depth profiling. fs-LA XPS depth profile results will be shown for selected thin films, coatings, multilayers and oxidised surfaces and the outlook for this new technique discussed.

Oral Presentation

EPITAXIAL GROWTH OF $CuAl_2$ FILMS AS CONDUCTOR FOR HIGH CONDUCTIVITY INTERCONNECTS

Zahra Ahmadian[1], Ching-Tzu Chen[2], Atharv Jog[3], Nargess Arabchi[3], Daniel Gall[1]

[1] *Materials Science and Engineering, Rensselaer Polytechnic Institute, Troy, 12180,*
[2] *Tomas J Watson Research Center, IBM Research, Yorktown Heights, 10598*
[3] *Advanced Logic Technology, IBM Research, Albany, 12203*

Ahmadz2@rpi.edu

This study explores the potential of tetragonal $CuAl_2$ as alternative conductor for narrow high-conductivity interconnect lines. Epitaxial and polycrystalline 46-350 nm thick $CuAl_2$ films are deposited on MgO(001) and SiO_2/Si substrates at T_s = 100-400 °C. Figure 1 shows typical x-ray diffraction (XRD) patterns from three films deposited at T_s = 100, 200, and 300 °C, demonstrating a transition from 110 orientation to 001 orientation with increasing T_s. XRD φ scans and pole figures indicate a single in-plane orientation where $CuAl_2$[110]‖MgO[100] for $T_s \geq$ 300 °C while $CuAl_2$ 110 films grown at T_s = 100 °C exhibit a two domain epitaxy.

In situ and ex situ transport measurements at 295 and 77 K quantify the effect of film thickness, deposition temperature, annealing, and compositional variations on the resistivity. $CuAl_2/SiO_2$/Si films have 6-10% higher room temperature resistivity than $CuAl_2$/MgO(001) due to electron scattering at grain boundaries in polycrystalline $CuAl_2$. Annealing reduces the resistivity of as-deposited films from 19.4-22.6 μΩ.cm to 7.2-8.5 μΩ.cm by improving crystallinity.

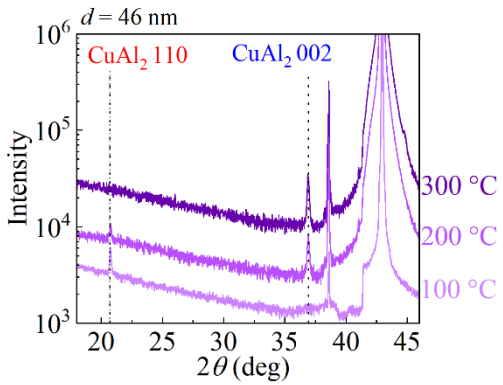


Figure 1: θ-2θ x-ray diffraction patterns of $CuAl_2$/MgO(001) layers as a function of deposition temperature

Oral Presentation
Graduate Student

HEATER DESIGN FOR SPUTTER DEPOSITION SYSTEM TO EXPLORE NEW INTERCONNECT MATERIALS

Jynene Alfay, Emma Sponga, Ethan Hendrix, Ethan Han and Daniel Gall

Rensselaer Polytechnic Institute, Troy, NY 12180

alfayj@rpi.edu

This project focuses on the design of a heater for a dual chamber ultrahigh vacuum magnetron sputter deposition system. The new system is specifically designed for epitaxial and polycrystalline thin film growth of metals, alloys, nitrides, and borides. The heater is manufactured from a 0.1-inch-thick substrate nucleated proclitic graphite with a 693 Ω-m resistivity at room temperature. A serpentine structure consisting of 0.124-inch-wide lines with a total length of 14 inches is designed to obtain resistive heating which, at maximum voltage and current of 9.7 V and 42.8 A is providing high-temperature sample heating up to 1200 °C. Initial calibrations using a pyrometer for temperature measurements indicate a substrate temperature of 1000 °C at a 42.8 A current. These features curate an environment well suited to explore a variety of potential interconnect materials and interfaces with controlled crystalline quality and surface morphology with the goal to quantify electron interface scattering and the back-end-of-line resistivity size effect.

Poster Presentation
Undergraduate Student

METHODS FOR IN-SITU TEM OBSERVATION OF ELECTROMIGRATION FAILURE IN Ru METALLIZATIONS

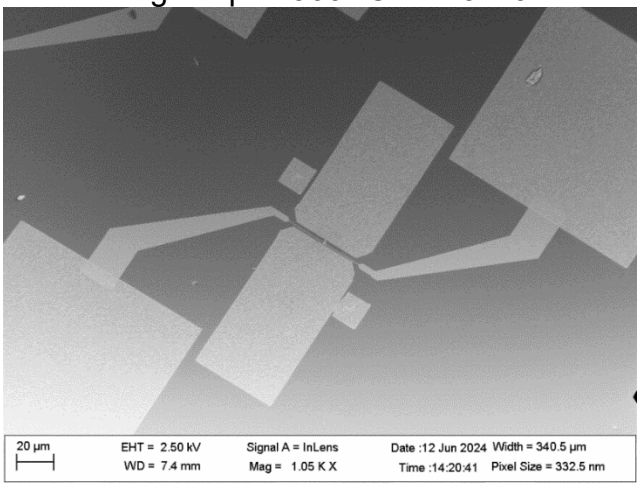
Brent Engler, Robert Hull

Center for Materials Devices and Integrated Systems (CMDIS),
Department of Materials Science and Engineering,
Rensselaer Polytechnic Institute, Troy NY, 12180

engleb3@rpi.edu

As industrial practices shift away from Cu as the first level back-end-of-line interconnect material due to resistivity limitations, new candidate metals are continuously being tested and characterized. Electromigration resistance is a particularly important factor in ultra-narrow lines and in-situ study provides unique insight into the formation and progression of electromigration damage which is complimentary to the testing resultant from ex-situ study. The authors have previously reported on methods for in-situ TEM observation of electromigration resistant materials under accelerated testing conditions as applied to cobalt metallization. The fabrication of lateral devices on electron transparent media, as required for TEM imaging, poses several unique challenges primarily concerning the accurate control and estimation of device temperature during operation.

Here we present our current investigation into the electromigration failure of narrow ruthenium lines. Through the use of electron beam lithography, we have fabricated test structures which consist of ~50nm wide, 50μm long Ru lines and a thick Ag support structure which provides both electrical contact pads and proximal heat sinks/thermal conduction pathways. These devices allow for accelerated testing conditions with functional temperature and current ranges up to 900 °C and $3x10^7$ A/cm^2, respectively. We will also explore the use of focused ion beam patterning to introduce voids and other defects with the objectives of decreasing the incubation time for void formation during in-situ experimentation and examination of the impact of specific void/damage morphologies on the subsequent failure mechanisms.



This work was supported by the Empire State Development's Division of Science, Technology and Innovation (NYSTAR) Focus Center at RPI, C210117, and made extensive use of the Micro- and Nano-Fabrication Clean Room (MNCR) and the Center for Materials Devices and Integrated Systems (CMDIS) characterization core facilities at RPI.

Poster Presentation

STUDY OF INTERFACIAL PROPERTIES OF Ti/ Ga_2O_3 SCHOTTKY JUNCTIONS PROCESSED WITH SiH_4 PLASMA

Sahyadri Patil and Mengbing Huang

Department of Nanoscale Science and Engineering, University at Albany, 257 Fuller Road, Albany, NY12203, USA

spatil@albany.edu

β-Gallium Oxide (β-Ga_2O_3) has been considered a promising material for next-generation power electronics due to its ultra-wide bandgap of 4.6-4.9 eV. Despite the excellent material properties of β-Ga_2O_3, the performance of metal-Ga_2O_3 contacts may hinder its applications in advanced power electronics. It remains a challenge to achieve ohmic contacts and Schottky junctions with good electrical performance and thermal stability in β-Ga_2O_3 due to complicated surface defects and metal-semiconductor interfacial reactions. In this study, we investigate the effects of SiH_4 plasma treatment on Fe-doped semi-insulating β-Ga_2O_3 surfaces, focusing on its impact on the chemistry and electronic properties at the interface formed by depositing a thin Ti film on β-Ga_2O_3 surfaces. The study has been aided with detailed x-ray photoelectron spectroscopy (XPS) characterizations of Ga/O stoichiometry, O vacancy, surface band bending, and Ti/Ga_2O_3 Schottky barrier. The analyses reveal an apparent increase in oxygen vacancy concentration in the β-Ga_2O_3 surface following 5-nm Ti thin film deposition, with a much stronger effect caused by the SiH_4 plasma treatment. The passivation of vacancy defects in the plasma-treated sample is evidenced by an increase in binding energy relative to the case without plasma treatment. While the SiH_4 plasma treatment significantly increases the downward surface band bending (~1.17 eV) as opposed to the control sample (~0.67 eV), the Schottky barrier heights remain almost the same in both cases (~1.36 vs. ~1.42 eV). Angle-resolved XPS measurements on the Ti/Ga_2O_3 samples suggest that a TiO_2 layer is formed at the Ti/Ga_2O_3 interface, with its thickness limited by the plasma treatment. These findings will be discussed to understand the plasma effects on β-Ga_2O_3 surface defects and provide insights to engineer metal/Ga_2O_3 contacts with plasma-induced surface/interface modifications.

Poster Presentation
Graduate Student

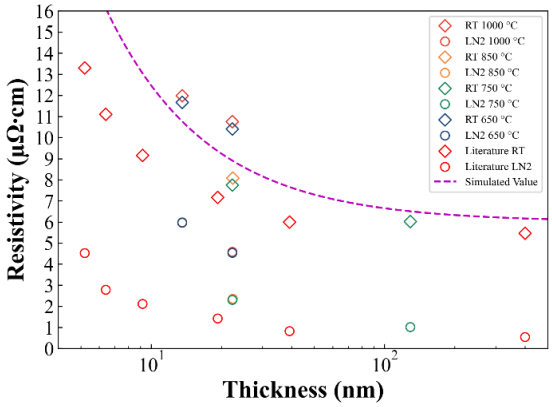
EFFECT OF DEPOSITION TEMPERATURE ON GROWTH OF EPITAXIAL Mo(011)/ $Al_2O_3(11\bar{2}0)$

Ethan Hendrix, Daniel Gall

Materials Science and Engineering,
Rensselaer Polytechnic Institute, Troy, 12180

hendre2@rpi.edu

Epitaxial Mo(011)/$Al_2O_3(11\bar{2}0)$ films are deposited by magnetron sputtering to quantify electron scattering and the resistivity size effect of Mo, which is a high-cohesive-energy metal with promise to replace Cu in back end of the line interconnect applications. Mo deposition in 20 mTorr Ar at T_s= 650-1000 °C is directly followed by *in situ* vacuum annealing at 1000 °C and 10^{-7} Torr for 2h. X-ray diffraction shows that all films exhibit a strong [011] out-of-plane alignment with full-width at half maximum *ω*-rocking curve widths decreasing from 0.22° for T_s = 750 °C to 0.02° for T_s = 1000 °C, confirming the Mo(011)/$Al_2O_3(11\bar{2}0)$ epitaxy. X-ray reflectivity measurements indicate a density of 9.5-11.1 g/cm^3, a surface roughness that decreases from 4.6 to 1.6 nm with increasing T_s = 650-850 °C, and a temperature-independent thickness *d* = 13.6 nm for 44 second depositions. Electron transport measurements reveal a resistivity minimum of *ρ* = 7.7 μΩ·cm for T_s = 750 °C but an increase to 10.4 and 10.8 μΩ·cm for 650 and 1000 °C, respectively. The resistivity increases with decreasing thickness, from *ρ* = 10.8 μΩ·cm for *d* = 22.4 nm to ρ = 12.0 μΩ·cm for d = 13.6 nm. This is attributed to an increasing resistivity contribution from electron-surface scattering and is well described using the Fuchs-Sondheimer model with an electron mean free path for electron-phonon scattering of 14.4 nm. All samples show a 5.7 ± 0.4 μΩ·cm lower resistivity if measured at 77 K. This confirms additive resistivity contributions from electron scattering at phonons, crystalline defects, and surfaces. These overall results provide quantitative data to guide microstructure optimization for polycrystalline Mo interconnects.



Poster Presentation
Graduate Student

OPTIMIZING ANISOTROPIC EMISSION PROPERTIES IN ERBIUM-DOPED THIN FILMS AND NANOSTRUCTURES FOR INTEGRATED QUANTUM APPLICATIONS BY FINITE-DIFFERENCE TIME-DOMAIN MODELING

Nick Winslow, Blair Garrett, Souryaya Dutta, Alex E. Kaloyeros, and Spyros Gallis

University At Albany, College of Nanotechnology, Science and Engineering (CNSE);
Department of Nanoscale Science and Engineering
257 Fuller Rd, Albany, NY 12203

nwinslow@albany.edu

Erbium-doped materials have emerged as promising platforms for telecom quantum information and integrated photonic technologies, owing to erbium's optical transition at ~1532 nm. Controlling the directionality and polarization of Er-related emission in these materials and their nanophotonic structures is crucial for advancing efficient photonic, optoelectronic, and quantum optical devices. Angle-resolved photoluminescence (ARPL) microscopy provides key insights into emission characteristics, which are essential for the development of quantum photonic integrated circuits (qPICs) optimized for low-loss operation in optical fiber networks. In this work, we develop an experimental ARPL system for studying the angular emission properties of erbium-implanted thin films and nanostructures, including materials such as silicon carbide and lithium niobate. The system allows precise control over both excitation and emission angles, enabling PL measurements across the visible and near-infrared spectrum. Using this setup, we systematically investigate the angle-dependent emission of erbium-doped thin films and nanostructures. To gain deeper insight into the underlying emission mechanisms and directional control, we perform finite-difference time-domain (FDTD) simulations. We use FDTD simulations to model the angle-dependent coupling of an electric field from an incident plane wave into thin films and nanostructures, enabling us to understand how optical excitation varies with incidence angle. In parallel, we simulate the angular emission patterns of dipole sources embedded within the same structures, to predict their far-field radiation profiles. These results are directly compared with experimental PL measurements. The FDTD simulations play a critical role in interpreting the experimental data and optimizing nanophotonic structures for enhanced directional emission in the telecom band.

Poster Presentation
Undergraduate Student

IN-SITU ELECTRON MICROSCOPY OF CONDUCTION FILAMENT (CF) DYNAMICS IN ASYMMETRIC METAL-INSULATOR-METAL (MIM) BASED RESISTIVE SWITCHING DEVICES

Subhangshu Sen[1], Brent Engler[1], Saurabh Pandey[2], and Robert Hull[1]

[1] Department of Materials Science & Engineering, Rensselaer Polytechnic Institute
[2] IBM

sens4@rpi.edu

Memristive devices, based on electrochemical metallization (ECM) mechanisms are emerging as strong contenders for next-generation non-volatile memory and neuromorphic computing due to their low power consumption and multistate switching capabilities. This work investigates the evolution of conduction filaments (CFs) in asymmetric Metal-Insulator-Metal (MIM) architectures, specifically Cu/SiO_2/Pt devices, with a focus on improving device reliability by understanding and reducing the stochasticity in switching behavior. Building on prior studies that explored CF dynamics in symmetric MIM systems, this study targets the role of asymmetric electrodes—where Cu acts as the active electrode and Pt as the inert electrode—in studying the formation, dissolution and subsequent reformation of CFs during multi-biasing cycles of resistive switching.

These devices are being laterally fabricated on electron transparent SiNx TEM-Grids, to facilitate the in-situ TEM observation of the CF dynamics, using electron beam lithography, followed by evaporative deposition of the metal electrodes. Fabrication techniques involving bilayer resists (PMMA A4 + LOR 5A) along with use of Cu heat sinks were used to overcome high-temperature thermal challenges faced during Pt deposition. Electrode positioning in nm-scale resolution is critical to CF formation and is achieved via electron beam lithography and manual alignment. In-situ Transmission Electron Microscopy (TEM), integrated with electrical biasing via a Gatan heating holder and Keithley picoammeter enable real-time correlation between structural filament evolution and electrical behavior. We expect that this work will provide significant insights into CF kinetics and electrochemical reactions. The systematic investigation of electrode asymmetry, temperature effects and multi-cycle dynamics will contribute towards the fundamental understanding of the resistive switching mechanism and facilitate the design of robust, low-energy memristive systems.

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Poster Presentation
Graduate Student

EFFECT OF DEPOSITION METHOD ON ELECTRON TRANSPORT IN Mo/W THIN FILMS FOR INTERCONNECT APPLICATIONS

Ethan Han, Ethan Hendrix, Daniel Gall

Department of Materials Science and Engineering,
Rensselaer Polytechnic Institute, Troy, 12180

hane2@rpi.edu

As transistor gate lengths shrink, metal interconnects also decrease in width, leading to narrower wires with higher resistivity. Copper, the current metal for interconnects, suffers from the size-dependent resistivity effects due to increased electron scattering at surfaces and grain boundaries. These scaling challenges, along with reliability concerns for copper, motivate the exploration of alternative materials like molybdenum (Mo) and tungsten (W) for interconnects.

This project studies how the deposition method and material affect the resistivity ρ of Mo and W thin films with thickness between 3 and 27 nm. Films are deposited on thermal oxide substrates using various deposition methods, including physical vapor deposition (PVD), plasma-enhanced atomic layer deposition (PEALD), chemical vapor deposition (CVD), and thermal atomic layer deposition (thermal ALD). The resistivity is measured at room temperature (298 K) and liquid nitrogen temperature at 77 K using a linear four-point probe. Mo films with a W adhesion layer exhibit the lowest ρ, decreasing from 20.4-11.2 μΩ·cm as thickness increases from d = 10.1-20.2 nm. In contrast, Mo without W adhesion layer yields much higher ρ = 20.7 and 34.2 μΩ·cm for PVD and PEALD with d = 10.7 and 9.1 nm, respectively. Observed data is compared with collaborator findings, validating measurements taken. Results show that both deposition method and interface design significantly impact the thin film resistivity, expanding on the importance of selecting future interconnect materials to replace copper.

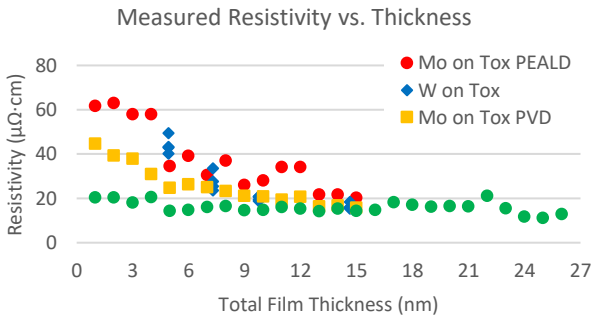

Figure 1: Measured resistivity plotted against total film thicknesses for Mo/W layers deposited by PEALD, CVD, PVD, and Thermal ALD.

Poster Presentation
Undergraduate Student

CORRELATIVE XPS & SEM ANALYSIS FOR NMC AND Na-ION BATTERY CATHODE MATERIAL SURFACE COMPOSITION

James Lallo, Nannan Shi, Albert Ge, Tim Nunney

Thermo Fisher Scientific, UK

James.Lallo@Thermofisher.com

Advanced energy storage has become increasingly vital in many fields, from transportation, to defence, to everyday connectivity. This has led to a growing market demand and development for lithium-ion battery storage solutions. High-tech products such as smartphones, tablets, drones, and electric vehicles all rely on compact, powerful energy storage, with lithium-ion batteries being an essential component. Lithium battery primarily consist of cathode, anode, electrolyte, and separator materials. In lithium battery material research, how to comprehensively characterize and analyse battery materials, and how to use this characterization information to further improve battery material performance has become the focus of current researchers. This poster uses LiNixCoyMn(1-x-y)O2 (NCM)/LiCoO2 [NMC] composite cathode and Sodium Ion Fe/Mg cathode materials as examples. We employ a combination of Scanning Electron Microscopy (SEM) and X-ray Photoelectron Spectroscopy (XPS) characterization techniques to conduct a comprehensive analysis of the composite cathode materials. This approach yields rich sample information, helping researchers quickly evaluate and study any battery cathode materials.

The workflow combines scanning electron microscopy (SEM) [Thermo Scientific AXIA Chemisem] and X-ray photoelectron spectroscopy (XPS) [Thermo Scientific Nexsa G2 & ESCALAB QXi] into a correlated process, enabling the same regions of interest to be investigated; providing both high-resolution imaging and surface analysis from the same positions, even when collected using separate tools.

While SEM can easily visualize 2D materials, these layers are typically too thin to be easily characterized with the analytics commonly present on the microscope such as energy dispersive X-ray (EDX) analysis. XPS, meanwhile, cannot easily resolve surface structures at the required resolution, but can clearly detect what material is present at the surface, and quantify any chemical changes that might have occurred. XPS instrumentation typically also incorporates additional analytical techniques, such as an in-situ Raman spectrometer that is coincident with the XPS analysis position, which can be used to obtain further information.

Poster Presentation

MULTIPLEXED BIOSENSING USING GRATING-COUPLED FLUORESCENCE PLASMONICS (GC-FP) FOR NEAR-POINT-OF-CARE DIAGNOSTICS

Dwiti Krushna Das [1], Benjamin Taubner [1], Jacob Pelton [1], Arturo Pilar [2], William Page [2], Ernest F. Guignon [2], George Gibson [3], Nathaniel C. Cady [1]

[1] College of Nanotechnology, Science, and Engineering, University at Albany, Albany, NY, 12203
[2] Ciencia Inc., Mansfield Center, CT, 06250
[3] Department of Physics, University of Connecticut, Storrs, CT, 06269

ddas2@albany.edu

The advances in nanotechnology have revolutionized diagnostics by enabling sensitive detection of disease biomarkers. Optical methods such as colorimetry and fluorescence-based assays are frequently used in near point-of-care (POC) applications due to their low cost, high sensitivity, and ease of use. This work presents an optical biosensing technology called grating-coupled fluorescence plasmonics (GC-FP). The GC-FP chip utilizes a periodic gold nanograting illuminated by polarized light to excite surface plasmons that interact with photo-excited fluorophores near the metal surface, significantly enhancing fluorescence through surface plasmon-coupled emission (SPCE), yielding 100-fold signal enhancement compared to a flat surface. This platform facilitates multiplexed detection of various biomarker targets, including antibodies or antigens, printed on the chip surface, resulting in heightened sensitivity while maintaining selectivity in biological samples.

GC-FP chips, which have a grating with a pitch of 500 nm, are fabricated using photolithography on silicon wafers at the CNSE/NY CREATES 300 mm wafer processing facility at the Albany NanoTech Complex. These wafers are coated with ~70 nm gold and ~3 nm titanium as an adhesion layer. Biomarkers, such as disease-specific antigens, are precisely printed onto the grating surface using the Scienion sciFLEXARRAYER S3, a piezo-driven microarrayer.

We have applied this technology to detect antibodies from serum/blood samples related to infectious diseases, including Lyme disease (LD) and COVID-19, highlighting its adaptability for a wide range of diseases. LD is caused by *Borrelia burgdorferi*, transmitted by black-legged ticks (*Ixodes scapularis*) in the northeastern U.S. GC-FP has shown better sensitivity than the CDC-recommended standard two-tiered test (STTT) while maintaining 100% specificity.

The assay currently uses an automated microfluidics setup for flowing samples and reagents across the chip, followed by imaging using the Centinela platform from Ciencia, Inc. Ongoing work focuses on developing near-POC formats like dipsticks and lateral flow assays using Centinela for readout. We are also collaborating with sxRNA Tech to integrate nucleic acid-based detection to broaden diagnostic utility. These developments highlight the synergy between plasmonics, microfabrication, and microfluidics in advancing diagnostic technologies.

Poster Presentation
Graduate Student

NbAs THIN FILM DEPOSITION FOR FUTURE INTERCONNECTS

Ariful Islam, Sadiq Shahriar Nishat, Daniel Gall

Materials Science and Engineering, Rensselaer Polytechnic Institute, Troy, 12180

islama8@rpi.edu

NbAs has been predicted to exhibit topological transport, making it a promising candidate to replace Cu as interconnect material at the nanoscale. $NbAs_x$ layers, 165 nm thick, are deposited by magnetron co-sputtering from $NbAs_2$ and As targets to explore NbAs as potential interconnect material. Increasing the deposition temperature leads to a decrease in As content from x = 2.0 at T_s = 25 °C to x = 0.75 at T_s = 400 °C without formation of the desired NbAs phase. This is caused by the high As vapor pressure which results in As loss. Room temperature deposition followed by *in situ* annealing results in a similar As reduction from x = 2.0 to 0.9, 0.57, and 0.49 for T_a = 400, 800, and 1000 °C. A 20-nm-thick Ru cap which is deposited on the as-deposited $NbAs_{2.0}$ layer prior to annealing reduces the As loss to x = 1.3, 0.87, 0.8 and 0.75 for T_a = 400, 800, 1000 and 1200 °C. Increasing the As content in as-deposited $NbAs_x$ layer to x = 5.4, 6.6 and 8.9 results in an exacerbated As loss during annealing at T_a = 1000 °C, yielding x = 0.61, 0.52 and 0.03. X-ray diffraction analyses indicate the formation of an As-deficient Nb_5As_3 phase for T_a = 1000 °C, but no peak from the desired NbAs phase for any T_a = 400-1200 °C. Future work will explore ionized deposition and additional cap-layer approaches to suppress As loss with the goal to form the topological NbAs phase and quantify its transport properties.

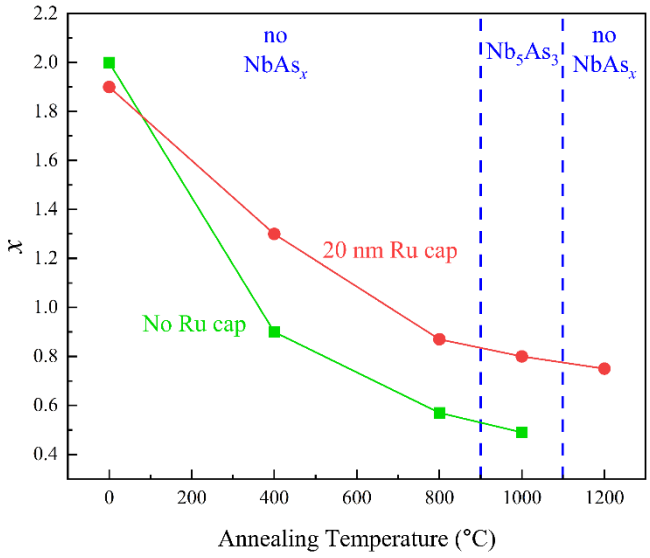

Figure 1. Arsenic content x in $NbAs_x$ layers with and without a 20-nm-thick Ru capping layer vs annealing temperature. Blue labels indicate phases detected by x-ray diffraction.

Poster Presentation
Graduate Student

ANGLE-RESOLVED PHOTOLUMINESCENCE SPECTROSCOPY OF ERBIUM-IMPLANTED THIN-FILMS AND NANOPHOTONIC STRUCTURES

Blair Garrett, Kevin Reyes, Prabha Prasad Nair, Alex E. Kaloyeros, and Spyros Gallis

Department of Nanoscale Science and Engineering, College of Nanotechnology, Science and Engineering (CNSE), University at Albany

btgarrett@albany.edu

In recent years, erbium-doped materials have attracted considerable attention as platforms for emerging telecom quantum information and integrated photonic technologies, primarily due to the key electronic transition of Er^{3+} around 1532 nm. Controlling the directionality and polarization of Er^{3+} light emission from these materials and associated nanophotonic structures is critical for advancing efficient photonic, optoelectronic, and quantum optical devices. In this research, we applied fundamental physics and engineering principles to develop an experimental system capable of performing angle-resolved photoluminescence (PL) studies on erbium-implanted thin films (e.g., silicon carbide and lithium niobate) and nanophotonic structures. This system, designed to control both excitation and emission angles, enables angle-resolved PL measurements across the visible and near-infrared spectra. Leveraging this capability, we systematically studied the angle-resolved PL of erbium-doped thin films. Additionally, we established a clear relationship between the laser excitation angle and the angular distribution of Er PL emission, corroborating these experimental results with finite-difference time-domain (FDTD) simulations. Our findings demonstrate that angle-resolved PL microscopy can yield valuable insights into the emission characteristics of Er^{3+} in films and nanophotonic structures, which are crucial for the development of integrated photonic circuits and for efficient coupling to telecom-band single-mode fibers.

Poster Presentation
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