NAMBE & QME 2023 Program Key

- GD MBE-Grown Devices
- **NM** Novel Materials
- **QME** Workshop on Quantum Materials Epitaxy
- **ST** Science and Technology of MBE

Key to Session/Paper Numbers

Sessions are labeled with acronyms (e.g. **QME, NM, etc.**), then a dash followed by the first two characters of the day of the week: **Sa**turday, **Su**nday, **Mo**nday, **Tu**esday, **We**dnesday, then a single letter for **M**orning, **A**fternoon, **P**oster, and finally a number indicating the starting time slot for the paper. Example: GD-MoA1-1 (Photonic Devices Session, Monday Afternoon, 1:30 pm).

NAMBE & QME 2023 Program Overview

Room /Time	BALLROOM A	HALL OF IDEAS E-J
SaM	QME-SaM1: Oxides I QME-SaM2: Topological and Magnetic Materials I	
SaA	QME-SaA1: 2D and Heteroepitaxial Integration QME-SaA2: Poster Highlights	
SaP	QME POSTER SESSION	
SuM	QME-SuM1: Oxides II QME-SuM2: Topological and Magnetic Materials II	
MoM	NM-MoM1: Oxide Semiconductors NM-MoM2: Nitrides	
МоА	GD-MoA1: Photonic Devices NM-MoA2: Strong Spin-Orbit Oxides	
МоР		NAMBE POSTER SESSIONS
TuM	NM-TuM1: Novel Materials, Optoelectronics NM-TuM2: Thin Film Membranes	
TuA	GD-TuA1: Solar Cell and Quantum Computing NM-TuA2: Novel Oxides and Superconductors	
WeM	ST-WeM1: Advancement in MBE Growth Approaches ST-WeM2: Fundamentals of MBE Growth	
WeA	NM-WeA: Low Dimensional and Topological Materials	

Saturday Morning, September 16, 2023

	Room Ballroom A			
8:00am 8:15am	INVITED: QME-SaM1-2 Hunting for New Oxide Superconductors using MBE, Darrell Schlom, Cornell University	Workshop on Quantum Materials Epitaxy Session QME-SaM1 Oxides I Moderator: Bharat Jalan, University of Minnesota		
8:30am	INVITED: QME-SaM1-4 Advanced Epitaxial Growth of Quantum Materials Using Thermal Laser Epitaxy, Jochen Mannhart, Max Planck Institute for Solid State Research, Germany			
8:45am				
9:00am	INVITED: QME-SaM1-6 Superconductivity at Interfaces of KTaO ₃ and its Possible Origins, <i>Anand Bhattacharya</i> , Argonne National Laboratory			
9:15am				
9:30am	INVITED: QME-SaM1-8 Synthesis of Electronic-Grade Quantum Heterostructures by Hybrid PLD, <i>Chang-Beom Eom</i> , University of Wisconsin-Madison			
9:45am				
10:00am	BREAK			
10:15am				
10:30am	INVITED: QME-SaM2-12 Invited Paper, <i>Stuart Parkin</i> , Max Planck Institute of Microstructural Physics, Germany	Workshop on Quantum Materials Epitaxy Session QME-SaM2 Topological and Magnetic Materials I		
10:45am		Moderator: Nitin Samarth, Pennsylvania State University		
11:00am	INVITED: QME-SaM2-14 The Art and Science of Molecular Beam Epitaxy — — from Topological Materials to Interfacial Superconductivity, <i>Cui-Zu Chang</i> , Pennsylvania State University			
11:15am				
11:30am	INVITED: QME-SaM2-16 Epitaxial Control of Topological Semimetals, <i>Kirstin Alberi</i> , National Renewable Energy Laboratory			
11:45am				
12:00pm	INVITED: QME-SaM2-18 Growth and Investigations of Topological and Quantum Phenomena in Epitaxial Semimetallic Thin Films, <i>Chris Palmstrøm</i> , University of California, Santa Barbara			
12:15pm				

Saturday Afternoon, September 16, 2023

	Room Ballroom A	
2:00pm	INVITED: QME-SaA1-1 Invited Paper, Grace Xing, Cornell University	Workshop on Quantum Materials Epitaxy Session QME-SaA1 2D and Heteroepitaxial Integration Moderator: Roman Engel-Herbert, Paul Drude Institute, Germany
2:30pm	INVITED: QME-SaA1-3 Growth of Topological Materials by Molecular Beam Epitaxy, <i>Stephanie Law</i> , Pennsylvania State University	
3:00pm	INVITED: QME-SaA1-5 Big Flat Quantum Crystals: Wafer-Scale Growth of 2D Materials by Metalorganic Chemical Vapour Deposition, <i>James A. Gupta</i> , University of Ottawa, Canada	
3:30pm	INVITED: QME-SaA1-7 Advanced Heterogeneous Integration Enabled by Remote Epitaxy, <i>Jeehwan Kim</i> , Massachusetts Institute of Technology	

Saturday Evening, September 16, 2023

Workshop on Quantum Materials Epitaxy Room Ballroom A - Session QME-SaP Workshop on Quantum Materials Epitaxy Poster Session 4:00 – 5:30 pm

QME-SaP-1 Optimization of Hybridized InAsSb/InGaSb Semiconductor Topological Materials, *Heather Haugan*, Air Force Research Laboratory; *D. Das, L. Ram-Mohan*, Worcester Polytechnic Institute; *J. Corbett, K. Mahalingam, R. Bedford, K. Eyink*, Air Force Research Laboratory

QME-SaP-2 Doping the Undopable: Hybrid Molecular Beam Epitaxy Growth, n-type Doping, and Field-Effect Transistor using CaSnO₃, *Fengdeng Liu*, University of Minnesota, USA; *P. Golani*, University of Minnesota; *T. Truttmann*, University of Minnesota, USA; *I. Evangelista*, University of Delaware; *M. Smeaton*, Cornell University; *D. Bugallo*, Drexel University; *J. Wen*, University of Minnesota; *A. Kamath Manjeshwar*, University of Minnesota, USA; *S. May*, Drexel University; *L. Kourkoutis*, Cornell University; *A. Janotti*, University of Delaware; *S. Koester*, University of Minnesota; *B. Jalan*, University of Minnesota, USA

QME-SaP-3 Solid Source Metal-Organic Molecular Beam Epitaxy for Epitaxial SrRuO₃ Films, *Anusha Kamath Manjeshwar, S. Nair, A. Rajapitamahuni, R. James, B. Jalan,* University of Minnesota

QME-SaP-4 Growth Mechanism of SrTiO₃ on a Graphene-covered Substrate using Hybrid MBEO, *Sooho Choo, H. Yoon,* University of Minnesota, USA, Republic of Korea; *B. Matthews,* Pacific Northwest National Laboratory; *S. Sharma,* University of Minnesota, USA; *S. Spurgeon, S. Chambers,* Pacific Northwest National Laboratory; *R. James, B. Jalan,* University of Minnesota, USA

QME-SaP-5 Growing Clean Crystals from "Dirty" Precursors in MBE, Rashmi Choudhary, University of Minnesota, USA; Z. Liu, J. Cai, X. Xu, J. Chu, University of Washington; B. Jalan, University of Minnesota, USA

QME-SaP-6 Growth of EuIn₂As₂ Thin Films by MBE: Towards Investigating the Topological Properties of a Candidate Axion Insulator, *Muhsin Abdul Karim*, University of Notre Dame, Ghana; *J. Wang*, University of Notre Dame, China; *K. Yoshimura*, University of Notre Dame, Japan; *S. Bac*, University of Notre Dame, Korea (Democratic People's Republic of); *X. Liu*, University of Notre Dame, China; *B. Assaf*, University of Notre Dame

QME-SaP-7 Synthesis of Free-Standing Membranes Using a Sacrificial Layer Method Grown by Hybrid MBE, *Shivasheesh Varshney*, S. Choo, Z. Yang, J. Wen, S. Koester, B. Jalan, University of Minnesota, USA

QME-SaP-8 Epitaxial Growth of Precursor Phases of Novel Cuprate Superconductors Using Oxide MBE, *Jinkwon Kim, C. Kim, D. Schlom*, Cornell University

QME-SaP-9 MBE of Ba₂BiTaO₆, a Candidate *p*-type Oxide Semiconductor, *Anna Park*, *Y. Birkhölzer*, *M. Barone*, *D. Schlom*, Cornell University

QME-SaP-10 Flexomagnetism and Strain Induced Superconductivity in Rippled GdAuGe Heusler Membranes, *Tamalika Samanta*, Z. LaDuca, D. Du, T. Jung, S. Manzo, K. Su, M. Arnold, J. Kawasaki, University of Wisconsin - Madison

QME-SaP-11 Engineering Metal Oxidation Towards Epitaxial Growth of Complex Iridates using Molecular Beam Epitaxy, *Sreejith Nair, Z. Yang, D. Lee, S. Guo,* University of Minnesota, USA; *J. Sadowski,* Brookhaven National Laboratory; *S. Johnson,* Auburn University; *A. Saboor,* University of Delaware; *Y. Li, H. Zhou,* Argonne National Laboratory, USA; *R. Comes, W. Jin,* Auburn University; *K. Mkhoyan,* University of Minnesota, USA; *J. Janotti,* University of Delaware; *B. Jalan,* University of Minnesota, USA

QME-SaP-12 Improved Epitaxy of Unconventional Metals for Quantum Applications, *Stefania Isceri*, *M. Giparakis*, *R. Svagera*, *M. Waas*, Technische Universität Wien, Austria; *V. Butera*, *E. Kolibalova*, *O. Man*, Central European Institute of Technology, Czechia; *L. Fischer*, *H. Detz*, *W. Schrenk*, *G. Strasser*, *S. Buehler-Paschen*, *A. Andrews*, Technische Universität Wien, Austria

QME-SaP-13 Growth and Angle-Resolved Photoemission of Strain-and Thickness-Tuned α -Sn Films, *Aaron Engel*, *C. Dempsey*, *H. Inbar*, *S. Nishihaya*, *Y. Chang*, University of California, Santa Barbara; *A. Fedorov*, Advanced Light Source, Lawrence Berkeley National Laboratory; *M. Hashimoto*, *D. Lu*, SLAC National Accelerator Laboratory; *P. Taylor*, *P. Folkes*, US Army Research Laboratory; *C. Palmstrøm*, University of California, Santa Barbara

QME-SaP-14 Electrostatic Gating of SrSnO₃ Thin Films with Improved Mobilities, *Zhifei Yang*, F. Liu, T. Truttmann, B. Jalan, University of Minnesota, USA

QME-SaP-15 Epitaxial Growth and Transport Properties of Square-Net Rare Earth Telluride Thin Films, *Adrian Llanos*, J. Falson, California Institute of Technology

QME-SaP-16 Improving MBE (Bi,Sb)₂(Te,Se)₃ Topological Materials Via Resonant and Magnetic Dopants, *Patrick Taylor*, Army Research Laboratory **QME-SaP-17** Growth of Cd_3As_2 on GaAs(001), GaAs(110), and Si(001) Substrates, *Anthony Rice, I. Leahy, A. Norman, K. Alberi*, National Renewable Energy Laboratory

QME-SaP-18 Molecular Beam Epitaxy of Superconducting ZrN Thin Films on GaN Substrates, *Kevin D. Vallejo*, *D. Hurley*, *K. Gofryk*, *B. May*, Idaho National Laboratory

QME-SaP-19 Quasi Van Der Waals Epitaxy of Magnetic Topological Insulators on a Gaas (111) Substrate, *Yuxing Ren*, University of California at Los Angeles; *L. Tai*, 404 Westwood Plaza, Engineering VI, 310; *K. Pan*, *S. Srivastava*, *Y. Xie*, *M. Goorsky*, *K. Wang*, University of California at Los Angeles

QME-SaP-20 Transforming Rotating RHEED Data for Post-Growth Characterization Using Automated Machine Learning, *Chris Price*, Atomic Data Sciences

Sunday Morning, September 17, 2023

	Room Ballroom A	
8:30am	INVITED: QME-SuM1-3 Design of Quantum Oxide Heterostructures, <i>Nini Pryds,</i> Technical University of Denmark	Workshop on Quantum Materials Epitaxy Session QME-SuM1 Oxides II Moderator: Julia Mundy, Harvard University
8:45am		and manay, nervara enversity
9:00am	INVITED: QME-SuM1-5 Interfacial Phenomena in 4d and 5d Transition Metal Oxides Grown by Metal-organic MBE, <i>Ryan Comes</i> , Auburn University	
9:15am		
9:30am	INVITED: QME-SuM1-7 Investigating the Electronic Structure of Coupled Electric Fields at the Surface and Buried Interface of an Epitaxial Complex Oxide/Group IV Semiconductor Heterostructure, <i>Scott Chambers</i> , Pacific Northwest National Laboratory; <i>J. Ngai</i> , University of Texas at Arlington; <i>P. Sushko</i> , Pacific Northwest National Laboratory; <i>E. Ramirez</i> , University of Texas at Arlington; <i>T. Lee, D. Biswas</i> , Diamond Light Source, UK	
10:00am	BREAK	
10:15am		
10:30am	INVITED: QME-SuM2-11 Molecular Beam Epitaxy of Topological Semimetal Heterostructures, <i>Nitin Samarth</i> , Penn State University	Workshop on Quantum Materials Epitaxy Session QME-SuM2 Topological and Magnetic Materials II
10:45am		Moderator: Chris Palmstrøm, University of California, Santa Barbara
11:00am	INVITED: QME-SuM2-13 Controlling Magnetism in Layered Quantum Materials Through Designer Defects, <i>Matthew Brahlek</i> , Oak Ridge National Laboratory	
11:15am		
11:30am	INVITED: QME-SuM2-15 Epitaxy of Rare Earth Compounds on Atomically Flat Surfaces, <i>Joseph Falson</i> , Caltech	
11:45am		
12:00pm	INVITED: QME-SuM2-17 Reactive Force Field Simulations as Versatile Tool to Explore the Growth Kinetics in Molecular Beam Epitaxy of Quantum Materials at the Atomic Scale, <i>Roman Engel-Herbert</i> , Paul Drude Institute, Germany	
12:15pm		

Monday Morning, September 18, 2023

	Room Ballroom A	
7:45am	Welcome and Sponsor Thank Yous	Novel Materials Session NM-MoM1 Oxide Semiconductors
8:00am	INVITED: NM-MoM1-2 Art Gossard MBE Innovator Awardee Talk: Setting a New Quality Standard for Both Holes and Electrons in GaAs Ultra-High Mobility Quantum Wells, <i>Loren N. Pfeiffer</i> , Princeton University	Moderator: Bharat Jalan, University of Minnesota
8:15am		
8:30am	NM-MoM1-4 Silicon-doped β -Ga ₂ O ₃ Films Grown at 1 µm/h by Suboxide Molecular-Beam Epitaxy, <i>Kathy Azizie</i> , <i>F. Hensling</i> , <i>C. Gorsak</i> , Cornell University; <i>Y. Kim</i> , Air Force Research Laboratory; <i>N. Pieczulewski</i> , Cornell University; <i>D. Dryden</i> , Air Force Research Laboratory; <i>M. Senevirathna</i> , <i>S. Coye</i> , Clark Atlanta University; <i>S. Shang</i> , Penn State University; <i>J. Steele</i> , <i>P. Vogt</i> , <i>N. Parker</i> , <i>Y. Birkhölzer</i> , Cornell University; <i>Z. Liu</i> , Penn State University; <i>M. Williams</i> , Clark Atlanta University; <i>K. Chabak</i> , Air Force Research Laboratory; <i>D. Muller</i> , Cornell University; <i>A. Neal</i> , <i>S. Mou</i> , Air Force Research Laboratory; <i>D. Schlom</i> , Cornell University	
8:45am	NM-MoM1-5 Improving Si Dopant Control in n-type &-Gallium Oxide, Brenton Noesges, Y. Kim, A. Neal, S. Mou, T. Asel, Air Force Research Laboratory, Materials and Manufacturing Directorate, USA	
9:00am	NM-MoM1-6 The Effect of Gallium Beam Flux on Electron Transoport in β -Ga ₂ O ₃ Grown via Plasma Assisted Molecular Beam Epitaxy, <i>Thaddeus Asel, B. Noesges, Y. Kim, A. Neal, S. Mou</i> , Air Force Research Laboratory, Materials and Manufacturing Directorate	
9:15am	NM-MoM1-7 Growth of α -(Al _* Ga _{1-x}) ₂ O ₃ by Suboxide Molecular-Beam Epitaxy, Jacob Steele, K. Azizie, N. Pieczulewski, J. McCandless, Cornell University; I. Matara Kankanamge, M. D. Williams, Clark Atlanta University; H. Xing, D. Jena, D. Muller, Cornell University; T. Onuma, Kogakuin University, Japan; D. Schlom, Cornell University (USA) and Leibniz-Institut für Kristallzüchtung (Germany)	
9:30am	NM-MoM1-8 Electrostatic Gating of SrSnO ₃ Thin Films with Improved Mobilities, <i>Zhifei Yang</i> , F. Liu, T. Truttmann, B. Jalan, University of Minnesota, USA	
9:45am	BREAK & EXHIBITS	
10:00am		
10:15am	NM-MoM2-11 Molecular Beam Epitaxy of Binary and Ternary Manganese and Chromium Nitrides, K. Vallejo, K. Gofryk, Idaho National Laboratory; S. Gutierrez-Ojeda, Universidad Nacional Autónoma de México; G. Cocoletzi, Benemérita Universidad Autónoma de Puebla, Mexico; Brelon May, Idaho National Laboratory	Novel Materials Session NM-MoM2 Nitrides
10:30am	NM-MoM2-12 Achieving Atomically Ordered GaN/AlN Quantum Heterostructures: The Role of Surface Polarity, <i>Yuanpeng Wu</i> , <i>P. Zhou</i> , <i>Y. Xiao</i> , <i>K. Sun</i> , <i>D. Wang</i> , <i>P. Wang</i> , <i>Z. Mi</i> , University of Michigan, Ann Arbor	Moderator: Lutz Geelhaar, Paul-Drude-Institut für Festkörperelektronik Leibniz-Institut im Forschungsverbund Berlin, Germany
10:45am	NM-MoM2-13 Epitaxial Cubic Boron Nitride Grown by Ion Beam-Assisted Molecular-Beam Epitaxy on Diamond, <i>David Storm</i> , <i>S. Maximenko</i> , <i>A. Lang</i> , <i>N. Nepal</i> , <i>T. Feygelson</i> , <i>B. Pate</i> , <i>D. Meyer</i> , US Naval Research Laboratory	
11:00am	NM-MoM2-14 Optical Properties of ScN Layers Grown on Sapphire Using Plasma-Assisted Molecular Beam Epitaxy, <i>Duc V. Dinh</i> , Paul-Drude-Institut für Festkörperelektronik, Leibniz-Institut im Forschungsverbund Berlin e.V., Germany; <i>F. Peiris</i> , Kenyon College; <i>J. Lähnemann, O. Brandt</i> , Paul-Drude-Institut für Festkörperelektronik, Leibniz-Institut im Forschungsverbund Berlin e.V., Germany	
11:15am	NM-MoM2-15 Epitaxial Growth of High ScN Fraction ScAlN on NbN and SiC, Matthew Hardy, A. Lang, E. Jin, N. Nepal, B. Downey, V. Gokhale, S. Katzer, V. Wheeler, U.S. Naval Research Laboratory	
11:30am	NM-MoM2-16 High Efficiency Micrometer Scale Green and Red Light Emitting Diodes, Yixin Xiao, R. Maddaka, Y. Wu, Y. Malholtra, Y. Guo, S. Yang, J. Liu, K. Sun, A. Pandey, J. Min, Z. Mi, University of Michigan	
11:45am	NM-MoM2-17 AIN/AIGaN Short Period Superlattices With Sub 2 nm Layers Grown by MME, <i>Alexander Chaney</i> , Azimuth Corporation; <i>C. Bowers, K. Mahalingam</i> , UES INC; <i>S. Mou, K. Averett, T. Asel</i> , Air Force Research Laboratory, Materials and Manufacturing Directorate, USA	

Monday Afternoon, September 18, 2023

Room Ballroom A			
1:30pm	GD-MoA1-1 Separate Absorption, Charge, and Multiplication Avalanche Photodiodes With InGaAs/GaAsSb Type-II Superlattices Grown by Molecular Beam Epitaxy, <i>Hyemin Jung</i> , <i>S. Lee</i> , The Ohio State University; <i>X. Jin</i> , <i>Y. Liu</i> , University of Sheffield, UK; <i>T. Ronningen</i> , The ohio state university; <i>C. Grein</i> , University of Illinois at Chicago; <i>J. David</i> , University of Sheffield, UK; <i>S. Krishna</i> , The Ohio State University	MBE-Grown Devices Session GD-MoA1 Photonic Devices Moderator:	
1:45pm	GD-MoA1-2 Growth of MWIR ICLEDs on Silicon using Molecular Beam Epitaxy, <i>Mega Frost, T. Rotter, F. Ince, G. Balakrishnan,</i> University of New Mexico; <i>M. McCartney, D. Smith,</i> Arizona State University; <i>C. Canedy, W. Bewley, S. Tomasulo, C. Kim,</i> U.S. Naval Research Laboratory; <i>M. Kim,</i> Jacobs Corporation; <i>I. Vurgaftman, J. Meyer,</i> U.S. Naval Research Laboratory	Minjoo Larry Lee, University of Illinois Urbana- Champaign	
2:00pm	GD-MoA1-3 Monlithic Integration of InAs Quantum Dot Lasers with Silicon Photonic Waveguides, <i>Alec Skipper, K. Feng,</i> University of California Santa Barbara; <i>G. Leake, J. Herman,</i> SUNY POLY, Albany; <i>C. Shang, R. Koscica,</i> University of California Santa Barbara; <i>D. Harame,</i> SUNY POLY, Albany; <i>J. Bowers,</i> University of California Santa Barbara		
2:15pm	GD-MoA1-4 Reducing Threading Dislocation Density of Pocket-Grown InAs Quantum Dot Lasers on Patterned SiO ₂ /Si, <i>Rosalyn Koscica</i> , <i>C. Shang</i> , <i>K. Feng</i> , <i>J. Bowers</i> , University of California Santa Barbara		
2:30pm	GD-MoA1-5 MBE Growth of Near-Infrared Heterojunction Phototransistors and Visible LEDs for Night Vision Applications, <i>David Montealegre</i> , University of Illinois at Urbana Champaign; <i>Y. Song</i> , Yale University; <i>S. Lee</i> , University of Washington; <i>B. Kim</i> , <i>M. Kim</i> , University of Illinois at Urbana Champaign; <i>F. Xia</i> , Yale University; <i>M. Li</i> , <i>A. Majumdar</i> , University of Washington; <i>M. Lee</i> , University of Illinois at Urbana Champaign		
2:45pm	GD-MoA1-6 Optically-Addressed Monolithically-Integrated Multi-band Photodetectors Using Type-II Superlattice Materials, <i>Zheng Ju, X. Qi, A. McMinn, Y. Zhang,</i> Arizona State University		
3:00pm	BREAK & EXHIBITS		
3:15pm			
3:30pm	NM-MoA2-9 Atomic Scale Modeling of the Hybrid Molecular Beam Epitaxy Growth Process Using Reactive Force Field Simulations, <i>B. Yalcin, D. Yilmaz, A. van</i> <i>Duin,</i> Pennsylvania State University; <i>Roman Engel-Herbert</i> , Pennsylvania State University, USA, Paul-Drude-Institute for Solid State Electronics, Berlin, Germany	Novel Materials Session NM-MoA2 Strong Spin-Orbit Oxides Moderator:	
3:45pm	NM-MoA2-10 Engineering Metal Oxidation Towards Epitaxial Growth of Complex Iridates using Molecular Beam Epitaxy, <i>Sreejith Nair, Z. Yang, D. Lee, S. Guo,</i> University of Minnesota, USA; <i>J. Sadowski</i> , Brookhaven National Laboratory; <i>S. Johnson,</i> Auburn University; <i>A. Saboor,</i> University of Delaware; <i>Y. Li, H. Zhou,</i> Argonne National Laboratory; <i>R. Comes, W. Jin,</i> Auburn University; <i>K. Mkhoyan,</i> University of Minnesota, USA; <i>A. Janotti,</i> University of Delaware; <i>B. Jalan,</i> University of Minnesota, USA	Ryan Comes , Auburn University	
4:00pm	NM-MoA2-11 Solid Source Metal-Organic Molecular Beam Epitaxy for Epitaxial SrRuO ₃ Films, <i>Anusha Kamath Manjeshwar, S. Nair, A. Rajapitamahuni, R. James, B. Jalan,</i> University of Minnesota		
4:15pm	NM-MoA2-12 Growth of Ruddlesden-Popper Ruthenates via Thermal Laser Epitaxy, <i>Brendan D. Faeth, F. Hensling, V. Harbola, L. Majer,</i> Max Planck Institute for Solid State Research, Germany; <i>H. Boschker,</i> Epiray GMBH, Germany; <i>W. Braun, J. Mannhart,</i> Max Planck Institute for Solid State Research, Germany		
4:30pm	NM-MoA2-13 Growing Clean Crystals from "Dirty" Precursors in MBE, <i>Rashmi</i> <i>Choudhary</i> , University of Minnesota, USA; <i>Z. Liu, J. Cai, X. Xu, J. Chu</i> , University of Washington; <i>B. Jalan</i> , University of Minnesota, USA		
4:45pm	NM-MoA2-14 MBE Growth of BaCo ₂ Ru ₄ O ₁₁ : A Metallic Ferromagnetic Hexaferrite, <i>Yilin Evan Li</i> , Department of Materials Science and Engineering, Cornell University; <i>M. Brützam</i> , Leibniz-Institut für Kristallzüchtung, Germany; <i>R. Cava</i> , Department of Chemistry, Princeton University; <i>C. Guguschev</i> , Leibniz-Institut für Kristallzüchtung, Germany; <i>D. Schlom</i> , Department of Materials Science and Engineering, Cornell University		
5:00pm	NM-MoA2-15 Hybrid Molecular Beam Epitaxy of SrIrO ₃ Films and Heterostructures, <i>Gaurab Rimal</i> , <i>T. Tasnim</i> , <i>J. Ahammad</i> , Auburn University; <i>G. Sterbinsky</i> , Argonne National Lab; <i>J. Sadowski</i> , Brookhaven National Laboratory; <i>M. Boebinger</i> , Oak Ridge National Laboratory; <i>R. Comes</i> , Auburn University		

Monday Evening, September 18, 2023

MBE-Grown Devices Room Hall of Ideas E-J - Session GD-MoP MBE-Grown Devices Poster Session 5:15 – 7:00 pm

GD-MOP-2 Parity-Time Symmetry Single-Mode Double-Microdisk InGaAs Quantum Dot Lasers, K. Lin, C. Xu, Tsong-Sheng Lay, National Chung Hsing University, Taiwan

GD-MoP-3 Impact Ionization Coefficients of AlxGa1-xAsSb (x=0-1) Lattice Matched to InP Substrates, *Seunghyun Lee*, The Ohio State University; *X. Jin*, University of Sheffield, UK; *H. Jung*, The Ohio State University; *J. David*, University of Sheffield, UK; *S. Krishna*, The Ohio State University

GD-MOP-4 Superconducting Germanium for Scalable Qubit Architectures, *Patrick Strohbeen, A. Brook, J. Shabani*, Center for Quantum Information Physics, New York University

GD-MoP-5 Epitaxial Growth of High-Quality Aluminum Thin Films via Mbe for the Experimental Realization of Majorana Bound States, A. Elbaroudy, B. Khromets, E. Bergeron, T. Blaikie, Y. Shi, A. Tam, S. Sadeghi, F. Sfigakis, **Zbig Wasilewski**, J. Baugh, University of Waterloo, Canada

GD-MOP-6 Submicron-Scale Light Emitting Diode with Efficient and Robust Red Emission, *Yixin Xiao, R. Maddakka,* University of Michigan, Ann Arbor

GD-MOP-7 Impact of Built-in Electric Field Direction on Performance of GaN-Based Laser Diodes, *Henryk Turski*, Institute of High Pressure Physics PAS, Poland; *L. van Deurzen*, Cornell University; *M. Hajdel*, *M. Chlipala*, *M. Zak*, *G. Muziol*, *C. Skierbiszewski*, Institute of High Pressure Physics PAS, Poland

GD-MOP-8 Demonstration of a 4.32 μm Cutoff InAsSbBi nBn Photodetector, a Lattice-matched Random Alloy III-V Solution for Mid-wave Infrared Sensing, *Preston T. Webster, J. Logan, L. Helms, P. Grant, C. Hains, R. Carrasco, A. Newell, Air Force* Research Laboratory, Space Vehicles Directorate; *M. Milosavljevic, S. Johnson, Arizona* State University; *G. Balakrishnan,* University of New Mexico; *D. Maestas, C. Morath, Air* Force Research Laboratory, Space Vehicles Directorate

GD-MOP-11 Zeeman Field-Induced Two-Dimensional Weyl Semimetal Phase in Cadmium Arsenide Thin Films, *Binghao Guo*, *W. Miao*, *V. Huang*, *A. Lygo*, University of California, Santa Barbara; *X. Dai*, University of Science and Technology, Hong Kong, China; *S. Stemmer*, University of California, Santa Barbara

GD-MOP-12 MBE Grown InAs/GaAs Quantum Dot Columns as a Buffer Layer for Spatial and Spectral Homogeneity, *Nazifa Tasnim Arony, L. McCabe, J. Zide,* University of Delaware

Novel Materials Room Hall of Ideas E-J - Session NM-MoP Novel Materials Poster Session 5:15 – 7:00 pm

NM-MoP-1 A Study of the Effect of Substrate Misorientation on the Strain Relaxation of InSb Grown on GaAs (001), *Trevor Blaikie*, *M. Tam*, *Y. Shi*, University of Waterloo, Canada; *A. Rahemtulla*, *N. Appathurai*, *B. Moreno*, Canadian Light Source, Inc., Canada; *Z. Wasilewski*, University of Waterloo, Canada

NM-MOP-2 2DEG Transport at the Interface of SrNbO₃/BaSnO₃, *Brian Opatosky*, S. Thapa, T. Tasnim, G. Rimal, P. Gemperline, Auburn University; S. Mahatara, New Mexico State University; H. Paik, University of Oklahoma; R. Vukelich, M. Giri, D. Hilton, Baylor University; B. Kiefer, New Mexico State University; R. Comes, Auburn University

NM-MoP-3 SrIrO₃ Films and Heterostructures Grown by Hybrid Molecular Beam Epitaxy, *Tanzila Tasnim*, Auburn University, Bangladesh; *G. Rimal, B. Opatosky*, Auburn University; *G. Sterbinsky*, Argonne National Laboratory; *M. Boebinger*, Oak Ridge Natinal Laboratory; *R. Comes*, Auburn University

NM-MoP-4 Characterization of MBE Grown Fe_{0.75}Co_{0.25} in Composite Multiferroics, *Katherine Robinson*, Ohio State University; *M. Newburger, M. Page*, Air Force Research Laboratory; *R. Kawakami*, Ohio State University

NM-MOP-5 Multicolor Micrometer Scale Light Emitting Diodes Monolithically Grown on the Same Chip, *Yifu Guo, Y. Xiao, Y. Malholtra, Y. Wu, S. Yang, J. Liu, A. Pandey, Z. Mi*, University of Michigan

NM-MoP-6 Bismuth Surfactant Enhancement of Surface Morphology and Film Quality of Low-Temperature Grown Gasb, *Pan Menasuta*, K. Grossklaus, J. McElearney, T. Vandervelde, Tufts University NM-MoP-7 Study the Temperature Effect on the Stability and Performance of III-Nitride HEMT Based Magnetic Fields Sensors , *Satish Shetty*, Institute for Nanoscience and Engineering, University of Arkansas; *A. Kuchuk*, 1Institute for Nanoscience and Engineering, University of Arkansas; *H. Mantooth*, Department of Electrical Engineering, University of Arkansas; *G. Salamo*, Institute for Nanoscience and Engineering, University of Arkansas; *G. Salamo*, Institute for Nanoscience and Engineering, University of Arkansas; *B. Mantooth*, Department of Electrical Engineering, University of Arkansas; *G. Salamo*, Institute for Nanoscience and Engineering, University of Arkansas

NM-MOP-8 Optimization of Heteroepitaxial ZnGeN₂/GaN Quantum Wells for Green LEDs, *M. Miller*, Colorado School of Mines; *A. Rice*, National Renewable Energy Laboratory; *D. Diercks*, Colorado School of Mines; *A. Tamboli*, *Brooks Tellekamp*, National Renewable Energy Laboratory

NM-MoP-9 Machine Learning Analysis and Predictions of PAMBE III–Nitride Growth, Andrew Messecar, S. Durbin, R. Makin, Western Michigan University

NM-MoP-10 Tuning the Emission Wavelength by Varying the Sb Composition in InGaAs/GaAsSb W-quantum Wells Grown on GaAs(001) Substrates, . Zon, S. Voranthamrong, Department of Electrical Engineering, National Chung Hsing University, Taichung, Taiwan; C. Cheng, Department of Physics, National Central University, Chung-Li, Taiwan; Z. Lee, T. Lo, C. Liu, Department of Electrical Engineering, National Chung Hsing University, Taichung, Taiwan; C. Chiang, L. Hung, M. Hsu, Epileds Co., Ltd., Tainan, Taiwan; W. Liu, Department of Electrical Engineering, Yuan Ze University, Chung-Li, Taiwan; J. Chyi, Department of Electrical Engineering, National Central University, Chung-Li, Taiwan; Charles Tu, Department of Electrical Engineering, National Chung Hsing University, Taichung, Taiwan

NM-MOP-11 Strong Correlation in Two-Dimensional 1T- NbSe₂, Joy Hsu, R. Birchmier, M. Altvater, V. Madhavan, University of Illinois at Urbana-Champaign

NM-MoP-12 Growth of Cobalt-containing Compounds for Back-End-of-Line Interconnects, *Yansong Li, G. Zhou, C. Hinkle, University of Notre Dame*

NM-MoP-13 Development of Al_xGa_{1-x}As_{1-y}Bi_Y for the Next Generation of APDs, Matthew Carr, N. Bailey, University of Sheffield, UK; M. Sharpe, J. England, University of Surrey, UK; R. Richards, J. David, University of Sheffield, UK

NM-MoP-15 Epitaxial Growth of *a*-plane Mn₃Sn on *c*-plane Al₂O₃ using Molecular Beam Epitaxy, *Sneha Upadhyay*, *T. Erickson*, Ohio University; *J. Moreno*, Universidad Autonoma de Puebla, Mexico; *H. Hall*, Ohio University; *K. Sun*, University of Michigan, Ann Arbor; *G. Cocoletzi*, Universidad Autonoma de Puebla, Instituto de fisica, Mexico; *N. Takeuchi*, Centro de Nanociencias y Nanotecnología, Universidad Nacional Autonoma de México; *A. Smith*, Ohio University

NM-MoP-16 Surfactant Effect of Mn on AlN MBE Growth, Jesús Fernando Fabian Jocobi, R. Trejo Hernández, A. Martínez López, Nanoscience and Nanotechnology Program, Center for Research and Advanced Studies of the National Polytechnic Institute (CINVESTAV), Mexico; Y. Casallas Moreno, CONACYT-Interdisciplinary Professional Unit in Engineering and Advanced Technologies, National Polytechnic Institute, Mexico; I. Koudriavysev, Electrical Engineering Department, Solid State Electronic Section, Center for Research and Advanced Studies of the National Polytechnic Institute (CINVESTAV), Mexico; D. Olguin Melo, Center for Research and Advanced Studies of the National Polytechnic Institute (CINVESTAV), Mexico; Department, Center for Research and Advanced Studies of the National Polytechnic Institute (CINVESTAV), Mexico Polytechnic Institute (CINVESTAV), Mexico Polytechnic Institute (CINVESTAV), Mexico Melo, S. Gallardo Hernández, M. López López, Physics Department, Center for Research and Advanced Studies of the National Polytechnic Institute (CINVESTAV), Mexico

NM-MoP-17 Growth and Scattering Mechanisms of Metamorphic In⁻⁻⁻0.81Ga0.19</sub>As Quantum Wells, *Jason Dong*, University of California at Santa Barbara; *Y. Gul*, University College London, UK; *A. Engel*, *C. Dempsey*, *S. Chatterjee*, University of California at Santa Barbara; *M. Pepper*, University College London, UK; *C. Palmstrøm*, University of California at Santa Barbara

NM-MoP-19 Light-enhanced Gating Effect at Conducting Interface of Laser MBE Grown EuO-KTO₃, *Manish Dumen*, *S. Chakraverty*, Institute of Nano Science and Technology, India

NM-MoP-20 4.3 μm InAs/AISb Quantum Cascade Detector Strain-Balanced to a GaSb Substrate, *Stefania Isceri*, *M. Giparakis*, *W. Schrenk*, *B. Schwarz*, *G. Strasser*, *A. Andrews*, Technische Universität Wien, Austria

NM-MoP-21 Growth and Surface Investigation of Antiferromagnetic $D0_{19}$ – Mn₃Ga Thin Films on GaN (0001), *Ashok Shrestha*, A. Abbas, D. Ingram, A. Smith, Ohio University

NM-MoP-22 Guided Anisotropic Oxygen Transport in Vacancy Ordered Oxides, *Jeffrey Dhas, Y. Du*, Pacific Northwest National Laboratory

NM-MoP-23 Impact of Unintentional Sb in the Tensile Electron Well of Type-II InAs/InAsSb Superlattices Grown on GaSb by Molecular Beam Epitaxy, *Marko Milosavljevic*, Arizona State University; *P. Webster*, Air Force Research Laboratory; *S. Johnson*, Arizona State University

NM-MoP-24 Local Droplet Etching and Filling Behavior of Nanoholes in In_{0.52}Al_{0.48}As Layers, *Dennis Deutsch, V. Zolatanosha, C. Buchholz, K. Jöns, D. Reuter,* Paderborn University, Germany

Monday Evening, September 18, 2023

NM-MoP-25 Heteroepitaxial growth of (111)-oriented SrTiO₃ on ScAlN/GaN, *E. Jin, A. Lang, B. Downey, V. Gokhale,* **Matthew Hardy,** *N. Nepal, S. Katzer, V. Wheeler,* Naval Research Laboratory

NM-MoP-26 Strain-Mediated Sn Incorporation and Segregation in Compositionally Graded Ge_{1-X}Sn_X Epilayers Grown by MBE at Different Temperature, *Nirosh M Eldose, H. Stanchu, S. Das, S. Shetty, C. Li, Y. I Mazur, S. Yu, G. J. Salamo,* University of Arkansas

NM-MoP-27 Growth and Characterization of GaAs (111) on 4H-SiC for Infrared Sensor, *Subhashis Das*, N. M Eldose, H. Stanchu, F. Maia de Oliveira, C. Li, M. Benamara, Y. I. Mazur, G. Salamo, University of Arkansas

NM-MOP-28 Growth and Conductivity Control of AlN by Plasma Assisted MBE, Neeraj Nepal, M. Hardy, B. Downey, A. Lang, D. Katzer, E. Jin, D. Storm, V. Gokhale, T. Growden, D. Meyer, V. Wheeler, U.S. Naval Research Laboratory

NM-MOP-29 Molecular Beam Epitaxy Grown Group-IV Alloys for Infrared Photodetector and Quantum Transport Applications, *Tyler McCarthy*, Arizona State University; *R. Basnet*, University of Arkansas; *Z. Ju*, *X. Qi*, *A. McMinn*, Arizona State University; *J. Hu*, *S. Yu*, University of Arkansas; *Y. Zhang*, Arizona State University

NM-MoP-30 Transport of Rare-Earth Nitrides Deposited via Molecular Beam Epitaxy, Kevin Vallejo, Z. Hua, Y. Zhang, K. Gofryk, B. May, Idaho National Laboratory

NM-MOP-31 High Al-Content AlGaN Grown on TaC Virtual Substrates with Metallic Conductivity, *M. Brooks Tellekamp*, *D. Roberts*, National Renewable Energy Laboratory; *M. Miller*, Colorado School of Mines; *A. Rice*, National Renewable Energy Laboratory; *J. Hachtel*, Oak Ridge National Laboratory; *N. Haegel*, National Renewable Energy Laboratory

NM-MoP-32 Grafted AlGaAs/GeSn p-i-n Heterojunction for GeSn MIR Electrically Pumped Laser Application, *Yang Liu*, J. Zhou, D. Vincent, J. Gong, S. Haessly, Y. Li, Q. Zhang, University of Wisconsin - Madison; S. Yu, University of Arkansas; Z. Ma, University of Wisconsin - Madison

NM-MOP-34 Molecular Beam Epitaxy of Kagome-Structured Antiferromagnetic FeSn Grown on LaAlO₃ (111), *Tyler Erickson, S. Upadhyay, H. Hall, D. Ingram, S. Kaya, A. Smith,* Ohio University

NM-MoP-35 Tuning Interface Sharpness and Superconductivity at Oxide Heterostructures, *Y. Eren Suyolcu*, Max Planck Institute for Solid State Research, Germany; *G. Kim*, Max Planck Institute for Solid State Research; *Y. Wu*, *G. Logvenov*, *P. van Aken*, Max Planck Institute for Solid State Research, Germany

NM-MoP-37 Molecular Beam Epitaxial Growth of GalnAs, GaNAs and GalnNAs Nanowires over 2-inch Si(111) Substrate Showing Emission at Near Infrared Regime, *Keisuke Minehisa*, H. Hashimoto, K. Nakama, F. Ishikawa, Hokkaido University, Japan

NM-MoP-38 Tunable Superconductivity in Hybrid Interface FeTe_{1-x}Se_x/Bi₂Te₃ Grown by Molecular Beam Epitaxy, *An-Hsi (Jane) Chen*, Oak Ridge National Laboratory, USA; *Q. Lu, R. Moore, M. Brahlek*, Oak Ridge National Laboratory

NM-MoP-39 Van Der Waals Epitaxy of 2D Ferromagnetic Fe_{5-x}GeTe₂ Films with Curie Temperature Above Room Temperature on Graphene, *Joao Marcelo J. Lopes, H. Lv, A. Kassa, A. da Silva, J. Herfort, M. Hanke, A. Trampert, R. Engel-Herbert, M. Ramsteiner,* Paul-Drude-Institut für Festkörperelektronik, Leibniz-Institut im Forschungsverbund Berlin, Germany

NM-MoP-40 Molecular Beam Epitaxy of MnBi₂Te₄ and Bi₂Te₃/ MnBi₂Te₄ Heterostructures, *Hyunsue Kim*, University of Texas at Austin; *M. Liu*, Harvard University; *L. Frammolino*, *Y. Li*, *F. Zhang*, University of Texas at Austin; *W. Lee*, University of Chicago; *X. Li*, *A. MacDonald*, *C. Shih*, University of Texas at Austin

NM-MoP-41 Effect of Spin-Orbit Field on the Magnetization Reversal in a Crystalline (Ga,Mn)(As,P) Ferromagnetic Layer, *Seongjin Park, K. Lee, S. Lee,* Korea University, Republic of Korea; *X. Liu,* Unversity of Notre Dame; *M. Dobrowolska, J. Furdyna,* University of Notre Dame

NM-MoP-42 Unraveling the Role of Dopant Clustering in Magnetic Impurity Doped Monolayers of Transition Metal Dichalcogenides, *Rehan Younas*, *G. Zhou*, *C. Hinkle*, University of Notre Dame

NM-MoP-43 Atomic Layer Molecular Beam Epitaxy Growth of Kagome Ferrimagnet RMn_6Sn_6 (R = Rare Earth) Thin Films, *Shuyu Cheng*, W. Zhou, R. Kawakami, Ohio State University

NM-MoP-44 Investigating Phase Transformations and Stability of Pt-Te Van Der Waals Materials Through Pt Vapor Exposure and Post-Growth Annealing, *Kinga Lasek*, Purdue University; University of South Florida

NM-MoP-45 Layer-Dependent Optical Properties of MBE-Grown ZrTe₂ Determined by in-Situ Spectroscopic Ellipsometry, *E. Houser, Frank Peiris*, Kenyon College; *A. Richardella, M. Stanley, N. Samarth*, Pennsylvania State University NM-MoP-46 Bi Heteroantisites at Ga(As,Bi)/(Al,Ga)As Interface: Role of the Surface Reconstruction?, *Esperanza Luna*, A. da Silva, K. Biermann, Paul-Drude-Institut für Festkörperelektronik, Leibniz-Institut im Forschungsverbund Berlin e.V., Germany; J. Puustinen, J. Hilska, M. Guina, Optoelectronics Research Centre, Tampere University, Finland; P. Laukkanen, M. Punkkinen, University of Turku, Finland; A. Trampert, Paul-Drude-Institut für Festkörperelektronik, Leibniz-Institut im Forschungsverbund Berlin e.V., Germany

NM-MoP-47 Substrate Preparation Methods for the MBE Growth of Van Der Waals Materials, *Ryan Trice, M. Yu, A. Richardella, M. Hilse, S. Law,* Penn State University

NM-MoP-49 Comparison of the Optoelectronic Properties of InGaAs and GaAsSb Absorbers on InP for 1.55 μm Avalanche Photodiodes, *Nathan Gajowski*, The Ohio State University; *P. Webster*, Air Force Research Lab; *S. Lee*, The Ohio State University; *P. Grant*, Air Force Research Lab; *S. Krishna*, The Ohio State University

NM-MoP-50 Transmission Electron Microscopy Studies of the Formation of In₂Se₃ Layers via Selenium Passivation of InP(111)B Substrates, *Kaushini Wickramasinghe, C. Forrester,* City College of New York, City University of New York

Science and Technology of MBE Room Hall of Ideas E-J - Session ST-MoP Science and Technology of MBE Poster Session 5:15 – 7:00 pm

ST-MOP-1 Shadow Mask Molecular Beam Epitaxy, *Shagorika Mukherjee*, *S. Sitaram, X. Wang*, University of Delaware; *S. Law*, Penn State University

ST-MoP-2 Strain Relaxation of Graded InGaN and AlGaN, *Reem Alhelais, F. Mais de Oliveira, H. Stanchu, M. Sarollahi, Y. Mazur, N. Al-Hosainy, M. Ware,* University of Arkansas

ST-MoP-3 Improved N-Type Doping Activation in AlGaAs:Si Through Digital Alloy Growth, *Xizheng Fang, B. Kim, D. Montealegre, Y. Wang, A. Birge, M. Lee,* University of Illinois at Urbana Champaign

ST-MoP-4 Metal Contact Etch Process Optimization of Metal Contact Etching in 3D Integration Devices, *Sung Gyu Pyo*, CAU, Republic of Korea

Tuesday Morning, September 19, 2023

	Room Ballroom A	
7:45am	Welcome and Sponsor Thank Yous	Novel Materials Session NM-TuM1 Novel Materials, Optoelectronics
8:00am	INVITED: NM-TuM1-2 NAMBE Young Investigator Awardee Talk: Dislocation Dynamics in InGaSb Graded Buffers on GaSb Grown by MBE, <i>Stephanie Tomasulo</i> , <i>M. Twigg, S. Maximenko, I. Vurgaftman, J. Nolde</i> , U.S. Naval Research Laboratory	Moderator: Jason Kawasaki, University of Wisconsin - Madison
8:15am		
8:30am	NM-TuM1-4 Emergent Ferromagnetism in Altermagnetic Candidate MnTe Films Grown on InP (111), <i>Matthew Brahlek</i> , Oak Ridge National Laboratory	
8:45am	NM-TuM1-5 Growth Parameters Impact on Electronic and Optical Properties of ErAs:InGaAlBiAs Materials, <i>Wilder Acuna</i> , W. Wu, J. Bork, M. Jungfleisch, L. Gundlach, J. Zide, University of Delaware	
9:00am	NM-TuM1-6 Heteroepitaxial Growth of Site-determined Quantum Emitters in 2D GaSe Films, <i>Mingyu Yu</i> , University of Delaware; <i>S. Law</i> , Pennsylvania State University	
9:15am	NM-TuM1-7 Evaluating (001) and (111)A InAs Quantum Emitters at Telecommunication Wavelengths Grown by Droplet Epitaxy, <i>Margaret Stevens</i> , US Naval Research Laboratory; <i>W. McKenzie, G. Baumgartner</i> , Laboratory for Telecommunication Sciences; <i>J. Grim, A. Bracker</i> , US Naval Research Laboratory	
9:30am	NM-TuM1-8 Growth of InSb Quantum Well on InAs Using AlInSb Buffer Layer Assisted by Interfacial Misfit Dislocation Arrays, <i>Fatih Furkan Ince, A. Newell, T.</i> <i>Rotter, G. Balakrishnan,</i> University of New Mexico; <i>M. McCartney, D. Smith,</i> Arizona State University	
9:45am	NM-TuM1-9 Molecular Beam Epitaxy of Kagome Antiferromagnetic Mn₃GaN grown on MgO(001), <i>Ali Abbas</i> , A. Shrestha, A. Smith, Ohio University	
10:00am	BREAK & EXHIBITS	
10:15am		
10:30am	NM-Tu2-12 Doping the Undopable: Hybrid Molecular Beam Epitaxy Growth, n- type Doping, and Field-Effect Transistor using CaSnO ₃ , <i>Fengdeng Liu</i> , University of Minnesota, USA; <i>P. Golani</i> , University of Minnesota; <i>T. Truttmann</i> , University of Minnesota, USA; <i>I. Evangelista</i> , University of Delaware; <i>M. Smeaton</i> , Cornell University; <i>D. Bugallo</i> , Drexel University; <i>J. Wen</i> , University of Minnesota; <i>A. Kamath Manjeshwar</i> , University of Minnesota, USA; <i>S. May</i> , Drexel University; <i>L. Kourkoutis</i> , Cornell University; <i>A. Janotti</i> , University of Delaware; <i>S. Koester</i> , University of Minnesota; <i>B. Jalan</i> , University of Minnesota, USA	Novel Materials Session NM-TuM2 Thin Film Membranes Moderator: Roman Engel-Herbert, Paul Drude Institute, Germany
10:45am	NM-TuM2-13 Controlling the Balance between Remote, Pinhole, and van der Waals Epitaxy of Heusler Films on Graphene/Sapphire, <i>Taehwan Jung, Z. LaDuca, D.</i> <i>Du, S. Manzo, K. Su, X. Zheng, V. Saraswat</i> , University of Wisconsin - Madison; <i>J. McChesney,</i> Argonne National Lab; <i>M. Arnold, J. Kawasaki,</i> University of Wisconsin - Madison	
11:00am	NM-TuM2-14 Synthesis of Flexomagnetic GdAuGe Membranes via Van Der Waals Epitaxy on Graphene Terminated Germanium, <i>Zachary LaDuca</i> , S. Manzo, T. Jung, T. Samanta, K. Su, M. Arnold, J. Kawasaki, University of Wisconsin - Madison	
11:15am	NM-TuM2-15 Flexomagnetism and Strain Induced Superconductivity in Rippled GdAuGe Heusler Membranes, <i>Tamalika Samanta, Z. LaDuca, D. Du, T. Jung, S. Manzo,</i> <i>K. Su, M. Arnold, J. Kawasaki,</i> University of Wisconsin - Madison	
11:30am	NM-TuM2-16 Growth Mechanism of SrTiO ₃ on a Graphene-covered Substrate Using Hybrid MBE, <i>Sooho Choo</i> , University of Minnesota, Republic of Korea; <i>H. Yoon</i> , University of Minnesota, USA, Republic of Korea; <i>B. Matthews</i> , Pacific Northwest National Laboratory; <i>S. Sharma</i> , University of Minnesota, USA; <i>S. Spurgeon</i> , <i>S. Chambers</i> , Pacific Northwest National Laboratory; <i>R. Janes</i> , <i>B. Jalan</i> , University of Minnesota, USA	
11:45am	NM-TuM2-17 Synthesis of Free-Standing Membranes Using a Sacrificial Layer Method Grown by Hybrid MBE, <i>Shivasheesh Varshney, S. Choo, Z. Yang, J. Wen, S.</i> <i>Koester, B. Jalan,</i> University of Minnesota, USA	

Tuesday Afternoon, September 19, 2023

	Room Ballroom A	
1:30pm	GD-TuA1-1 InSb-Based Dilute-Bismide Alloys Towards Long-Wave Infrared Sensing, <i>Corey White</i> , M. Bergthold, T. Leonard, A. Ricks, D. Wasserman, S. Bank, The University of Texas at Austin	MBE-Grown Devices Session GD-TuA1 Solar Cell and Quantum Computing
1:45pm	GD-TuA1-2 Abrupt Te Doping of MBE-Grown GaInP for Solar Cell Applications, <i>Brian Li, Y. Sun, R. Hool, M. Lee,</i> University of Illinois, Urbana-Champaign	Moderator: Minjoo Larry Lee, University of Illinois Urbana- Champaign
2:00pm	GD-TuA1-3 MBE Growth of Metamorphic 1 eV InGaAs Solar Cells with Low Threading Dislocation Density, <i>Adrian Birge</i> , <i>M. Kim</i> , <i>B. Kim</i> , <i>D. Montealegre</i> , <i>M. Lee</i> , University of Illinois at Urbana-Champaign, USA	
2:15pm	GD-TuA1-4 Strained Superlattice InAlGaAs/AlGaAs Spin-Polarized Photocathodes Implemented with Random and Digital Alloying, <i>Aaron Engel</i> , University of California, Santa Barbara; <i>M. Stutzman</i> , Thomas Jefferson National Accelerator Facility; <i>J. Dong</i> , University of California, Santa Barbara; <i>C. Palmstrøm</i> , University of California, Santa Barabara	
2:30pm	GD-TuA1-5 Molecular Beam Epitaxy Growth and Characterization of InAs Quantum Wells Grown on Metamorphic III-V Buffer Layers, <i>I. Levy, Patrick</i> Strohbeen, W. Strickland, M. Hatefipour, J. Issokson, L. Baker, New York University; M. Mikalsen, new york University; S. Farzaneh, J. Shabani, New York University	
2:45pm	GD-TuA1-6 Cryogenic Growth of Superconducting Thin Films on GaAs, Si, and Sapphire Substrates, <i>Teun van Schijndel, A. Engel,</i> University of California Santa Barbara; <i>J. Dong,</i> University of California at Santa Barbara; <i>A. McFadden,</i> NIST-Boulder; <i>C. Palmstrøm,</i> University of California Santa Barbara	
3:00pm	BREAK & EXHIBITS	
3:15pm		
3:30pm	NM-TuA2-9 TaO ₂ - The New Kid on the 5 <i>d</i> Block, <i>Yorick Birkhölzer, A. Park, M. Barone, D. Schlom,</i> Cornell University	Novel Materials Session NM-TuA2 Novel Oxides and Superconductors
3:45pm	NM-TuA2-10 Growth of KTaO ₃ , KNbO ₃ and KNb _x Ta _{1-x} O ₃ solid solutions by Suboxide Molecular-Beam Epitaxy, <i>Tobias Schwaigert</i> , Cornell University; <i>S. Hazra</i> , Penn State University; <i>S. Salmani-Razaie</i> , Cornell University; <i>T. Kuznetsova</i> , Penn State University; <i>S. Ganschow</i> , Leibniz-Institut für Kristallzüchtung, Germany; <i>H. Paik</i> , Oklahoma State University; <i>D. Muller</i> , Cornell University; <i>R. Engel-Herbet</i> , Paul Drude Institute, Germany; <i>V. Gopalan</i> , Penn State University; <i>D. Schlom</i> , Cornell University; <i>K. Ahadi</i> , North Carolina State University	Moderator: Matthew J. Brahlek, Oak Ridge National Laboratory
4:00pm	NM-TuA2-11 Studying Electronic Structures of Pure SrCoOx Thin Films, Ordered Phases, and Heterostructures, Jibril Ahammad, G. Rimal, Auburn University; J. Sadowski, Brookhaven National Laboratory; G. Sterbinsky, Argonne National Laboratory; M. Boebinger, Oak Ridge National Laboratory; R. Comes, Auburn University	
4:15pm	NM-TuA2-12 Synthesizing Metastable Ruddlesden-Popper Titanates by Mbe in Pursuit of Next-Generation Millimeter-Wave Tunable Dielectrics, <i>Matthew Barone</i> , Cornell University; <i>Z. Tian</i> , University of California at Berkeley; <i>M. Papac</i> , National Institute of Standards and Technology, Boulder; <i>B. Goodge, E. Fleck, G. Olsen</i> , Cornell University; <i>K. Lee</i> , Hongik University, Republic of Korea; <i>L. Kourkoutis</i> , Cornell University; <i>N. Orloff</i> , National Institute of Standards and Technology, Boulder; <i>L. Martin</i> , University of California at Berkeley; <i>D. Schlom</i> , Cornell University	
4:30pm	NM-TuA2-13 MBE Synthesis and UV Raman Characterization of hexagonal ScFeO ₃ films, <i>Nicholas Parker</i> , <i>D. Schlom</i> , Cornell University; <i>D. Tenne</i> , Boise State University; <i>M. Barone</i> , Cornell University	
4:45pm	NM-TuA2-14 Growth and Characterization of Complex Nickelates with High Sr Concentration, B. Paudel, L. Wang, Z. Yang, M. Bowden, Pacific Northwest National Laboratory; J. Liu, Shanghai Institute of Microsystem and Information technology, China; K. Koirala, T. Kaspar, P. Sushko, S. Chambers, Yingge Du, Pacific Northwest National Laboratory	
5:00pm	NM-TuA2-15 Sharpening the Superconducting Transition of Bi ₂ Sr ₂ Ca _{n-1} Cu _n O _{2n+4} Films with <i>n</i> =1–3 Grown by MBE, <i>Y. Eren Suyolcu</i> , <i>Y. Li</i> , <i>D. Schlom</i> , Cornell University	
5:15pm	NM-TuA2-16 High-Temperature Superconductor FeSe Films Enabled Through Temperature and Flux Ratio Control, <i>Maria Hilse</i> , H. Yi, C. Chang, N. Samarth, The Pennsylvania State University; R. Engel-Herbert, Paul-Drude-Institut für Festkörperelektronik, Germany	

Wednesday Morning, September 20, 2023

	Room Ballroom A	
8:00am	ST-WeM1-2 Thermal Laser Epitaxy - the Universal Epitaxy Tool(?), <i>Wolfgang Braun</i> , D. Kim, F. Hensling, T. Smart, L. Majer, B. Faeth, S. Smink, D. Dereh, Max Planck Institute for Solid State Research, Germany; H. Boschker, Epiray GmbH, Germany; J. Mannhart, Max Planck Institut for Solid State Research, Germany	Science and Technology of MBE Session ST-WeM1 Advancement in MBE Growth Approaches Moderator:
8:15am	ST-WeM1-3 Routes Towards Making BaZrSe ₃ Thin Films in the Perovskite Structure by MBE, <i>Ida Sadeghi, K. Ye, J. Van Sambeek, R. Jaramillo</i> , MIT	Darrell Schlom, Cornell University
8:30am	ST-WeM1-4 Adsorption Controlled Homoepitaxial Growth of <i>c</i> -Plane Sapphire by Thermal Laser Epitaxy, <i>Felix Hensling</i> , <i>L. Majer, S. Smink, J. Mannhart, W. Braun,</i> Max Planck Institute for Solid State Research, Germany	
8:45am	ST-WeM1-5 Prediction of MBE-grown Oxide Film Composition Using Neural Networks and Big Data Analytics, <i>Patrick Gemperline, R. Paudel, S. Thapa, S. Provence,</i> <i>S. Battles, R. Markland,</i> Auburn University; <i>R. Vasudevan,</i> Oak Ridge National Laboratory; <i>R. Comes,</i> Auburn University	
9:00am	ST-WeM1-6 Autonomous Synthesis in the MBE Using Real-Time Artificial Intelligence, <i>Tiffany Kaspar, L. Wang, J. Christudasjustus, M. Sassi, B. Helfrecht, J. Pope, A.</i> <i>Harilal, S. Akers, S. Spurgeon,</i> Pacific Northwest National Laboratory	
9:15am	ST-WeM1-7 The Role of Optical Excitation on Misfit Dislocations in Epitaxial ZnS on GaP, <i>Alexandra Fonseca Montenegro</i> , <i>M. Baan, A. Blackston, R. Myers, T. Grassman</i> , The Ohio State University	
9:30am	BREAK	
9:45am		
10:00am	ST-WeM2-10 Doping and Surfactant Behavior of Antimony and Gallium in Molecular Beam Epitaxy Grown Germanium-Tin, <i>Amanda Lemire, K. Grossklaus, C. Jamison, V. Vazquez, P. Hennessey, T. Vandervelde,</i> Tufts University	Science and Technology of MBE Session ST-WeM2 Fundamentals of MBE Growth Mederator:
10:15am	ST-WeM2-11 SiO ₂ Surface Planarization for Selective Area Regrowth of High Aspect Ratio Microstructures, <i>Ashlee Garcia</i> , A. Skipper, M. Bergthold, S. Bank, University of Texas at Austin	Stephanie Law, University of Delaware
10:30am	ST-WeM2-12 INP Lateral Epitaxial Overgrowth by Solid-Source Molecular Beam Epitaxy, <i>Yiteng Wang</i> , <i>R. Hool, W. North, S. Pandey, E. Raftery, K. Choquette, M. Lee</i> , University of Illinois at Urbana-Champaign	
10:45am	ST-WeM2-13 Effect of Molecular Beam Epitaxy (Mbe) Growth Conditions on the Structural and Magnetic Properties of High Curie Temperature (MnSb ₂ Te ₄) _X (Sb ₂ Te ₃) _{1-X} Magnetic Topological Insulators, <i>Candice Forrester</i> , The City college of New York, Lehman College; <i>C. Testelin</i> , Institute des NanoSciences de Paris, France; <i>K. Wickramasinghe</i> , The City College of New York; <i>I. Levy</i> , New York University; <i>X. Ding, L. Krusin-Elbaum</i> , The City College of New York; <i>G. Lopez</i> , Lehman College; <i>M. Tamargo</i> , The City College of New York	
11:00am	ST-WeM2-14 Evolution of Antiferromagnetic Spin Texture in MBE-Grown Epitaxial Multiferroic BiFeO3, <i>Maya Ramesh</i> , 105 Worth Street; <i>P. Meisenheimer</i> , University of California, Berkeley; <i>S. Zhou</i> , Brown University; <i>P. Stevenson</i> , Northeastern University; <i>L. Caretta</i> , Brown University; <i>R. Ramesh</i> , Rice University; <i>D. Schlom</i> , Cornell University	
11:15am	ST-WeM2-15 Adsorption-Controlled Growth of SrTiO ₃ by Oxide MBE, <i>Dylan Sotir</i> , <i>M. Barone, D. Schlom</i> , Cornell University	
11:30am	ST-WeM2-16 MBE of Ba ₂ BiTaO ₆ ,a Candidate <i>p</i> -type Oxide Semiconductor, <i>Anna Park</i> , <i>Y</i> . <i>Birkhölzer, M. Barone, D. Schlom</i> , Cornell University	

Wednesday Afternoon, September 20, 2023

	Novel Materials	
	Room Ballroom A - Session NM-WeA	
	Low Dimensional and Topological Materials Moderator: Joshua Zide, University of Delaware	
12:15pm	NM-WeA-1 Piezo- and Flexoelectricity Arising from Extreme Strain Gradients in Bent GaAs Nanowires, <i>F. Marin, O. Brandt, Lutz Geelhaar</i> , Paul- Drude-Institut für Festkörperelektronik Leibniz-Institut im Forschungsverbund Berlin, Germany	
12:30pm	NM-WeA-2 InAs Quantum Dot Nucleation on Finite Surface for Scalable Quantum Light Sources, <i>Chen Shang</i> , <i>Y. Pang</i> , <i>M. Kennedy</i> , University of California Santa Barbara; <i>G. Moody</i> , <i>J. Bowers</i> , University of California at Santa Barbara	
12:45pm	NM-WeA-3 Epitaxial Cd ₃ As ₂ Heterostructures for Vertical Device Architectures, <i>Anthony Rice, J. Nelson, A. Norman, K. Alberi</i> , National Renewable Energy Laboratory	
1:00pm	Closing Remarks and Thank Yous	

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Advanced Heterogeneous Integration Enabled by Remote Epitaxy

Jeehwan Kim

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Associate Professor of Materials Science and Engineering



For future of electronics such as bioelectronics, 3D integrated electronics, and bendable electronics, needs for flexibility and stackability of electronic products have substantially grown up. However, conventional wafer-based single-crystalline semiconductors cannot catch up with such trends because they are bound to the thick rigid wafers such that they are neither flexible nor stackable. Although polymerbased organic electronic materials are more compatible as they are mechanically complaint and less costly than inorganic counterparts, their electronic/photonic performance is substantially inferior to that of singlecrystalline inorganic materials. For the past half a decade, my research group at MIT has focused on mitigating such performance-mechanical compliance dilemma by developing methods to obtain cheap, flexible, stackable, single-crystalline inorganic systems. In today's talk, I will discuss about our strategies to realize such a dream electronic system and how these strategies unlock new ways of manufacturing advanced electronic systems. I will highlight our remote epitaxy technique that can produce singlecrystalline freestanding membranes including III-nitrides, III-V and complex oxide system with their excellent semiconducting performance. In addition, I will present unprecedented artificial heterostructures enabled by stacking of those freestanding 3D material membranes, e.g., world's smallest vertically-stacked full color micro-LEDs, world's best multiferroic devices, battery-less wireless e-skin, and heat dissipating system GaN power devices.



Biography

Prof. Jeehwan Kim is a tenured faculty at MIT. His research group's focuses on material innovations for next generation computing and electronics. Prof. Kim joined MIT in September 2015. Before joining MIT, he was a Research Staff Member at IBM T.J. Watson Research Center in Yorktown Heights, NY since 2008 right after his Ph.D. He worked on next generation CMOS and energy materials/devices at IBM. Prof. Kim is a recipient of 20 IBM high value invention achievement awards. In 2012, he was appointed a "Master Inventor" of IBM in recognition of his active intellectual property generation and commercialization of his research. After joining MIT, he continuously worked nanotechnology for advanced electronics/photonics. As its recognition, he received LAM Research foundation Award, IBM Faculty Award, DARPA Young Faculty Award, and DARPA Director's Fellowship. He is an inventor of > 200 issued/pending US patents and an author of > 50 articles in peer-reviewed journals. He currently serves as Associate Editor of *Science Advances*, AAAS. He received his B.S. from Hongik University, his M.S. from Seoul National University, and his Ph.D. from UCLA, all of them in Materials Science.

Flexomagnetism And Strain-Induced Superconductivity in Rippled GdAuGe Heusler Membranes

Tamalika Samanta, Zachary LaDuca, Dongxue Du, Taehwan Jung, Sebastian Manzo, Katherine Su, Michael Arnold, and Jason Kawasaki



Figure 1: (a) Phase diagram for rippled GdAuGe membranes. The circle and star denote differently exfoliated rippled membranes. (b) The field-dependent onset of diamagnetism in a rippled membrane shows the Meissner response, implying superconductivity.

Supplementary Material

Figure 1. SEM image of a 60-nm-thick YbRh₂Si₂ film on a Ge(001) substrate.



Figure 2. AFM image of the $5 \times 5\mu m^2$ surface morphology of a 10- nm-thick YbRh₂Si₂ film on Ge after a sub-monolayer Yb soak, RMS = 1.8 nm









Figure 1 Control of doping in α -Sn films via surface termination of the InSb(001) substrate. a) ARPES measurement of 13 BL α -Sn grown in the In-rich c(8x2) reconstruction. b) ARPES measurement of 13 BL α -Sn grown in the Sb-rich c(4x4) reconstruction. A photon energy of 21 eV is chosen to accentuate the surface states. A clear shift in chemical potential from below the Dirac node to at the Dirac node is evident from a) to b). c) shows R_{xx} and d) shows R_{xy} measurements of 56 BL α -Sn grown on the same InSb surface terminations. Conductive InSb substrates make quantification difficult, but a clear change in carrier type is evident, showing the change in doping in a), b) is carried through to the bulk α -Sn.



Figure 2 Confirmation of 3D topological insulator-like phase. ARPES measurement at 21 eV before a) and after b) potassium dosing the surface. Potassium dosing effectively electron dopes the surface, allowing to see further above the surface Dirac node. The surface Dirac node is preserved without a gap opening. c) ARPES measurement at 127 eV after potassium dosing the surface. At this photon energy the bulk states at the bulk Γ point are observed. There is clear evidence of the valence band, but no conduction band evident below the Fermi level. This indicates at least a 200 meV bulk band gap. This film is thus 3D topological insulator-like.



13 BL Sn 13 BL Sn_{0.92}Ge_{0.08} 13 BL Sn-K dosed 13 BL Sn_{0.95}Ge_{0.05} c)d) a) b) Ma> 0.0-E-E_F (eV) 21eV -0.4 Min e) f) g) h) 0.0 Ma (eV) ů, -0.2 Curvature -0.4 Mir -0.2 0.0 0.2 -0.2 0.0 0.2 -0.2 0.0 0.2 -0.2 0.0 0.2 k_{\parallel} (Å⁻¹) $k_{\rm H}$ (Å⁻¹) k_{\parallel} (Å⁻¹) $k_{||}\,(\hat{\mathbb{A}}^{-1})$

Figure 3 Growth of α -SnGe thin films. a) RHEED oscillations showing preservation of layer by layer growth mechanism when the Sn films are alloyed with Ge. b) RHEED pattern of (2x1)/(1x2) in 50 BL α -Sn. c) The same as b) in 50 BL α -SnGe. d) High resolution XRD reciprocal space map around the InSb(115) peak showing the α -SnGe is fully strained. Pendellosung fringes in the (001) direction are clear, indicative of highquality interfaces.

Figure 4 Topological phase transition upon Ge alloying α -Sn films studied via ARPES measurements at 21 eV to accentuate the surface states. a) Pristine 13 BL Sn, b) Potassium dosing the film in a). c) 5% Ge alloying, resulting in about +0.5% strain. d) 8% Ge alloying, resulting in about +0.9% strain. A small gap opens at the surface Dirac node. A double peak is evident just above the gapped Dirac node. The exact cause is unclear, but is likely an additional, unpredicted surface state. e)-h) shows the curvature of a)-d), enhancing the contrast of the bands.

Improving MBE (Bi,Sb)₂(Te,Se)₃ Topological Materials Via Resonant and Magnetic Dopants

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Figure 1: In-situ ARPES measurements from pure Bi₂Se₃ (left) and Bi₂Se₃ doped with resonant Sn (right) showing the behavior predicted by DFT calculations.



Figure 2: The improvement in transport properties of (Bi,Sb)₂(Te,Se)₃ doped with europium sulfide showing the desired reduction of bulk carriers (left), and near complete elimination of conduction band states with the Fermi level approaching the Dirac-like states.



Quasi Van der Waals Epitaxy of Magnetic Topological Insulators on a GaAs (111) Substrate

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Magnetic topological insulator could achieve quantum anomalous Hall (QAH) effect and spin-orbit torque (SOT) switching in the same structure. This is promising for its future applications in memory or switching with its robust surface properties by topological protection. Considering the van der Waals nature of the epitaxial layers, it has very weak van der Waals bonding with the substrate. This gives rise to a novel quasi Van der Waals epitaxial growth mode at the interface of GaAs (111) substrates and the epitaxial layers, which has the advantages of both good crystallinity from substrate confinement, and a less influence from defects and roughness on the substrate surfaces. This is very crucial for achieving the quantization regime.

In this work we have done hetero-epitaxy of $Cr:(Bi_xSb_{1-x})_2Te_3$ and other magnetic topological insulators on GaAs (111) substrates by MBE (Molecular Beam Epitaxy). Unlike the pure Van der Waals epitaxy which has more freedom at the interfaces epitaxial layer and substrates, we found out that in this quasi Van der Waals growth mode, strain exist and relaxes quickly within the 1st epitaxial layer. While the surface defects quickly get screened within the 1st layer, the surface confinement also gives the epitaxial layer a uniform in-plane orientation which is important for achieving a single crystalline structure. Growth mechanism and the influence on its transport properties are also discussed.



Figure 1. qvdWE of Cr: (Bi_xSb_{1-x})₂Te₃ (CBST) on GaAs (111)

Figure 2. Reciprocal Space Mapping (RSM) for 6 QL CBST on GaAs (111)



[1] Alaskar Y, Arafin S, Martinez-Velis I, Wang KL. Heteroepitaxial growth of III–V semiconductors on 2D materials. Two-dimensional Materials-Synthesis, Characterization and Potential Applications. 2016 Aug 31

[2] arXiv:2103.09878

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Figure 1 – a) Schematic structure of test structure to study impacts of plasma bulbs and Si dopant source during growth interrupts. b) TOF-SIMS depth profile showing Si only accumulates at the sample surface during growth interrupts while the Si cell was hot enough to provide a Si flux while no Si accumulated regardless of exposure time to just the quartz plasma bulb with a 250W O plasma.



Ga Beam Flux = 1 × 10⁻⁷ Torr "Gallium Rich" Regime

Figure 1: Transport of a gallium rich film and the fits to quantify defects and donors. A donor at 27 meV shows a concentration of 4.25×10^{17} cm⁻³ and an acceptor of 7.26×10^{16} cm⁻³.



Figure 2: Transport of a gallium rich film and the fits to quantify defects and donors. A donor at 38 meV shows a concentration of 2.6×10^{17} cm⁻³ and an acceptor of 4.5×10^{15} cm⁻³.

Paper NM-MoM1-7, Room Ballroom A, 9:15 AM

Molecular Beam Epitaxy of Binary and Ternary Manganese and Chromium Nitrides.

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Left column: Resistance vs temperature for Mn_xCr_yN with increasing amounts of Cr (purple to red). The binary compounds are metallic, while the ternaries are semiconducting.

Right column: X-ray diffraction for the same Mn_xCr_yN samples deposited on MgO (001) substrates, the corresponding beam equivalent pressure ratio ($\Phi_{Mn}: \Phi_{Cr}$) are shown in the top right of each panel. The ternary compounds fall outside of the two binaries, suggesting a nonrocksalt phase.





Achieving Atomically Ordered GaN/AIN Quantum Heterostructures: The Role of Surface Polarity

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Figure 1. Structural characterization of GaN/AIN quantum heterostructures on *c*-plane. (a) Lowmagnification HAADF-STEM image of monolayer GaN incorporated on the *c*plane of an AlN nanowire. (b) Highresolution HAADF-STEM image of the

orange-boxed region in (a). The ML GaN as well as the AIN barriers are indicated by the arrows. (c) ADF intensity analysis of the yellow-boxed region in (b). The yellow-shaded region indicates the cation intermixing region. (d) HAADF-STEM image of GaN/AIN digital alloys of 2 MLs GaN/6 MLs AIN (Sample A2).



Figure 2. Structural characterization of GaN/AlN quantum heterostructures on the semipolar plane. (a) Low-magnification HAADF-STEM image of 10 periods of GaN/AlN digital alloys embedded in an AlN nanowire. (b) HAADF-STEM image of the orange-boxed region in (a). (c) High-resolution HAADF-STEM image of the green-boxed region in (b). (d) Fast Fourier transform of (c). (e) ADF intensity analysis of the yellow-boxed region in (c). (f) HAADF-STEM image of the active region of Sample B2 consisting of 2 MLs GaN/6 MLs AlN.





Fig. 1. RHEED images of the (a, b) 1-step $Sc_{0.40}Al_{0.60}N$ sample, (c, d) 2-step $Sc_{0.32}Al_{0.68}N/Sc_{0.40}Al_{0.60}N$ sample, and (e, f) graded $Sc_{0.32\rightarrow0.40}Al_{0.68\rightarrow0.60}N/Sc_{0.40}Al_{0.60}N$ sample taken (a, c, e) just after nucleation and (b, d, f) after growth of the 150-nm total-thickness film.

Fig. 2. (a, b) Transmission electron micrographs of a 1step and graded start $Sc_{0.40}Al_{0.60}N$ sample, respectively. (c, d) Bragg-filtered images of the same regions on each sample highlighting the presence of rock-salt grains.



Fig. 3. $2\theta/\omega$ XRD scan about the 0002 reflection of a $Sc_{0.40}Al_{0.60}N$ sample having a graded initiation layer, an AlN interlayer and an NbN epitaxial metal layer grown on SiC.



Fig. 4. Atomic force microscopy image of a $Sc_{0.40}Al_{0.60}N$ sample having a graded initiation layer, an AlN interlayer and an NbN epitaxial metal layer grown on SiC. The rms roughness from the 5 μ m \times 5 μ m scan was 1.02 nm.

DISTRIBUTION STATEMENT A. Approved for public release: distribution unlimited.
High efficiency micrometer scale green and red light

emitting diodes

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Figure 1. Ultrahigh efficiency green emitting μ LEDs. (a) Schematic of the nanowire LED design, with a green InGaN/GaN multiple-quantum-dot (MQD) structure serving as the active region. (b) Scanning electron microscope of such a nanowire array. Scale bar: 3 μ m. (c) Variation in external quantum efficiency due to differences in nanowire diameters, with the navy blue curve coming from a thin nanowire diameter array and the purple curve coming from a larger diameter array. The thinner diameter array allows for more active region formation on the semi-polar plane rather than the polar c-plane, thus allowing for radiative excitonic recombination channels that are more efficient than traditional free carrier radiative recombination for InGaN.



Figure 2. High efficiency red emitting μ LEDs. (a) Schematic of the nanowire design, which employs a short-period superlattice (SPS) that allows for high levels of In incorporation in the single segment (SS) active region. (b) High angle annular dark field scanning transmission electron micrograph of such one such nanowire, where the four layers of SPS InGaN and the single segment active region InGaN are clearly visible at a higher contrast, as InGaN has a higher atomic number than GaN. (c) Electroluminescence of a red emitting μ LED at 2 A/cm². (d) The external quantum efficiency (EQE) of such red emitting μ LED devices can reach >7%.



Figure 1: XRD coupled scan of the first attempt at a think layer SPSL. Shows faint Pendelosung fringes. Inset image shows a cross-sectional TEM image of the sample, highlighting the strong ALN/GaN intermixing.



Figure 2: XRD coupled scans of the samples using various growth conditions used. The introduction of a N only pause step generates 2 regions of SPSL uniformity.







Figure 3: TEM images of the various altered growth conditions. A) Grown using alternating Al and Ga shutters. Resulting AlN and AlGaN layer thicknesses are approximately 5 ML and 3 ML respectively B) Grown using half the normal Ga flux. Resulting AlN and AlGaN layer thicknesses are the same as (A) but there is more variation in the AlN thickness C) Grown using alternating shutter conditions with an additional N-pause step. Shows 2 regions: strong intermixing (left) and strong layer uniformity (right). AlN and AlGaN layer thicknesses are 3 ML and 4 ML respectively.

Separate Absorption, Charge, and Multiplication Avalanche Photodiodes With InGaAs/GaAsSb Type-II Superlattices Grown by Molecular Beam Epitaxy.

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Abstract

Avalanche photodiodes (APDs) can be used in remote sensing applications, such as atmospheric greenhouse gas monitoring, free-space optical communications, and medical diagnostics, including the extended short-wavelength infrared (eSWIR) range between 1.3 µm and 2.5 µm. APDs have internal multiplication characteristics that allow them to detect weak signals. However, traditional *p-i-n* structure APDs, commonly used for longer infrared wavelengths $(1.55 - 3.4 \,\mu\text{m})$, can be performance-limited by the high dark currents due to band-to-band tunneling when subject to high electric fields. A separate absorption, charge, and multiplication (SACM) structure can be employed to improve their performance. The SACM structure decouples the absorption region from the multiplication regions, maintaining the absorber region below the tunneling threshold while keeping a high electric field only in the multiplier. In this work, we designed, grew, and fabricated an eSWIR SACM APD. The epitaxial layers grown by molecular beam epitaxy consist of a 5 nm-In_{0.53}Ga_{0.47}As/5 nm-GaAs_{0.51}Sb_{0.49}(InGaAs/GaAsSb) type-II superlattice (SL) absorber and 1000 nm-thick Al_{0.85}Ga_{0.15}AsSb (AlGaAsSb) multiplier on a InP substrate. The development of the SL involved the growth of InGaAs with a growth rate of 1 µm/hr and a V/III beam equivalent pressure (BEP) ratio of ~10, along with GaAsSb grown at a rate of 0.47 µm/hr and a V/III BEP ratio of ~20. Both were grown at a temperature of 470 °C, as measured by the Bandit system. Meanwhile, AlGaAsSb was grown at a rate of 0.6 µm/hr and a temperature of 500 °C. The X-ray diffraction (XRD) result of our devices is presented in Figure 1, which reveals a mismatch of -440 arcsec and -260 arcsec for AlGaAsSb and SL, respectively. The period of the SL was calculated from a distance between the satellite peaks, determined to be 9.75 nm. These devices have a cutoff wavelength of 2.4 µm, a gain of up to 60 at room temperature, and a resulting quantum efficiency of 600% at 2 µm. as shown in Figure 3. Furthermore, the excess noise factor of our AlGaAsSb-based SACM APD stays below 2.2, up to a gain of 30. This value is considerably lower than competing technologies, with 2 times lower than InAlAs-based SACM APD and 1.2 times lower than InAlAsSb SACM APD on GaSb at the gain of 10.

These results demonstrate the potential of AlGaAsSb-based SACM APDs with InGaAs/GaAsSb SLs for various eSWIR detection applications and provide insight into the design and fabrication of SACM APDs with good noise and sensitivity characteristics, making them suitable for a range of remote sensing applications in the eSWIR range. These results have significant implications for developing highly sensitive and low-noise APDs for use in various applications.



Figure 1. The XRD result of our SACM APDs with AlGaAsSb multiplier and InGaAs/GaAsSb SL on the InP substrate.



Figure 1. External quantum efficiency of an eSWIR AlGaAsSb-based SACM APDs with InGaAs/GaAsSb SL absorber at various reverse biases. The dotted line is for a commercial extended InGaAs photodiode with a cut-off wavelength of 2.6 µm.



Figure 2. Excess noise as a function of gain for the SACM APD described in this work, compared with a 1000-nm thick AlGaAsSb *p-i-n* APD.

ACKNOWLEDGMENTS

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Growth of MWIR ICLEDs on Silicon using Molecular Beam Epitaxy

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Previously, interband cascade light-emitting diodes (ICLEDs) grown on GaSb substrates have been demonstrated as useful emitters in the mid-wave infrared (MWIR) region of $3 - 5 \mu m$ for room-temperature (RT) continuous wave (CW) operation [1,2]. Transferring this technology to growth on Silicon substrates would be advantageous for applications in chemical sensing and IR scene projectors (IRSPs), providing improved manufacturability through direct integration onto these circuits. This presentation will discuss the comparison of high-performance ICLEDs grown at NRL on GaSb/Si buffers that were grown at UNM and on lattice-matched GaSb substrates, including L-I characteristics, cross-section transmission electron microscopy (XTEM) and x-ray reciprocal space mapping (RSM).

The growth of GaSb/Si involves GaSb buffer layers which were grown on Silicon (001) with a 4° offcut towards (111). The native oxide was removed using a dilute HF solution to obtain a hydrogen-passivated surface. To achieve III-V nucleation on Silicon, a ~10 nm thick AlSb layer was grown at a substrate temperature of 500°C followed by a 1 μ m buffer layer and an antimony cap to prevent oxidation. The GaSb/Si wafers were then transferred to NRL where an additional 2-3 μ m GaSb buffer and the ungrouped active ICLED stages were grown. This same 22-stage structure was grown on a GaSb substrate as a control sample. Accounting for differences in architecture, the ICLED structures grown on Silicon show efficiencies that are 75% of those measured in ICLEDs grown on GaSb. At 100 mA, 200- μ m-diameter mesas produce 184 μ W CW at 25°C and 140 μ W at 85°C.

Threading dislocations were observed in GaSb buffer grown on Si from the XTEM images, showing a higher density near the Silicon substrate but reduced near the ICLED. Individual dislocations which reached the active ICLED layers exhibited a multiplying effect throughout the structure. Another growth artifact seen in these images was a slow-varying oscillation in the ICLED layers. Our presentation will provide a detailed explanation for both mechanisms and a comparison of the ICLEDs grown on Silicon to those grown on GaSb. Possible strategies for improving the epitaxial quality and device performance will also be discussed.

[2] N. Schäfer et al., Opt. Engr. 58, 117106 (2019).

^[1] C. S. Kim et al., Opt. Engr. 57, 011002 (2018).

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Figure 1 (left) – CW L-I characteristics at room temperature for multiple 200- μ m-diameter ICLEDs from Wafers A-D on silicon and control Wafer E on GaSb. Figure 2 (right) - RT CW L-I characteristics of multiple epi-up ICLEDs on Silicon, compared to that for an epi-down and AR-coated ICLED on GaSb, all 200 μ m mesa diameter. Adjustment of the right power scale by a factor of 3.3 accounts for architectural differences.



Figure 3 – XRD Reciprocal Space Map of GaSb on Silicon buffer grown at UNM. Threading dislocation density is ~ 10^{8} /cm³ and the GaSb is 99.2% relaxed.



Figure 4 – (left) RSM of ICLED grown on GaSb buffer on Silicon and (right) RSM of ICLED grown lattice matched on GaSb. There is a reduction in the number of fringes in the metamorphic growth due to undulations in the ICLED structure.



Figure 1: Sketch of the III-V laser stack grown in a pocket on a silicon photonics wafer with the active region aligned to a silicon nitride waveguide.



Figure 2: Cross-sectional scanning electron microscope images showing a laser grown under conventional growth conditions with a large gap (a) and a laser grown with a selective buffer and a reduced gap (b).



Figure 3: Layer stack of the III-V InAs quantum dot laser structure grown on silicon.



Figure 1. (a) Cross sectional schematic of blanket-grown laser on planar GaP/Si substrate with ultralow threading dislocation density (TDD) after thermal cyclic annealing (TCA). (b) Pocket-grown laser directly on SiO₂/Si. (c) New platform for reduced TDD and reduced polycrystal formation, where TCA is applied to a planar buffer prior to SiO₂ and passive structure deposition.



Figure 2. (a) Cross sectional scanning electron microscope image of pocket laser on TCA GaAs/GaP/Si. (b) Comparison of laser light-current characteristics at elevated temperature for blanket GaAs or (c) Si pocket-grown substrate devices.



Figure 1: (a) Schematic of the NIR upconverter components in series, as demonstrated in this work. (b) Circuit diagram of the NIR upconverter where V_D , V_{LED} , and V_{CE} refer to voltage drops across the full device, the LED, and HPT, respectively. (c) Schematic showing future work where the LED will be metalmetal bonded to the HPT with the LED substrate removed.

Figure 2: (a) False color cross-sectional SEM of the HPT and (b) stack diagram of the HPT growth labeling the layer composition, thickness, growth temperature, and nominal bulk doping.



Figure 3: (a) IV characteristics of the HPT under different input powers (λ =1.55 µm). An input power density as low as 12.2 nW/cm² generates a current signal I_C that is distinguishable from the dark current. (b) Current above dark current vs input power (V_{CE} = 0.8V) showing linear response.







Bibliography

1. Spitzer, Cary R., and Cary Spitzer, eds. *Digital Avionics Handbook*. CRC press, (2000): 126-135.



Supplementary Pages

Figure 1: (Left) Triple-band PD layer structure, and (right) its operating principle under optical addressing.







Figure 3: PL spectra of MWIR and LWIR T2SL measured by FTIR showed peaks at 6 10 µm for MWIR and LWIR, respectively.



Fig. 4. (left) Cross-section of the PD device design, and device layout (up to 4-inch wafers) with aperture sizes 200, 100, 50µm and metal contact pads.

Parity-time symmetry single-mode double-microdisk InGaAs quantntum dot lasers

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We successfully demonstrate the parity-time symmetry (PT-symmetry) single-mode lasing operation of laterally coupled double-microdisk lasers. The microdisk lasers of disk diameter = 2.85 µm are fabricated by using MBE-grown InGaAs quantum dots as the gain medium. The gain materials of dots-in-a-well (DWELL) structures are grown on (001) n⁺-GaAs substrate by molecular beam epitaxy. The wafer structure consists of a 1 µm-thick Al_{0.5}Ga_{0.5}As sacrifice layer, and an active layer comprised of a stack of six InGaAs DWELLs. In spite of the lasing output of multiple whispering-gallery modes (WGMs) from the single microdisk lasers, the laterally coupled double-microdisk lasers achieve single WGM lasing under gain-loss contrast pumping condition, literally pumping only one disk for the double- microdisk. We change the air gap distance (*d*) for the coupled double-microdisk structures to change the coupling strength (*k*) between the microdisks. Under single selective pumping (gain-loss contrast) at room temperature, the laterally coupled double microdisk lasers of *d* = 150nm, and 200nm show single lasing mode at WGM m = 1, 21 (λ = 1199nm). We also fabricate the double-microdisk lasers by coating the microdisks with HfO₂ to change the coupling strength *k*. Under single selective pumping, the HfO₂-coated double microdisk lasers show a single lasing mode at WGM m = 1, 20 (λ = 1277nm).



Fig. 1. SEM picture for single microdisk of diameter = $2.85 \mu m$, and the lasing output of multiple WGMs .



Fig. 2. Under single selective pumping (gain-loss contrast) at room temperature, single lasing mode at WGM m = 1,21 $(\lambda = 1199 \text{ nm})$ is obtained for the laterally coupled double- microdisk laser of d = 150 nm.

Impact Ionization Coefficients of Al_xGa_{1-x}AsSb (x=0 – 1) Lattice Matched to InP Substrates

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Abstract

Impact ionization is a crucial process in the physics of semiconductors that influences the operation and performance of various semiconductor devices. It is utilized in avalanche photodiodes (APDs) to increase signal-to-noise ratio, but it can also lead to avalanche breakdown in electronic devices. To ensure reliable device operation, it is vital to determine the impact ionization coefficients of electrons and holes (α and β), respectively. In this study, we present the α and β for a range of Al_xGa_{1-x}AsSb compositions, covering x from 0 to 1, as determined through measurements of avalanche multiplication. Additionally, we explore the relationship between the impact ionization coefficients and the bandgap (E_g) change (Γ and X points) along with the indirect-to-direct transition. This is because the impact ionization process is influenced by the material's band structure and the E_g .

Four PIN Al_xGa_{1-x}AsSb APDs with x of 0, 0.5, 0.65 and 0.85 were grown on InP using the RIBER Compact 21DZ molecular beam epitaxy, and standard photolithography with a citric-based wetetch technique was used to fabricate devices for electrical characterizations. The measured photocurrent spectra of the four APDs are presented in Fig. 1 (a), which illustrates that the cut-off tail moves toward lower energy as the x gradually decreases. To investigate the behavior of the E_g with various Al compositions, the $E_{g,\Gamma}$ and $E_{g,X}$ were extracted, as shown in Fig. 1 (b), and compared with the theoretical change in E_g proposed by Adachi [1]. The discrepancy of E_g between the theory and experiment may come from the alloy disorder that can induce lower E_g than expected in the theoretical calculation. The result suggests that the cross-over should happen around x=0.5 which is similar value predicted by Adachi [1].

The α and β for Al_xGa_{1-x}AsSb with x=0, 0.85 [2], and 1 [3] were plotted as a function of inverse electric field as shown in Fig. 2 (a). Fig. 2 (b) illustrates the α and β for Al_xGa_{1-x}AsSb with x=0, 0.85, and 1 as a function of x at 290 kV/cm. The α remains fairly constant until x=0.85, where it jumps up at x=0, while the β gradually increases as the x decreases from 1 to 0. This suggests that the α can change abruptly at a critical x point, and a similar point may exist for the rate of change in the β , as seen in other material systems such as AlGaInP and AlGaAs on GaAs [4]. To gain more insight, we will explore the behavior of E_g and α and β for additional x=0, 0.2, 0.4, 0.45, 0.50, 0.55, 0.65, 0.75, 0.85, and 1 in Al_xGa_{1-x}AsSb. Knowing these coefficients and E_g parameters will allow engineers and scientists to design and optimize the performance of optoelectronic and electronic devices.



Figure 1 (a) The photocurrent spectra of $Al_xGa_{1-x}AsSb$ (x=0, 0.5, 0.65, 0.85, and 1) and (b) their band gap change as a function of Al composition. The measured bandgaps were compared with the ones theoretically calculated by Adachi.



Figure 2 (a) Impact ionization coefficients (α and β) of Al_xGa_{1-x}AsSb (x=0, 0.85, and 1) as a function of inverse electric field. (b) The α and β values extracted at 290 kV/cm as a function of Al composition.

References

- [1] S. Adachi, *Properties of semiconductor alloys: group-IV, III-V and II-VI semiconductors*. John Wiley & Sons, 2009.
- [2] B. Guo *et al.*, "Impact ionization coefficients of digital alloy and random alloy Al 0.85 Ga 0.15 As 0.56 Sb 0.44 in a wide electric field range," *Journal of Lightwave Technology*, vol. 40, no. 14, pp. 4758-4764, 2022.
- [3] X. Yi *et al.*, "Extremely low excess noise and high sensitivity AlAs 0.56 Sb 0.44 avalanche photodiodes," *Nature Photonics*, vol. 13, no. 10, pp. 683-686, 2019.

[4] H. I. Lewis *et al.*, "Impact Ionization Coefficients in (Al x Ga 1-x) 0.52 In 0.48 P and Al x Ga 1-x As Lattice-Matched to GaAs," *IEEE Transactions on Electron Devices*, vol. 68, no. 8, pp. 4045-4050, 2021.

Acknowledgement

This work was supported by the Advanced Component Technology (ACT) program of NASA's Earth Science Technology Office (ESTO) under Grant No. 80NSSC21K0613.



AFM scans of two aluminum layers grown on $In_{0.75}Ga_{0.25}As/In_{0.53}Ga_{0.47}As$ (6nm/100nm) on the InP(001) substrate. In both cases, the nominal thickness of the Al layer was 10 nm.

- a. The layer was deposited at 0.5 Å/s.
- b. The layer was deposited at 3.0 Å/s.



Superconducting to normal phase transition signatures for three Al layers:

G0972 was deposited at 3.0 Å/s (10 nm thick) G0973 was deposited at 2.0 Å/s (10 nm thick) G0965 was deposited at 2.0 Å/s (8.6 nm thick)

Layers deposited at lower growth rates did not show superconductive behavior.



Figure 1. Schematic image of the bottom tunnel junction laser diode.



Figure 2. (a) Emission spectra for different driving currents with inset showing zoomed-in spectra at 250 mA. (b) Real-color picture of the farfield of the bottom tunnel junction laser diode directed onto sheet of paper.



Figure 3. Comparison of current-voltage characteristics for the reference p-up laser diode with Si- and Ge-doped bottom tunnel junction laser diode.

Title: Zeeman Field-Induced Two-Dimensional Weyl Semimetal Phase in Cadmium Arsenide Thin Films

Abstract

We report a topological phase transition in MBE-grown, quantum-confined cadmium arsenide (Cd_3As_2) thin films under an in-plane Zeeman field when the Fermi level is tuned into the topological gap via an electric field. Symmetry considerations in this case predict the appearance of a two-dimensional Weyl semimetal (2D WSM), with a pair of Weyl nodes of opposite chirality at charge neutrality that are protected by space-time inversion (C_2T) symmetry. We show that the 2D WSM phase displays unique transport signatures, including saturated resistivities on the order of h/e^2 that persist over a range of in-plane magnetic fields. Moreover, applying a small out-of-plane magnetic field, while keeping the in-plane field within the stability range of the 2D WSM phase, gives rise to a well-developed odd integer quantum Hall effect, characteristic of degenerate, massive Weyl fermions. A minimal four-band $k \cdot p$ model of Cd_3As_2 , which incorporates first-principles effective g factors, qualitatively explains our findings.

Figure



Caption

Out-of-plane and in-plane magnetotransport. (a) Longitudinal conductivity σ_{xx} as a function of the out-of-plane field B_{oop} and the scaled (relative to V_{CNP}) top-gate voltage for the 18 nm Cd₃As₂ sample (device, hb1). Quantum Hall plateau regions are indexed by their filling factor v up to 6. The measured voltage V_g is offset by V_{CNP} , which corresponds to the charge neutrality condition.

(b) Longitudinal resistivity ρ_{xx} as a function of the in-plane field B_{ip} and the top-gate voltage for the 18 nm Cd₃As₂ sample (device, hb1). The same is shown in (c) for the 22 nm sample. $V_{CNP} = -1.35$ V for the 18 nm sample, $V_{CNP} = -1.165$ V for the 22 nm sample. Measurements were done at T = 2 K in the transverse configuration.

Reference:

B. Guo ... S. Stemmer, *Phys. Rev. Lett.* 131, 046601 (2023)



Figure 1: Two Polar plots of reciprocal space. The two coordinates of each point on the plot correspond to, an amount of tilt, ψ , away from the exact (001) planes and also an azimuthal angle, ϕ , that indicates the direction of the tilt. The relative intensities of points on the plot reveal what proportion of the crystal structure is tilted in that direction. Figure (a) corresponds to sample A and Figure (b) corresponds to sample B. The tilt ψ is measured as the radius and ϕ is the azimuthal angle measured counter-clockwise from the positive x axis. At $\phi = 0^{\circ}$ the incident X-ray beam is travelling in the [011] crystallographic direction. Figures (a) and (b) can be thought of as a 2D projection of the surface of the hemisphere shown in (c).



Figure 2: Scanning electron microscope ECCI images for (a) sample A and (b) sample B. Small dots of increased contrast caused by TDD are circled in red. The corresponding crystallographic directions and image scale are indicated by the blue arrows on the right.

Multicolor micrometer scale light emitting diodes monolithically grown on the same chip

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Figure 1. Schematics and structural characterization of a nanowire array. (a) Schematic of the nanowire array with a green InGaN/GaN multiple-quantum-dot (MQD) design for the active region. (b) A sample scanning electron microscopy of such a nanowire array. The scale bar (in white) is 1 micron. (c) Layout of the two-dimensional honeycomb shaped photonic crystal, which is parametrized by nanowire diameter and lattice constant. The two vertical lines indicate the nanowire diameter length, and the vertical double-headed arrow indicates the lattice constant length in this sample crystal design.



Figure 2. Variation in photoluminescence peak wavelength due to varying nanowire diameter. (a) Photoluminescence spectra for nanowire arrays with a classic multiplequantum-disk design but different nanowire diameters. The lattice constant is 240 nm

for all curves here. (b) The peak wavelength of photonic crystal mode emissions can be modulated with the nanowire diameter as well. The lattice constant is 280 nm for all curves here. (c) Scatterplot showing the effect of peak wavelength modulation persists for different lattice constants.

References

- A. W. Bett and O. V. Sulima. GaSb photovoltaic cells for applications in TPV generators. *Semiconductor Science and Technology*, 18(5):S184, April 2003.
- [2] T. N. Danilova, B. E. Zhurtanov, A. N. Imenkov, and Yu. P. Yakovlev. Light-emitting diodes based on GaSb alloys for the 1.6–4.4 m mid-infrared spectral range. *Semiconductors*, 39(11):1235–1266, November 2005.
- [3] Daniel Kandel and Effhimios Kaxiras. The surfactant effect in semiconductor thin film growth, January 1999. arXiv:cond-mat/9901177.
- [4] Shouzhu Niu, Zhipeng Wei, Xuan Fang, Dengkui Wang, Xinwei Wang, Xian Gao, and Rui Chen. Brief Review of Epitaxy and Emission Properties of GaSb and Related Semiconductors. *Crystals*, 7(11):337, November 2017. Number: 11 Publisher: Multidisciplinary Digital Publishing Institute.
- [5] B. Z. Nosho, B. R. Bennett, E. H. Aifer, and M. Goldenberg. Surface morphology of homoepitaxial GaSb films grown on flat and vicinal substrates. *Journal of Crystal Growth*, 236(1):155–164, 2002.

1

1 **RESULTS AND DISCUSSION:**

2 The $Al_{0.34}Ga_{0.66}N/GaN$ microfabricated Hall sensor [Fig. 1(b)], where evaluation of the 2-3 DEG is achieved by investigating the Hall voltage which has direct influence on drift velocity of 4 carrier, as a function of thermal aging time. Fabricated Micro-Hall sensor sensitivity tested under 5 constant current and voltage bias mode for all thermal annealing protocol, corresponding data 6 presented in Fig. 2(a & b). The efficiency of Al_{0.34}Ga_{0.66}N/GaN micro-Hall sensor under thermal 7 aging, we calculated the Absolute Sensitivity (S_A), of a Hall device is defined as the change in 8 output Hall voltage (V_H) divided by the change in applied magnetic field (H) i.e., $S_A =$ $G_{H} \frac{r_{H}}{qN_{2deg}} I_{b} - -(1)$. Similarly, Supply Current Related Sensitivity (S_{scrs}) expressed as S_{scrs} = 9 $G_{\rm H} \frac{r_{\rm H}}{qN_{2deg}} - -(2)$, and Supply Voltage Related Sensitivity (S_{svrs}) can be defined as S_{svrs} = 10 $G_{\rm H} \frac{r_{\rm H}}{R_{\rm q} N_{\rm 2 deg}} - -(3)$ which implies that $S_{\rm svrs} = \mu_{\rm H} G_{\rm H} \frac{r_{\rm H}}{\left(\frac{L}{W}\right)} - -(4)$. From above relation, it is 11 clear that current-related sensitivity (S_{scrs}) is inversely proportional to (n_s) and the voltage-related 12 sensitivity (S_{syrs}) is directly proportional to electron mobility. The measured taken current-related 13 sensitivity (S_{scrs}) were found to be 74 $VA^{-1}T^{-1}$ and 82 $VA^{-1}T^{-1}$ (SCRS), and voltage-related 14 sensitivity (S_{svrs}) are measured to be 0.053 T⁻¹ and 0.051 T⁻¹ (SVRS) for pristine sample and 15 16 after 2800 hours thermal aging at 200 °C in air. As we seen from Fig. 2 there will be ~2% 17 improvement in SCRS and ~2% change in SVRS of the Hall sensor after a prolonged baking times 18 of 2800 hours at 200 °C. As expected, the Hall sensor has the ability to survive at 200 °C in air for 19 an extended period of time. The slight increasing trend of SCRS and decreasing trend of SVRS 20 with heating due to the combined changes in sheet carrier density and mobility $(n_s\mu)$.

21 CONCLUSIONS:

We have investigated the temperature response of Al_{0.34}Ga_{0.67}N/GaN Hall sensors, in terms 22 23 of the Hall sensitivity, and Ohmic contacts during thermal aging at 200 °C for up to 2800 hours 24 under atmospheric conditions. The MBE grown Al_{0.34}Ga_{0.67}N/GaN Hall sensors were 25 characterized by using HR-XRD, micro-Raman, and XPS on Hall sensor device before and after 26 thermal aging time. To compare the performance of the Hall sensor we have correlated the 27 structural evolution in Al_{0.34}Ga_{0.67}N/GaN Hall sensor heterostructures with measured electric 28 response of Hall device. Results indicate that the Al_{0.34}Ga_{0.67}N/GaN Hall sensor provides stable 29 performance for as long as 2800 hours aging at 200 °C without any significant degradation to the 30 sensitivity, and Ohmic contacts. However, this study conducted for Hall sensor device does not 31 have surface passivation, though we have noticed the out-diffusion of 'Ga' and 'Al' does not affect 32 much on performance of the Hall sensor. Addition we have found initial stage of contacts 33 resistance droop which could be due to out 'Ga' or Al diffusion process may be consequence of a 34 reduction of oxygen concentration at the GaN/Ti interface resulting in a reduced contacts barrier 35 height. The 'Pt' based ohmic contact enables bumpy free surface morphology after 800°C RTA.

36

1 FIGURES:



after 800 °C RTA

- 3 Fig. 1. (a) Cross-sectional growth diagram of AlGaN/GaN Hall sensor, (b) Plan view of Greek-
- 4 Cross Hall sensor device before RTA, (c) Plan view of Greek-Cross Hall sensor device after Ohmic
- 5 contact after RTA annealing (d) TLM structure used for contact resistance measurement.



6

2

7 Fig. 2. Measured (a-b) Micro-Hall sensor have a linear response to magnetic field, both in current

and voltage bias mode over a wide range of thermal annealing time at 200 °C in atmospheric
condition.



Optimization of Heteroepitaxial ZnGeN₂/GaN Quantum Wells for Green LEDs

Figure 1: (left) APT (top) and EDS (bottom) of the $ZnGeN_2/GaN$ five-unit quantum well, showing unintentional incorporation of Ge and Ga; (right) STEM/EDS of a 5 MQW $ZnGeN_2/GaN$ heterostructure showing clear abrupt interfaces.



Figure 2: APT of the optimized ZnGeN₂/GaN five-unit quantum well, showing reduced unintentional incorporation of Ge and Ga.



Machine Learning Analysis and Predictions of PAMBE III-Nitride Growth

Figure 1: (a) P-values for GaN growth parameters – initial nitrogen pressure, substrate temperature, RF plasma source power, and gallium effusion cell temperature – measured with respect to the crystallinity value. (b) Decision tree fit to the GaN synthesis parameter data indicating the splitting rules which most accurately predict the crystallinity value in the GaN growth data.



Figure 2: (a) Distribution of GaN training data points across a synthesis space of the two most statistically significant growth variables. (b) Class conditional probability value of a GaN sample growing as single crystalline as predicted by a random forest ensemble algorithm trained upon the growth data. During these predictions, the gallium effusion cell temperature was held constant at 960 °C and the RF plasma power was held constant at 350 W.



Fig. 1. Schematic diagrams of (a) sample layer structure of three cycles of the InGaAs/GaAsSb/InGaAs W-QW and (b) band alignment of one cycle of the W-QW with GaAsP strain-compensation layers.



Fig. 2. X-ray rocking curves of W-QW with various Sb compositions in the GaAsSb layer. The red arrows show the shift of the rocking curves as a function of different Sb compositions.



Fig. 3. Low-temperature PL (excitation power of 50 mW) of W-QW with various Sb compositions. The spectra are shifted vertically for clarity.

Growth of Cobalt-containing Compounds for Back-End-of-Line Interconnects

Yansong Li, Guanyu Zhou, Christopher Hinkle University of Notre Dame



FIG. 1. (a) SEM image of as-grown CoSi nanobelt on HOPG substrate. (b) Dimension-dependent resistivity curve of CoSi nanobelts.



FIG. 2. (a) $\theta - 2\theta$ XRD of PtCoO₂ thin film. (b) XPS spectra of Pt 4f and Co 2p for the PtCoO₂ thin film.

References

- [1] Y. Liu *et al.*, "Valence band engineering of GaAsBi for low noise avalanche photodiodes," *Nat. Commun.*, vol. 12, no. 1, 2021.
- [2] R. D. Richards, "Molecular beam epitaxy growth and characterisation of GaAsBi for photovoltaic applications," no. September, p. 197, 2014.

Supplementary Material



Figure 1 Sample architecture for Al_xGa_(1-x)As_(1-y)Bi_y growth investigation. Capping growth temperature varied only for purpose of annealing investigation.



Figure 2 Room Temperature Photoluminescence Spectra of $Al_xGa_{(1-x)}As_{(1-y)}Bi_y$ samples with varied Al contents between 0-15%. Bi content between 2.3-2.7% across the series with the main peak of interested marked.



Figure 3 X-Ray Diffraction of Al_{0.05}Ga_{0.95}As_{0.976}Bi_{0.024}



Figure 4 Normaski microscope Images of sample surfaces A,B & C for X= 0.0, 0.05 & 0.15 Al_xGa_(1-x)As_(1-y)Bi_y alloys respectively with 300μm scale bar.



Figure 1. Samples structure and RHEED patterns observed at different stages of AIN growth.



Sample growth at 790 °C Sample growth at 830 °C RMS=1.74 nm RMS=0.354 nm Figure 2. AFM surface micrographs of samples grown at 790 and 830 °C.



Figure 3. SIMS depth profile of Mn in the samples grown at 790 and 830 °C.

Growth and scattering mechanisms of metamorphic In_{0.81}Ga_{0.19}As quantum wells

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Supplementary Figures:



Figure 1: a) Low temperature (2 K) magnetotransport of an In_{0.81}Ga_{0.19}As quantum well. b) Electron mobility as a function of carrier density of a gated In_{0.81}Ga_{0.19}As quantum well.



Supplementary Materials

Figure 1. XRD of an InAs/AlSb QCD grown strain balanced on GaSb with a designed absorption wavelength of 4.3 μ m.



Figure 2. AFM of a $3 \times 3 \mu m$ surface of the InAs/AlSb QCD grown strain balanced on GaSb. The RMS surface roughness of this scan is 0.189 nm

Supplemental document: Impact of unintentional Sb in the tensile electron well of type-II InAs/InAsSb superlattices grown on GaSb by molecular beam epitaxy Marko S. Milosavljevic, Preston T. Webster, and Shane R. Johnson

The figure below shows the photoluminescence spectra from four 5.3 μ m midwave and four 12.0 μ m longwave InAs/InAsSb superlattices, measured at 80 K with an 808 nm pump power of 200 mW. The solid vertical lines indicate the superlattice bandgap energy extracted from each spectra. The dashed lines indicate the expected bandgap position for a structure with a pure tensile InAs layer. The blue shift in the measured bandgap indicates the presence of unintentional Sb in the tensile InAs layer.



In the figure below, left panel (a) shows measured Sb mole fractions in the compressive layer as open black circles and the tensile layer as open red circles for the mid and long wave structures. The fit to the model is shown as solid black and red curves for the tensile and compressive layers respectively. The mole fraction versus monolayer number is shown in panels (b) and (c) for the mid and long wave InAs/InAsSb superlattices; the Sb profile is in red and the average of the profile is in black.



The average structure of the grown midwave and longwave InAs/InAsSb superlattices is shown in the table below. The layer thicknesses and Sb mole fractions are averages and are labeled as the "Grown" structure. For comparison, an "Ideal" structure with no unintentional Sb in the tensile InAs layer is also shown. The 80 K bandgap, compressive Sb mole fraction, and tetragonal distortion are the same for both the grown and ideal structures. The grown structures have a significantly thicker tensile layer. a slightly thinner compressive layer, and a smaller electron-hole wavefunction overlap.

Superlattice type	Superlattice tetragonal distortion (%)	80 K Bandgap			Sb mole fraction (%)		Thickness (nm)		Electron-hole
		(meV)	(µm)	Structure	Tensile InAs(Sb)	Comp. InAsSb	Tensile InAs(Sb)	Comp. InAsSb	overlap squared (%)
Mid-wave	-0.0013	233	5.3	Grown Ideal	1.8 0	40.0 40.0	4.61 3.87	1.12 1.18	58.2 63.1
Long-wave	0.0269	103	12.0	Grown Ideal	1.2 0	40.5 40.5	9.56 8.54	2.56 2.62	22.2 24.8



Fig. 1: Surface density of etched nanoholes vs. the inverse etching temperature T_{etch} . Data points were generated by counting nanoholes at 2,000x magnification in an SEM evaluating at least 40 nanoholes per temperature.



Fig. 2: AFM images and line profiles for samples overgrown with 50 nm $In_{0.52}Al_{0.48}As$ and etched at 410°C (a) and b)), at 435°C (c) and d)), and at 460°C (e) and f)), respectively. Etching was performed with 4.1 ML of InAl. The size of the AFM images is $1 \times 1 \ \mu m^2$.



Fig. 3: AFM images and profiles for nanoholes etched with approximately 2 ML of Al (a) and b)) and 2 ML of In (c) and d)). The etching temperature T_{etch} was in both cases 435°C. Holes etched with Al are significantly more elongated along the [011] direction as can be seen from the image a) and the line scans along the high symmetry directions b).



Fig. 4: Ensemble photoluminescence from quantum dots generated by In_{0.53}Ga_{0.47}As filling of nanoholes etched at 435°C and 460°C and 50 nm In_{0.52}Al_{0.48}As overgrowth (see Fig. 2 c) - f)). The filled holes have been capped by 100 nm In_{0.52}Al_{0.48}As. The In_{0.53}Ga_{0.47}As deposition amount is given in the figure as an equivalent homogeneous layer deposition and corresponds to the maximum possible filling amount for nanoholes generated at these temperatures, which was found by investigating uncapped holes filled with the same parameters.
Strain-mediated Sn incorporation and segregation in compositionally graded Ge_{1-x}Sn_x epilayers grown by MBE at different temperature

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Group IV alloys of Ge and Sn are extensively studied for various electronic and optoelectronic applications on a Si platform. Ge_{1-x}Sn_x with α -Sn concentrations as low as 6% [1] allows for a transition from an indirect bandgap to a direct optical. Higher Sn content makes possible mid and even long-range infrared optical emission and detection [2]. At the same time, due to the low solid solubility of Sn in Ge (~1%), as well as the large lattice mismatch of α -Sn with Ge (~14%), the realization of high-quality Sn-rich Ge_{1-x}Sn_x structures has proved challenging. In this study, we demonstrate enhanced Sn content using molecular beam epitaxy (MBE) growth of compositionally graded Ge_{1-x}Sn_x on Ge (001). High-quality GeSn alloys with Sn composition reaching 6% at constant temperature. The maximal fraction of Sn was further increased to 9.0% when the growth temperature was continuously lowered while increasing the Sn flux. The analysis of surface droplets and SIMS (secondary ion mass spectrometry) profiles of elemental composition give evidence of Sn rejection during the growth, potentially associated with a critical energy of elastic strain. The intentional reduction of Sn in the Ge_{1-x}Sn_x layer and lower surface segregation. Supporting data (Fig.2) shows an approach for XRD spectra simulation was developed for strain and composition characterization.



Fig. 1. (a) XRD (004) $\omega/2\theta$ scans, (b) ($\overline{2}\overline{2}4$) RSMs of samples G1 and G2 and (c) The SIMS profiles of Sn and Ge in the Ge_{1-x}Sn_x epilayer of samples S1 and S2.

S. Wirths, D. Buca, S. Mantl, Prog. Cryst. Growth Charact. Mater. 2016, 62 (1), 1–39.
 J. Bass, H. Tran, W. Du, R. Soref, S.-Q. Yu, Opt. Exp. 2021, 29 (19),30844-30856.

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Supplementary Pages (Optional)

Fig. 2. Calculated X-ray diffraction 004 $\omega/2\theta$ spectra for several pseudomorphic compositionally graded Ge_{1-x}Sn_x/Ge heterostructures showing the effect of (a) linear grading, (b) stepwise grading, and (c) exponential grading on the scattered intensity.

Growth and Characterization of GaAs (111) on 4H-SiC for Infrared Sensor

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Epitaxial growth of III-V semiconductors on 4H-SiC would potentially allow the integration of optical sensors on SiC based power devices. We report on the growth of high-quality crystalline GaAs layer on the SiC hexagonal substrate by molecular beam epitaxy (MBE). For fabrication on SiC, a 5 nm AlAs nucleation layer was grown at 700 °C followed by a 60 nm GaAs layer buffer grown at 600 °C. We will discuss the surface morphology, structural quality, and the optical properties of the MBE grown samples. The ω -2 θ scan result (fig.1. (a)) corroborates the crystalline growth of GaAs (111) on 4H-SiC. The structural quality is further illustrated by the cross-sectional TEM image in fig. 1(b). It consists of a high-quality GaAs layer and a highly defected interface region between GaAs and the 4H-SiC substrate. This defect region is attributed to the lattice and crystal structure mismatch between substrate and film. Fig. 1(c) shows the temperature dependent photoluminescence properties of the grown structure. Good free-exciton (FE) emission has been observed at room temperature (300 K) and lower temperature (77 K). Excitingly, the optical results were comparable with the same structure grown on a GaAs substrate. Overall, these observations exhibit potential to achieve an optical emitter for sensors integrated on SiC based power device platform.



Figure 1. (a) XRD (ω -2 θ) scan, (b) cross-sectional TEM image, (c) temperature dependent photoluminescence spectra of GaAs/SiC structure.

[1] S. K. Saha, R. Kumar, A. Kuchuk, M. Z. Alavijeh, Y. Maidaniuk, Y. I. Mazur, S.-Q. Yu, and G. J. Salamo, Cryst. Growth Des., **19**, 5088–5096 (2019).

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Suplementary Pages (Optional)

Fig. 2 depicts the nominal structure of the GaAs grown on 4H-SiC. A 5 nm AlAs nucleation layer was grown at 700 °C whereas, the buffer layer of 60 nm GaAs was grown at 600 °C. All the growth temperatures were measured by the thermocouple. Fig. 3 illustrates reflection high energy electron diffraction (RHEED) images before growth (fig. 3(a)) and after growth (fig. 3(b). A streaky RHEED image is evidence of high cleanliness and smoothness of substrate surface. The spotty pattern from fig. 3(b) indicates the 3D growth mode and the existence of twining.



Fig. 2. Schematic structure of GaAs/SiC.



Fig. 3. RHEED images of GaAs/SiC structure (a) before growth and (b) after growth.



Fig. 1. After a few monolayers of α -Sn(Ge) growth, RHEED becomes a streaky (2x2) pattern (a,b). The thickness and Ge composition were determined from XRD simulation and Pendellösung fringes (c). Cross sectional SEM imaging confirmed thickness and showed single crystal layers with abrupt interfaces between α -Sn(Ge)/CdTe/InSb (d) and smooth surfaces (e).



Fig. 2. α -Sn and dilute Ge alloys exhibit large magnetoresistance, Shubnikov-de Haas oscillations and weak antilocalization (a,b). Expanded Shubnikov-de Haas quantum oscillations as a function of inverse magnetic field (c).



Fig. 3. RHEED reconstruction changes from (2x) to (1x) with increasing Sn composition (a,b). XRD spectra of GeSn samples towards achieving *k*-SCS with increasing Sn content, showing nice Pendellösung fringes (c). (inset) Sn composition versus Sn cell temperature calibration curve for constant substrate and Ge cell temperature.

[1] D. Zhang, H. Wang, J. Ruan, G. Yao, and H. Zhang, "Engineering topological phases in the Luttinger semimetal *a*-Sn," *Physical Review B*, vol. 97, no. 19, p. 195139, 05/21/2018

[2] T. T. McCarthy, Z. Ju, S. Schaefer, S.-Q. Yu, and Y.-H. Zhang. "Momentum(k)-Space Carrier Separation Using SiGeSn Alloys for Photodetector Applications" *Journal of Applied Physics* **130**, 223102 (2021)

Supplemental Material



(left) AFM of Al_{0.7}Ga_{0.3}N grown on TaC (a) and AlN (b) showing spiral hillocks indicative of step-flow growth and a large dislocation density. (right) STEM image of a defect propagating from TaC to AlGaN



RHEED images of Al_{0.7}Ga_{0.3}N nucleation on TaC. (a) shows the streaky-smooth TaC surface before growth. (b) shows RHEED captures from the first few cycles of metal-modulated epitaxy. The arrows point to an incommensurate spot which is more pronounced in metal-rich conditions and is not seen after 7 cycles. (c) shows the AlGaN at the end of growth.



Figure 1: (a) AlGaAs /GeSn heterostructure band diagram (b) Silvaco simulated band structure



Figure 2: (a) AlGaAs/GeSn diode device structure (b) Optical microscope image of the diodes



Figure 3: (a)I-V performances from -2V to 2V from the different regions of the sample

(b) C-V performances under frequency from 10KHz to 200KHz(100KHz was measured multiple times to check the stability)

Van der Waals epitaxy of 2D ferromagnetic Fe_{5-x}GeTe₂ films with Curie temperature above room temperature on graphene

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Desired session: NM9: Van der Waals Materials Preferred Presentation Type: Oral

Abstract

Van der Waals (vdW) heterostructures combining layered ferromagnets and other twodimensional (2D) crystals such as graphene and transition metal dichalcogenides are promising building blocks for the realization of ultra-compact devices with integrated magnetic, electronic and optical functionalities. Their implementation in various technologies depends strongly on the development of a bottom-up, scalable synthesis approach allowing to realize highly uniform heterostructures with well-defined interfaces between different 2D layered materials. It also requires that each material component of the heterostructure remains functional, which ideally includes ferromagnetic order above room temperature for 2D ferromagnets. In this contribution, we will present our recent results on van der Waals (vdW) epitaxy of the 2D itinerant ferromagnetic metal Fe_{5-x}GeTe₂ (FGT, $x \sim 0$) on single crystalline epitaxial graphene using molecular beam epitaxy. For the growth of FGT films (with thickness ranging from 10 to 15 nm), elemental Fe, Ge, and Te were co-supplied from conventional effusion cells, and a growth temperature of 300 °C was employed. As a substrate, epitaxial graphene on 4H-SiC(0001), synthesized via SiC surface graphitization, was employed. Morphological and structural characterization using methods such as atomic force microscopy, synchrotron-based grazing incidence X-ray diffraction, and scanning transmission electron microscopy (STEM) revealed that epitaxial FGT films exhibiting very good surface morphology, high crystalline quality, and a sharp interface to graphene could be realized. Interestingly, stacking faults related to the presence of single FGT layers with thicknesses exceeding those expected for the Fe₅GeTe₂ phase could be identified by STEM. We expect these to be novel FGT metastable phases with Fe composition higher than 5 and potentially enhanced magnetic properties. Temperaturedependent magneto-transport measurements and superconducting quantum interference device (SQUID) magnetometry were employed to assess the magnetic properties of the samples. Ferromagnetic order with a predominant out-of-plane magnetization was shown to persist above 350 K. Furthermore, magneto-transport also revealed that the epitaxial graphene continues to exhibit a high electronic quality. These results represent an important advance beyond non-scalable flake exfoliation and stacking methods, thus marking a crucial step toward the implementation of ferromagnetic 2D materials in practical applications.



(a). RHEED pattern of $ErMn_6Sn_6(0001)$ thin films. (b). In-plane hysteresis loops of $ErMn_6Sn_6$ thin films at different temperatures taken with SQUID. (c). AHE hysteresis loops of $ErMn_6Sn_6$ thin films at different temperatures. (d). RHEED pattern of $TbMn_6Sn_6(0001)$ thin films. (e). Out-of-plane hysteresis loops of $TbMn_6Sn_6$ thin films at different temperatures taken with SQUID. (f). Temperature dependence of remanence magnetization of $TbMn_6Sn_6$ thin films, suggesting out-of-plane to in-plane spin reorientation above T = 300 K.

Layer-dependent Optical Properties of MBE-grown ZrTe₂ Determined by in-situ Spectroscopic Ellipsometry

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Two-dimensional transition metal dichalcogenides (TMDCs) are an interesting platform to interrogate fundamental physics questions as well as to advance the development of optoelectronic technologies. Both these endeavors are heavily dependent on having high-quality TMDCs, realized only after employing extensive growth optimization procedures. In this work, we investigated the growth and the optical properties of $ZrTe_2$, a candidate topological Dirac semimetal. During the growth of 12 unit cells (u.c.) of $ZrTe_2$ on a sapphire substrate, we obtained in-situ spectroscopic ellipsometry after the deposition of each u.c. After the deposition of the $ZrTe_2$, we deposited a Te capping layer to protect the TMDC film. X-ray reflectivity measurements performed subsequently indicated that the total thickness of ZrTe₂ and the thickness of Te to be 5.95 nm and 19 nm, respectively.

A standard inversion technique was used to model the ellipsometry spectra by specifying a three layer model (i.e., sapphire substrate, $ZrTe_2$ layer and the Te capping layer) to fit the final ellipsometry spectra. The thicknesses obtained from X-ray reflectivity allowed us to obtain the precise dielectric function of the final $ZrTe_2$ layer (i.e., 12 u.c.). Subsequently, we fit the remaining ellipsometry spectra obtained for 11 u.c. through 1 u.c. $ZrTe_2$ and obtain their dielectric functions. Clearly, the dielectric functions show a noticeable change with the thickness of the $ZrTe_2$ layers, where the absorption depicted by the imaginary part of the dielectric function increases with the thickness of $ZrTe_2$. Additionally, the layer-dependent dielectric functions were analyzed by incorporating a Drude oscillator to account for the free electrons and two Kramers-Kronig-consistent oscillators to represent the band-to-band transitions. Interestingly, we find that the Drude contribution reduces as the thickness of $ZrTe_2$ gets smaller, suggesting that its metallic character diminishes as the thickness reduces. Further analysis of the optical conductivity verifies this observation.

The work at Kenyon is funded by DMR-2004812 and the work at The Pennsylvania State University Two-Dimensional Crystal Consortium – Materials Innovation Platform (2DCC-MIP) is supported by NSF cooperative agreement DMR-1539916 and DMR-2039351.



Fig. 1. High-angle annular dark-field (HAADF) image with atomic number Z-contrast of the 7 nm thick Ga(As,Bi) QW with 20 nm thick (Al,Ga)As barriers. The expected HAADF bright contrast of the QW is due to the presence of Bi, $Z_{Bi} = 83$, in the layer.



Fig. 2. Chemically-sensitive g_{002} dark-field TEM micrograph of the Ga(As,Bi) QW with 20 nm thick (Al,Ga)As barriers. Note the presence of two lines with darker contrast delimiting the interface position, at the location of the growth interruptions (GI).



Fig. 3. High-resolution (HR) TEM micrograph of the Ga(As,Bi) QW. $CuPt_B$ atomic ordering is detected inside the 7nm-thick QW but not at two unintentional layers before and after the QW, at the GI positions.



Figure 1: Sapphire surface structure annealed at 750°C (1) and 1550°C (2). Growth of Bi_2Se_3 on sapphire annealed at 750°C (3) and 1550°C (4). The sample grown on sapphire annealed at 1550°C appears to have less vertical island growth with slightly larger, less distinctive, domains. This sample also clearly grows on the same terraced step structure as the base sapphire.



Fig. 1 Photoluminescence spectra for unintentionally doped $In_{0.47}Ga_{0.53}As$ (a) and $GaAs_{0.50}Sb_{0.50}$ (b) on InP substrate as a function of temperature from 5 K to room temperature.



Fig. 2 Temperature-dependent band gap extracted from photoluminescence for both $In_{0.47}Ga_{0.53}As$ and $GaAs_{0.50}Sb_{0.50}$ samples lattice matched to InP (triangles and squares). The data was fit to the Einstein single oscillator equation shown for each sample (solid lines).



Fig. 3 Urbach Energy extracted from the sub band gap slope of the photoluminescence as a function of temperature for both $In_{0.47}Ga_{0.53}As$ and $GaAs_{0.50}Sb_{0.50}$ samples lattice matched to InP (triangles and squares). The data was fit to the Einstein single oscillator equation shown for each sample (solid lines).

 $\label{eq:table1} \begin{array}{l} \textbf{Table 1} \ \text{Einstein single oscillator fit parameters for the band gap as a function of temperature} \\ & \text{for unintentionally doped In}_{0.47}\text{Ga}_{0.53}\text{As and GaAs}_{0.50}\text{Sb}_{0.50}. \end{array}$

Sample	$T_E(K)$	S_0	$E_0 (meV)$
GaAsSb	70	2.855	779.1
InGaAs	69	2.618	781.0

Table 2 Einstein single oscillator fit parameters for the Urbach Parameter as a function of
temperature for unintentionally doped In_{0.47}Ga_{0.53}As and GaAs_{0.50}Sb_{0.50}.

Sample	$T_E(K)$	S ₀	X
GaAsSb	75	0.109	18.04
InGaAs	69	0.196	7.65

Kaushini S. Wickramasinghe et al., Transmission Electron Microscopy Studies of the Formation of In₂Se₃ Layers via Selenium Passivation of InP(111)B Substrates



Figure 1. Cross-sectional HR-TEM image of Bi_2Se_3 on In_2Se_3 layer grown via selenium passivation of InP(111)B substrate showing abrupt interfaces between the layers.



Figure 2. Cross-sectional (a)HAADF and (b) BF image of Bi_2Se_3 on In_2Se_3 layer grown via selenium passivation of InP(111)B substrate clearly showing abrupt interface between Bi_2Se_3 and In_2Se_3 layers and the zinc blende InP lattice and the rhombohedral In_2Se_3 layer. Images also show selenium diffusion further into the substrate without changing the crystal structure of zinc blende InP.



Fig. 1: Schematic of sample (top view of in-plane GPM sample). The sides indicate the elemental cells they face during the growth of the film.



Fig. 2: Surface profile of in-plane GPM sample in the direction of side1 to side3. This figure represents the thickness gradient of the sample. The thickness gradient gives rise to composition gradient, which in turn gives rise to doping gradient leading to permittivity gradient in the sample.



Fig. 3: Characterization by s-SNOM (scattering-type scanning near-field optical microscopy) using mid-IR light source on in-plane GPM. This figure illustrates that the GPM confines different wavelengths of light (corresponding to the gradient in wavenumber) with respect to distinctive in-plane positions in the GPM.

Strain relaxation of graded InGaN and AlGaN

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III-nitride semiconductor materials have proved to be ideal materials for high-power, high-frequency, and high-temperature applications because of their tunable direct band gaps, high breakdown voltage, high absorption coefficient, resistance to defects, lattice match, and polarization characteristics. These materials form a continuous alloy system with direct bandgaps from 6.2 eV (AlN) through 3.4 eV (GaN) to 0.7 eV (InN). The compositionally graded Group III-nitride alloy enables access to large range of energies through varying the bandgap. This change in bandgap is achieved through varying the indium and aluminum composition during growth, which yields excellent compatibility for various optoelectronic applications.

The growth and quality of mismatched heteroepitaxial III-Nitrides layers are generally influenced by strain relaxation mechanisms that release the accumulated strain energy. Plastic relaxation is generally started by the formation of misfit dislocations above the critical thickness. This has been well studied and is generally understood for heteroepitaxial films with fixed composition. Graded composition films have been investigated recently for potential incorporation into semiconductor devices, however the issue of plastic relaxation for graded III-Nitride semiconductors has not been thoroughly investigated.

Graded InGaN and AlGaN can be grown pseudomorphically strained to its substrate until some critical amount of strain energy is built up. This can happen either as a result of reaching a maximum composition or a maximum growth thickness. These two parameters are not independent in terms of their contribution to the buildup of strain energy, and the goal of this study is to determine both the range over which these alloy layers can be grown without relaxation and the mechanisms by which they exhibit relaxation.

In the present work, we have grown both graded InGaN and AlGaN layers with 30 % of In and Al composition of increasing thicknesses for 15 min, 30 min, and 60 min on GaN substrates. We investigated their properties through X-ray diffraction reciprocal space mapping (RSM). With increasing the thickness of these graded layers, the InGaN or AlGaN signature in the RSM shifts from a fully strained position. Atomic force microscopy will be also used to characterize the

sample surface of interest, including dislocation density, while transmission electron microscopy will be used to understand the nature of relaxing defects that is formed in these layers. How these introduced dislocations impact the electrical and optical properties will be demonstrated through photoluminescence and Raman spectroscopy.

• X-ray diffraction reciprocal space mapping (RSM)



With increasing the thickness of these graded layers, the InGaN or AlGaN signature in the RSM shifts from a fully strained position.



Growth Method	n ₀ (cm⁻³)	Doping enhancement over bulk alloy	Activation (%)	T _{sub} (°C)	T _{si} (°C)	RMS (nm)
Bulk Alloy	7.3E15	1	0.073	610	1223	2.1
Delta doped	1.0E16	1.4	0.10	610	1191	4.0
6/4 DA	1.9E16	2.6	0.19	610	1223	1.0
3/2 DA	1.0E17	14	1.0	500	1219	/
3/2 DA	2.5E17	34	2.5	610	1223	1.4

Table 1. Description of bulk, delta-doped, and DA samples in this work. Activation = bulk doping/target doping = bulk doping/1E19 cm⁻³.

Supplemental Documents

Supplemental Document placeholder continued for Abstract 77550, Paper ST-MoP-3 (page 2 of 2)

T_{sub}=455 °C







Nomarski microscopy images of InGaSb graded buffers grown at T_{sub}= 455 °C (left) and 495 °C (right)



(004) Reciprocal space maps of InGaSb graded buffers with T_{sub} = 455 °C (left) and 495 °C (right) taken along [110], revealing positive tilt and negative tilt, respectively.



(004) Reciprocal space maps of InGaSb graded buffers with T_{sub} = 455 °C (left) and 495 °C (right) taken along [110], revealing little tilt.

Electron concentration [e/cm3]





Figure 1. Impact of Er incorporation and growth temperature on InGaAs materials.

1. Co-deposition. ErAs ~1.7% Interrupt growth:

2. 20 nm period InGaAs, As shutter always open. ErAs~0.3%

3. 22 nm period InGaAs, As closed during Er deposition + 30 s all shutters close. ErAs~1.3%

4. 30 nm period InGaAs, As closed during Er deposition + 30 s all shutters close.
ErAs~1%

> **Figure 2.** Carrier concentration in ErAs:InGaAlBiAs digital alloys. For interrupt growth, the matrix period is 30 nm and Er shutter was open for 45 s without As, plus 30 s with all shutters close. (Data labels on top correspond to the approximated %ErAs composition)



Figure 3. Optical pump (800 nm) THz probe on ErAs:InGaAlBiAs materials, showing a fast decay component of a few ps in samples with Er. We have also achieved sub-picosecond dynamics.

94

Atomic

force

Fig.

S1

(a)



Supplementary Pages (Optional)

9.1 nm

Fig. S2 AFM images (5×5µm²) of samples 2 (a), 3 (b), and 4 (c). AFM images (1×1µm²) of samples 2 (d), 3 (e) and 4 (f). The red triangle boxes mark typical GaSe nucleation domains. (g) In-situ RHEED patterns taken at the end of growth of sample 3, along two in-plane orientations of GaSe. The red and white arrows indicate a-plane and m-plane diffractions, respectively. (h) $2\theta/\omega$ X-ray diffraction curves of samples 2-4. FWHM (full width at the half maximum) indicates the crystallite sizes. Samples 2-5 were grown using the same Se:Ga flux ratio and growth rate. Samples 2 and 3 were grown at 375°C, but sample 3 was annealed in Se at 375°C for 30min before growth. Sample 4 was grown via 2-step method: initially grew at 375°C for 8min, then grew at 450°C for 60min. Sample 5 was grown at 375°C for 8min (the first step of growing sample 4).



Fig. S3 AFM images $(5 \times 5 \mu m^2)$ (a) and $(1 \times 1 \mu m^2)$ (b) of sample 5. It used same growth conditions as sample 2, but used a freshly cleaved GaAs(111)B substrate. Red boxes mark GaSe nucleation domains.

[1] M. Yu, L. Murray, M. Doty, and S. Law, J. Vac. Sci. Technol. A 41 (3), 2023.



Fig S1: Photoluminescence spectra at 4 K of InAs droplet epitaxy structures with different morphologies. By varying the flux and temperature conditions during the crystallization stage of droplet epitaxy, the resulting emission is redshifted into the telecommunication wavelength ranges. Figure modified from Stevens et al. *JVSTA* **41** 032703 2023.



Fig S2: Atomic force microscopy images of quantum dots formed during different manipulations of the As crystallization step. Increasing the temperature ramp results in a high density of larger quantum dots. Increasing the temperature ramp and increasing the low-flux hold time reduces the quantum dot density.



Fig S3: AFM images and PL spectroscopy of DE structures on InP (001) substrates compared to InP (111)A substrates.

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Supplementary Pages







Figure 2: TEM image of InSb QW using AlInSb buffer shown (a). Interfacial misfit dislocations at the AlInSb/InAs interface



Figure 3: *TEM* of the $Al_{0.2}In_{0.8}Sb/InAs$ buffer layer interface showing a stacking fault formation and FFT of the image shows two distinct lattice parameters $Al_{0.2}In_{0.8}Sb$ and InAs



Figure 4 – HR-XRD ω -2 θ scans of a) InSb/InAs b) Al_{0.1}In_{0.9}Sb and c) Al_{0.2}In_{0.8}Sb buffer layers

Flexomagnetism And Strain-Induced Superconductivity in Rippled GdAuGe Heusler Membranes

Tamalika Samanta, Zachary LaDuca, Dongxue Du, Taehwan Jung, Sebastian Manzo, Katherine Su, Michael Arnold, and Jason Kawasaki



Figure 1: (a) Phase diagram for rippled GdAuGe membranes. The circle and star denote differently exfoliated rippled membranes. (b) The field-dependent onset of diamagnetism in a rippled membrane shows the Meissner response, implying superconductivity.



Fig. 1 (a) Coupled XRD ω-2θ scans about the (004) peak of InSb of three InSb_{1-x}Bi_x films demonstrating a shift to greater angles with increasing bismuth beam equivalent pressure (BEP). (b) The effective strained mismatch between the InSb_{1-x}Bi_x layer peaks and the InSb substrate was converted to a lattice parameter. The lattice parameter increased as a function of total bismuth concentration, as measured by RBS, enabling linear extrapolation of the lattice parameter of InBi yielding a value of 6.627 Å.



Fig. 2 (a) PL spectra measured at 83 K for the InSb_{1-x}Bi_x films demonstrating wavelength extension with increasing bismuth concentration as expected due to the bismuth-induced bandgap reduction. **(b)** PL spectra for the film with the highest bismuth content exhibiting increasing wavelength extension with increasing temperature consistent with an optical interband transition as expected for a III-V alloy.



Fig. 3 5 μ m × 5 μ m atomic force microscopy scans of (a) InSb with large bismuth droplets as grown; as well as individual pieces of the same sample after (b) 3 cycles of HCl/H₂O₂ digital etching leaving pits remaining where the droplets had been (c) physical polishing showing scratches left behind and (d) ion milling with remnants of droplets still present on the surface.





Figure 1: Growth structures for GaInP:Te SIMS profiling, grown on GaAs (001) substrates (not shown). Te pre-dose values indicated by dotted lines in monolayers (ML). (a) target [Te] = 1.7×10^{18} cm⁻³ with GaAs spacer to absorb excess Te. (b) target [Te] = 5.7×10^{17} cm⁻³ with unintentionally doped (UID) GaInP spacers to absorb excess Te.



Figure 3: IQE of GaInP solar cells with GaInP:Si and GaInP:Te emitters, experimental (solid) and modeled (dotted). The model indicates a $\sim 4 \times$ improved carrier lifetime for n-GaInP:Te. Inset simplified cell structure shows AlInP window and n/p GaInP absorber region.

Figure 2: SIMS profiles corresponding to growth structures in Figure 1. (a) SIMS for target [Te] = 1.7×10^{18} cm⁻³ shows greatly reduced but visible segregation at T_{sub} = 420 °C. (b) SIMS for [Te] = 5.7×10^{17} cm⁻³ shows complete suppression of surface segregation at T_{sub} = 420 °C, as seen by abrupt Te pre-dose spikes.



Figure 4: Lighted IV curves of GaInP cells with GaInP:Si and GaInP:Te emitters, and figures of merit of open-circuit voltage (V_{oC}), short-circuit current density (J_{sc}), fill factor (FF), and efficiency (η).

References in abstract

- [1] M. A. Green *et al.*, "Solar cell efficiency tables (Version 61)," *Prog. Photovoltaics Res. Appl.*, vol. 31, no. 1, pp. 3–16, 2023.
- [2] Y. Sun, B. D. Li, R. D. Hool, S. Fan, M. Kim, and M. L. Lee, "Improving the performance of GaInP solar cells through rapid thermal annealing and delta doping," *Sol. Energy Mater. Sol. Cells*, vol. 241, no. August 2021, p. 111725, 2022.
- K. Takahashi, S. Yamada, Y. Minagawa, and T. Unno, "Improved efficiency of Al0.36Ga0.64As solar cells with a pp-n-n structure," *Sol. Energy Mater. Sol. Cells*, vol. 66, no. 1–4, pp. 517–524, 2001.
- [4] E. E. Perl *et al.*, "Development of a 2.0 eV AlGaInP solar cell grown by OMVPE," 2015 *IEEE 42nd Photovolt. Spec. Conf.*, pp. 1–6, 2015.
- [5] O. Kumagai, H. Kawai, Y. Mori, and K. Kaneko, "Chemical trends in the activation energies of DX centers," *Appl. Phys. Lett.*, vol. 45, no. 12, pp. 1322–1323, 1984.
- [6] K.-J. Lee, H. K. Chen, and J. C. Chen, "Photoluminescence of the Se and Si DX centers in (AlxGa1-x)0.5In0.5P grown by metalorganic vapor phase epitaxy," J. Appl. Phys., vol. 82, no. 3, pp. 1350–1351, 1997.
- [7] I. García, I. Rey-Stolle, B. Galiana, and C. Algora, "Analysis of tellurium as n-type dopant in GaInP: Doping, diffusion, memory effect and surfactant properties," J. Cryst. Growth, vol. 298, no. SPEC. ISS, pp. 794–799, 2007.



Figure 1: Reciprocal space maps (RSM) of the (a) 004 and (b) 115 lattice planes of the InGaAs graded buffer. A linear grade of 3% In composition intervals with a 0.7%/um grade rate and an overshoot layer of $In_{0.35}Ga_{0.65}As$ were used to realize 97.9% relaxation (-0.04% strain) in the $In_{0.30}Ga_{0.70}As$ cap. The change of relative omega in the graded buffer for both lattice planes is caused by epilayer tilt. ~100% relaxation is indicated by the vertical alignment of the $In_{0.30}Ga_{0.70}As$ cap and overshoot layer in the 004 RSM and an offset in omega between the $In_{0.30}Ga_{0.70}As$ cap and overshoot layer in the 115 RSM.



Fig 3: $10x10 \ \mu\text{m}^2$ (a) and $1x1 \ \mu\text{m}^2$ (b) atomic force microscopy of the $In_{0.30}Ga_{0.70}As$ graded buffer cap.

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Figure 2: ECCI (top) and SEI (bottom) micrographs of $In_xGa_{1-x}As$ graded buffers grown at various temperatures. At ~510°C (a), rampant PS causes large-scale dislocation nucleation. At 500°C (b), dislocation nucleation is suppressed, but small patches of PS are present. Finally, when growing at 500°C for x=0-0.18 and 460°C for x=0.18-0.30 (c), PS is eliminated and the TDD of 7.0x10⁵ cm⁻³ is comparable to the lowest reported values for $In_{0.30}Ga_{0.70}As$.



Figure 4: (a) Layer structure of 1 eV InGaAs solar cell grown on a two-step graded buffer. All layers of the device were grown at 460°C. (b) Cross-sectional SEM micrograph of the as-grown solar cell.



Figure 5: IQE spectra of AG and RTA'd cells. IQE of the RTA'd cell is significantly higher than the AG cell at longer wavelengths due to improved minority electron diffusion length in the base.



Figure 6: LIV curves under 1-sun AM1.5 and Suns- V_{oc} curves of the AG and RTA'd cells; the Suns- V_{OC} method allows a 'pseudo IV' curve to be collected without series resistance (R_S). No antireflection coatings were used. The RTA'd cell has similar J_{SC} and V_{OC} to other MBE-grown 1eV solar cells⁶, but series resistance hinders its FF. However, the pFF extracted from Suns-V_{oc} measurements indicates potential for improvement of the cell if series resistance can be reduced.

- [1] N. J. Quitoriano and E. A. Fitzgerald, J. Appl. Phys. 102, 033511 (2007).
- [2] M. Kim et al., in 2021 IEEE 48th Photovoltaic Specialists Conference (PVSC), 1762 (2021).
- [3] L. Yang et al., J. Crystal Growth **324**, 103-109 (2011).
- [4] Y. Sun et al., Solar Energy Materials and Solar Cells 241, 111725 (2022).
- [5] R. M. France et al., Joule 6, 1121-1135 (2022).
- [6] R. Oshima et al., J. Crystal Growth 447, 267-271 (2017).



Initial characterization of strained superlattice InAlGaAs/AlGaAs photocathode structures grown pseudomorphically on GaAs(001)

a) X-ray diffraction measurements around the GaAs(004) peak for the same photocathode structure at three different growth temperatures. The sample grown at 520 °C likely had a poorly calibrated temperature, resulting in some phase segregation and the splitting of the **-1** peak. The other films show good superlattice ordering.

b) The same measurement comparing a photocathode grown with analog AlGaAs barriers and digital alloy AlGaAs barriers. The overall superlattice structure is preserved in the digital alloy scheme.

c) Quantum efficiency and spin polarization measured in a photocathode fabricated from the sample grown at 520 °C with phase segregation. Despite this, the peak figure of merit measured is only slightly worse than the state-of-the-art



Fig 1. Initial structural and electrical characterization of Ta thin film. *a*) Atomic Force Microscopy (AFM) image of the 20 nm tantalum grown at RT on SiO₂/Si. From this 500 x 500nm scan, the roughness is calculated to be RMS = 480.2 pm. b) AFM image of the tantalum grown at LT. From this 500 x 500nm scan, the roughness is calculated to be RMS = 262.0 pm. c) Four-probe resistance measurement of RT (red) and LT (blue) grown tantalum for a 20 nm thick film. Superconducting transition is observed at 3.95K. d) Four-probe resistance measurement LT grown tantalum for a 20 (black) and 50 (red) nm thick film. Superconducting transition for 50 nm thick film is observed at 4.14K.

Supplemental Material

Studying Electronic Structures of Pure SrCoO_x Thin Films, Ordered Phases, And Heterostructures



Fig 1: LaAlO₃ (LAO) substrate before growth (top), SrCoO_x (SCO) film grown on LAO (*bottom*)



Fig 2: XPS spectra of Co 2p



Fig 3: XRD analysis of SCO film grown on LAO



Figure 1 (a) Scanning transmission electron microscopy with spatially resolved electron energy loss spectroscopy (STEM-EELS) of an $(ATiO_3)_{20}AO$ film with $A = Ba_{0.6}Sr_{0.4}$. Barium atoms are shown in green and titanium atoms in magenta. Arrows indicate the $(AO)_2$ layers of the Ruddlesden-Popper phases separated by 20 perovskite unit cells. **(b)** Diagram of an MIM capacitor heterostructure. **(c)** Hysteresis loops measured from the MIM heterostructure represented by (b) at 233 K and 83 K. **(d)** Room temperature dielectric tunability of the same MIM heterostructure.
Paper ST-WeM1-1, Room Ballroom A, 8:00 AM



Fig. 1: State of the art triplechamber TLE research systems. The smaller system in the back is designed for substrate sizes up to 2", the larger one in the front for substrate sizes up to 4". The 1 µm wavelength source heating lasers are coupled to the machine via the yellow fiber cables, 10 µm wavelength CO₂ beamline-guided lasers are used for substrate heating. The compact design ensures high pumping speeds and small footprints. The sources are transferred into and out of the growth chamber via a single transfer mechanism also used for sample transfer. They may be stored in the middle chamber for high purity and rapid exchange.

Fig. 2: Growth rates of TLE Al sources (12 mm diameter sapphire crucibles) at three different O₂ background pressures as a function of laser power for a fixed spot diameter on the source of about 0.7 mm FWHM. In the presence of 10⁻³ hPa O₂, the flux deviates from the approximately straight line measured in UHV at low powers, indicating the formation of a volatile suboxide at the source surface depending on the oxygen pressure (not shown) and the metallic area as defined by either a stationary (bottom) or circularly moving beam (top).





< λ < d_{substrate,target}Fig. 3: Transition of Al₂O₃ growth from the ballistic to the diffusive transport regime at around 10⁻² hPa O₂ background pressure. This transition corresponds to the mean free path of the O₂ dropping below the source-sample distance of 80 mm. RT denotes deposition at room temperature, the red points show the deposition rate in the adsorption-limited homoepitaxial growth regime at a substrate temperature of 1600 °C. For details on the adsorption-limited epitaxy, refer to the submission by Felix Hensling. The very high dynamic range of TLE sources, spanning

over 5 orders of magnitude in flux for a factor of 20 in laser power (see Fig. 2), combined with very rapid power modulation allows high growth rate deposition at ultrahigh quality with economic use of source material.



Electron channeling contrast imaging (ECCI) of ZnS on GaP (100) thin films at (a) 50, (b) 25, (c) 20, and (d) 15 nm shows misfit dislocations along (220) directions.



Figure 1. (a) Scanning electron microscopy (SEM) images of silica gratings and film (~28 nm height) show no polycrystal formation after 100 nm of 10% PSE growth of GaAs at 600°C demonstrating feature-size independent selective growth. (b) Poly-GaAs formation observed on 1.5 μ m tall gratings after same growth was performed. (c) Atomic force microscopy of respective SiO₂ surfaces indicates that increased roughness of 1.5 μ m features promotes nucleation of poly-GaAs in this growth regime.



Figure 2. (a) Root-mean-square surface roughness of SiO_2 deposited by plasma-enhanced chemical vapor deposition (PECVD) compared to HSQ planarization. (b) Atomic force microscopy of a 1.5 μ m SiO₂ film (left) before and (right) after planarization by 100 nm hydrogen silsesquioxane (HSQ) layer.



Figure 3. (a) Resulting poly-GaAs nuclei densities on cured HSQ and PECVD SiO_2 films after 100 nm GaAs was grown with varying PSE cycles ($t_{cycle} = 60$ s) at 600°C. Scanning electron microscope images of poly-GaAs on (b) cured HSQ and (c) PECVD SiO_2 .



Fig. 1. (a)-(c) Cross-sectional schematics after 20, 350, and 1300 nm of p-InP (p=10¹⁸cm⁻³) growth on patterned n-InP substrate. Pattern consists of isosceles-right-triangles (side length = 965 nm) of SiN (40 nm thick); (d) plan-view SEM after 20 nm growth showing selectivity; (e) and (f) XSEM after 350 and 1300 nm of p-InP growth.

1300 nm InP growth

20 nm InP growth

350 nm InP growth (a) 1110 nm triangle 110 nm triangle 1110 nm triangle No TD, SF est SFD No III-V on dielectric TDD = 4.2×10⁷ cm⁻² p-InP pits SiN TDs h) 465 nm triangle (b) 465 nm triang $TDD = 9.7 \times 10^7 \text{ cm}^{-2}$ TD on dielect lo III-V TDs pit (i) 266 nm polygon 66 nm polygon (f) 266 nm polygc 1 µm owest SFD, **III-V on dielec** $TDD = 5.0 \times 10^6 \text{ cm}^{-2}$ TDs ECCI ECCI SEI ECC SE

Fig. 2. (a) - (c) ECCI/SEI of 20 nm p-InP grown on patterned SiN/n-InP substrate with feature size of (a) 1110 nm, (b) 465 nm, and (c) 266 nm; (d) - (f) ECCI/SEI of 350 nm p-InP grawn on similar patterns; (g) - (i) ECCI/SEI of 1300 nm p-InP grown on similar patterns. SF = Stacking fault, TD = threading dislocation, SFD/TDD refers to density. Scalebar = 1µm.



Fig. 3. (a) Plan-view schematics of patterned $SiO_2/n-InP$ substrate (line pattern); (b) - (d) ECCI of 580 nm p-InP grown on the same substrate with SiO_2 line oriented along (b) [0 -1 1], (c) [0 1 1], and (d) [0 1 0] crystallographic directions. Dashed line represent the two sides of buried SiO_2 lines. The [0 1 0] stripes show the lowest defect density.

References

- [1] K. Hirose et al., *Nature Photonics* 8, no. 5 (May 2014): 406–11.
- [2] Z. Wang et al., *Materials Science and Engineering: B* 177, no. 17 (October 2012): 1551–57.
- [3] D. Ironside et al., *Progress in Quantum Electronics* 77 (May 2021): 100316.
- [4] M. Fahed et al., *Nanotechnology* 26, no. 29 (July 24, 2015): 295301.

Candice Forrester et al., Effect of molecular beam epitaxy (MBE) growth parameters on the structural and magnetic properties of high Curie temperature $(MnSb_2Te_4)_x(Sb_2Te_3)_{1-x}$ magnetic topological insulators



Figure 1: Energy Dispersion X-Ray Spectroscopy (EDS) study exploring the elemental contribution of Mn, Sb and Te to the crystal structure as a function of percent of septuple layers. The black lines represent stochiometric (MnSb₂Te₄)_x(Sb₂Te₃)_{1-x}. For (MnSb₂Te₄)_x(Sb₂Te₃)_{1-x} samples with 0.7 < x < 0.85 and grown with a **fast GR (red)**, Mn and Sb intermixing was observed. However for samples (MnSb₂Te₄)_x(Sb₂Te₃)_{1-x} samples with 0.7 < x < 0.85 and grown with a **slow GR (blue)**, not only, showed increased Sb and Mn intermixing, but also, some Mn and Te intermixing.

<u>Adsorption-Controlled Growth of SrTiO₃ by Oxide MBE</u> Dylan Sotir^{1, 2}, Matthew Barone^{1,2}, Darrell Schlom^{1,2,3,4}

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 ⁴ Leibniz-Institut f
ür Kristallz
üchtung

Historically, the growth of stoichiometric $SrTiO_3$ by conventional molecular-beam epitaxy (MBE), utilizing elemental sources, has been challenging due to the precise calibration required. It would be useful if there were a thermodynamic regime where the composition of $SrTiO_3$ was self-regulating. One demonstrated way to achieve such automatic control of stoichiometry in $SrTiO_3$ is by supplying an excess of the volatile organometallic precursor titanium isopropoxide to grow $SrTiO_3$ by metalorganic MBE (MOMBE). Another means, and the one investigated here, is to stick with elemental sources but increase the substrate temperature. When $SrTiO_3$ is heated to high temperature, it does not evaporate congruently; rather, it loses more strontium than titanium. This difference in the vapor pressures of the volatile species suggests that adsorption-controlled growth of $SrTiO_3$ may be possible by conventional MBE. We report a thermodynamic window in which $SrTiO_3$ can be grown via adsorption control by conventional MBE. A new high-temperature laser substrate temperatures to reach up to 2000 °C.

We show that the growth window for our highest quality adsorption-controlled $SrTiO_3$ is from approximately 1450-1475°C, with a Sr:Ti ratio of 5:1. All films were grown on LaAlO₃ (100) substrates. Figure 1 shows XRD data for samples grown at several temperatures including the adsorption-control window.



Figure 1: θ -2 θ x-ray diffraction scan showing approximately 33 nm thick films of SrTiO₃ grown by MBE on LaAlO₃ (100) at a range of temperature from 1350-1550 °C at a background pressure of 10% ozone of 1×10⁻⁶ Torr.

Paper NM-WeA-1, Room Ballroom A, 12:15 PM

Supplemental to: Piezo- and flexoelectricity arising from extreme strain gradients in bent GaAs nanowires

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Fig. 1: Schematic illustrating the growth of bent GaAs nanowires (NWs). NWs are grown under Ga droplets, their diameter is thinned by thermal evaporation, and a lattice-matched symmetric (Al,Ga)As shell is grown for surface passivation. Last, a lattice-mismatched (Al,In)As stressor shell is grown and induces bending by strain partitioning.



Fig. 2: Low-temperature photoluminescence (PL) spectra for single straight and bent GaAs NWs with low degree of polytypism. Only the donor-acceptor pair (D^0 , C^0) and the free exciton X_{hh} transition are observed. The insets are side-view micrographs of the corresponding NWs.



Fig. 3: NW curvature as a function of stressor shell thickness. The curves correspond to elastic strain calculations for different diameters. Data points represent experimental values, and the double arrows indicate a constant offset from the model.



Fig. 4: Low-temperature PL spectra of single bent GaAs NWs. a) Same diameter, different curvature, as indicated by the bending angles. b) Similar curvature, different diameter as given by labels. The insets are side-view micrographs of the corresponding NWs.



Figure 1: (a) Nomarski image of the as-fabricated oxide pattern on GaAs. The pocket size various between 45 μ m × 450 μ m to 1 μ m × 1 μ m. (b) Example room temperature PL spectra of the as-grown material. The legend is structured as "W×L" in micrometers. The red vertical dashed line indicates the emission wavelength of the QDs grown on planar GaAs.



Figure 2: AFM scan of the exposed surface dots. The top roll indicates the widths of the pockets. Each AFM image shows a 500 nm \times 500 nm scan area. The red dashed line indicates a "boundary" between the pocket with and without observed dots.

Table	1:	QD	surface	density	(cm ⁻²)	measure	ed in	pocket	with	various	dimensions.	The
reference density is approximately 5×10^{10} cm ⁻² on planar GaAs substrate												
	5274											

W(µm) L/W	45	40	35	30	25	20	15
10	1.60E+10	1.58E+10	1.10E+10	9.20E+09	2.40E+09	2.00E+07	0.00E+00
5	1.53E+10	1.44E+10	8.80E+09	6.10E+09	0.00E+00	0.00E+00	0.00E+00
3	1.04E+10	7.60E+09	4.40E+09	1.00E+07	0.00E+00	0.00E+00	0.00E+00
1	4.00E+06	1.00E+06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table 2: Typical dot height (nm) measured in pocket with various dimensions. The reference height is 8 to 9 nm on planar GaAs substrate

W(µm) L/W	45	40	35	30	25	20	15
10	4.6	4.6	4.8	4.8	5.35	6.6	N/A
5	4.6	4.6	5.1	5.25	N/A	N/A	N/A
3	4.6	4.6	5.3	5.55	N/A	N/A	N/A
1	4.6	5.5	N/A	N/A	N/A	N/A	N/A

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