Monday Morning, November 9, 2026

Advances in EUV Lithography
Room 316 - Session EUV-MoM

Advances in EUV Lithography II

Moderators: Prof. Alain Diebold, University at Albany-SUNY, **Mr. Lior Huli**, TEL, **Prof. Gregory Denbeaux**, University at Albany-SUNY, **Dr. Kandabara Tapily**, TEL

10:00am **EUV-MoM-1 Pushing the Limits of High-Volume Manufacturing with EUV Litthography*, Mike Lercel,*** ASML **INVITED**

EUV lithography has transitioned from an emerging technology to a core manufacturing enabler for advanced logic and memory. Continued innovation with EUV will sustain semiconductor scaling through the next decade. EUV is now established for critical layers in high-volume manufacturing, delivering a step-change in resolution relative to DUV and enabling continued transistor density scaling, while its evolution to higher numerical apertures (0.33 NA to 0.55 NA and beyond) will further improve resolution, simplify patterning, and reduce process complexity and cost through single-exposure solutions. Productivity, availability, and source power are continuing to evolve to make EUV cost effective while improvements in overlay and imaging continue EUV into future nodes. EUV is positioned within a holistic lithography strategy—integrating computational lithography, metrology, and systems—to control edge placement error and enable cost-effective scaling as device architectures evolve toward 3D integration. Overall, EUV for manufacturing will remain central to sustaining Moore's Law and enabling AI-driven semiconductor growth, with expanding opportunities across both 2D scaling and emerging 3D integration schemes.

10:30am **EUV-MoM-3 High NA EUV Challenges and Opportunities*, Christopher Penny,*** IBM Research **INVITED**

The recent demonstrations of High NA EUV lithography provide significant opportunities to extend scaling for future technology nodes. While many of the key capabilities of High NA EUV have been demonstrated, there remain many significant challenges that must be resolved for High NA EUV to be fully adopted in manufacturing. For example, initial demonstrations have demonstrated single expose patterning for interconnects at 21nm pitch and below; however, further co-optimization of the lithography and etch processes will be required to achieve yield and defectivity levels required for manufacturing. One specific challenge is the introduction of metal oxide resists, and the subsequent process optimization in resist, develop and etch that will be required. Minimizing defectivity (line breaks and bridges) and LER/LWR will continue to be challenging as pitches scale with High NA EUV. The introduction of new materials and processes, such as subtractive Ru patterning, may offer an alternate path to utilize High NA EUV for continued scaling.

11:00am **EUV-MoM-5 Climate-Aware Semiconductor Manufacturing:the Pivotal Role of Lithography*, Emily Gallagher,*** imec **INVITED**

The semiconductor industry is built on technological innovation, historically guided by familiar metrics: power, performance, area, and cost. Today, increasing emphasis on reducing electrical power demand and improving supply-chain resilience drives growing awareness of environmental impacts. Connecting manufacturing choices to climate impact can be challenging, particularly across highly complex process flows comprising more than 1,000 individual process steps. Addressing the processes that consume demands modelling. To this end, imec has developed a framework based on a bottom–up, virtual fab model to represent a high–volume manufacturing fab.

This "virtual fab" is used to identify global trends in semiconductor manufacturing and the dominant role that lithography plays. Through illustrative, lithography–focused examples, we demonstrate how design, process, and operational decisions influence impacts., and how quantified insights can guide lower–emissions manufacturing. Since performance optimization remains essential, we highlight the need to treat environmental impacts as co-optimized engineering objectives.

11:30am **EUV-MoM-7 EUV Pattern Rectification by the Directed Self-Assembly (DSA) of Block Copolymers*, Dustin Janes,*** *Jon-L Innocent-Dolor,* Tokyo Electron America, Inc.

Leading edge manufacturing customers are installing 0.55 NA EUV tools into development fabs, but their resist selection is still uncertain. Interest exists in finding ways to extend chemically amplified resist (CAR) usage to tighter pitch while maintaining a robust etch budget for pattern transfer. EUV rectification by DSA is one strategy to achieve that goal while increasing scanner throughput. Positive-tone developed CAR patterns were rectified by an integrated process flow containing intermediate etch and wet cleans process steps. The exemplary process benefit of DSA at 24 nm line-and-space pitch is achieving uLWR 3σ = 1.6 nm and healing >99% of stochastic defects.

11:45am **EUV-MoM-8 Real-Time Monitoring of Chemical Evolution in Vapor-Deposited Zn-Based Hybrid EUV Resists*, Thi Thu Huong Chu,*** *Dan N. Le, Minjong Lee, Dushyant M. Narayan,* University of Texas at Dallas, USA*; Nikhil Tiwale,* Brookhaven National Laboratory*; Oleg Kostko,* Lawrence Berkeley National Laboratory*; Chang-Yong Nam,* Brookhaven National Laboratory*; Jiyoung Kim,* University of Texas at Dallas, USA

Extreme ultraviolet (EUV) lithography is a key enabling technology for sub-10 nm metal half-pitch semiconductor nodes.[1] However, establishing a clear relationship between EUV resist chemistry and lithographic performance remains critical for advancing next-generation patterning with enhanced sensitivity, resolution, and stochastic control.[2] The inherently transient and environment-sensitive nature of irradiation-induced chemistry in EUV resists, however, has limited direct experimental access to reaction pathways under realistic processing conditions.

To address this challenge, we report real-time monitoring of chemical evolution in vapor-deposited Zn-based hybrid EUV resists, providing operando insight into resist reaction mechanisms during e-beam/EUV exposure. In particular, we investigate the distinct roles of organic components (aromatic versus aliphatic) in molecular atomic layer-deposited (MALD) Zn-based hybrid resist thin films to elucidate their influence on sensitivity and patterning performance under both EUV and low-energy electron exposures. By combining operando techniques such as Fourier transform infrared (FTIR) spectroscopy and residual gas analysis (RGA), we directly track chemical bond transformations in real time, enabling the identification of key reaction steps associated with crosslinking and bond scission. Our results reveal distinct exposure mechanisms underlying the observed performance differences. Aromatic-based resists predominantly undergo deformation of aromatic rings, as indicated by a dip at the C=C bond in the FTIR spectrum during 80 eV electron exposure. In contrast, aliphatic systems form dense networks through coordination-driven bonding. Furthermore, we conducted complementary in-operando RGA and electron emission measurements under EUV flood exposure, which revealed the major by-products released during EUV exposure. Together, these findings provide a more comprehensive understanding of the chemical transformations that occur under realistic exposure conditions and highlight the value of real-time, operando approaches in linking molecular structure to lithographic behavior.

The insights provide guiding principles for designing next-generation vapor-deposited hybrid EUV resists with improved performance and reduced stochastic variability.

This research was supported by the U.S. DOE Office of Science Accelerate Initiative Award 2023-BNL-NC033-Fund. This research used resources of the Advanced Light Source, which is a DOE Office of Science User Facility under contract no. DE-AC02- 05CH11231.

[1] I. Giannopoulos *et al.,* Nanoscale, **2024**, 16, 15533–15543.

[2] T. Manouras *et al.,* Nanomaterials, **2020**, 10, 1593.

Author Index

Bold page numbers indicate presenter

— C —
Chu, Thi Thu Huong: EUV-MoM-8, **1**
— G —
Gallagher, Emily: EUV-MoM-5, **1**
— I —
Innocent-Dolor, Jon-L: EUV-MoM-7, 1
— J —
Janes, Dustin: EUV-MoM-7, **1**
— K —
Kim, Jiyoung: EUV-MoM-8, 1
Kostko, Oleg: EUV-MoM-8, 1
— L —
Lee, Minjong: EUV-MoM-8, 1
Lercel, Mike: EUV-MoM-1, **1**
— M —
M. Narayan, Dushyant: EUV-MoM-8, 1
— N —
N. Le, Dan: EUV-MoM-8, 1
Nam, Chang-Yong: EUV-MoM-8, 1
— P —
Penny, Christopher: EUV-MoM-3, **1**
— T —
Tiwale, Nikhil: EUV-MoM-8, 1