E1

Next Generation Lithography and EB Lithography

ICPST-43 (2026)
The 43rd International Conference of
Photopolymer Science and Technology

June Thu 25, 2026 15:15 - 16:15
Room A [Arcrea Himeji, Medium Hall]

E1. Next Generation Lithography and EB Lithography

E1-1-1
Improvements of Applying RAFT Polymerization in High-performance Photoresist Manufacture

Xiang Dong [1], Xiangang Pan [1]

[1] Xuzhou B&C Chemical Technology Co.,Ltd.

To meet the increasingly stringent requirements for critical dimension uniformity (CDU) and line edge roughness (LER) in ArF and extreme ultraviolet (EUV) lithography, it is imperative to address the growing impact of local variations in resist films. Reversible addition-fragmentation chain-transfer (RAFT) polymerization offers a superior alternative to conventional free radical polymerization (FRP) for synthesizing chemically amplified resists, enabling the production of polymers with more uniform size and composition. This study investigates the heterogeneity originating from the polymerization process, and evaluates the improvements of applying RAFT technique in resin synthesis.

June Thu 25, 2026 15:15 - 16:15
Room A [Arcrea Himeji, Medium Hall]

E1. Next Generation Lithography and EB Lithography

E1-1-2

An Efficient Approach to Compare Acid Diffusive Ability in DUV Resist Using Open Frame Exposure

Ruiwen Ai [1], Liang Xu [1], Xingang Pan [1]

[1] Xuzhou B&C Chemical Technology Co.,Ltd

The diffusivity and acidity of photo acid generator (PAG), along with quencher, play a crucial role in the performance of all types of chemically amplified resists (CAR). In this paper, we presented an efficient method to fasunderstand the relative properties of large numbers of PAGs and quenchers. By gradually increasing the dose under using Litho Tech Japan (LTJ) exposing tool, we were able to slow down the acid movement deliberately and measure the remaining thickness in various doses then plot contrast curves for different PAGs and quenchers, eventually help resist suppliers create databases and choose the right combination during resist formula adjusting process.

June Thu 25, 2026 15:15 - 16:15
Room A [Arcrea Himeji, Medium Hall]

E1. Next Generation Lithography and EB Lithography

E1-1-3
Development and optimization of new bio-sourced resist for lithography applications.

Jeanne Aigoin [1], Anaïs Delehelle D'affroux [1], Ivanie Mendes [1], Isabelle Servin [1], Foscolos Angeliki-Sofia [14], Vidali Veroniki P. [14], Charalampos Katsogridakis [14], Soultati Anastasia [14], Argitis Panagiotis N. [14], Virieux Kylian [4 5 6 7 8], Trombotto Stéphane [4 5 6 7 8], Leclercq Jean-Louis [5 6 7 9 10 11], Trombotto Yann [5 6 7 9 10 11], Ferrer Magin [2 3 7 13], Soppera Oliver [2 3 7 13], Léonard Didier [5 7 12]

[1] Université Grenoble Alpes, CEA, LETI, [2] Université de Strasbourg, [3] Université de Haute-Alsace, [4] Université Jean Monnet Saint-Etienne, [5] Université Claude Bernard Lyon 1, [6] INSA Lyon, [7] CNRS, [8] Ingénierie des Matériaux Polymères (IMP), UMR 5223, [9] INL, UMR5270, [10] CPE Lyon, [11] Ecole Centrale de Lyon, [12] Institut des Sciences Analytiques (ISA), UMR 5280, [13] IS2M, UMR 7361, [14] Institute of Nanoscience & Nanotechnology, Demokritos

Making the electronics world greener becomes crucial: **RESIN GREEN** is a European project aimed at developing sustainable chemistries for optical lithography applications. The core of the project targets formulation of new bio-sourced resists and photo-acid generators with eco-friendly solvent, such as water. This innovative approach proposes an alternative to conventional petroleum-based resists, reducing both toxicity and environmental impact. A step forward has been made on using chitosan as a photoresist, a natural polysaccharide. The work presented focuses on process optimization of these materials, employing industrial tools to achieve high-resolution patterns on 300 mm silicon substrates in a pilot line environment.

E2

EUV Lithography

ICPST-43 (2026)

The 43rd International Conference of Photopolymer Science and Technology

E2. EUV Lithography

E2-1-1(Invited)
Engineering the Future of EUV: A Collaborative Journey in Metal-Oxide Resist Innovation

Danilo De Simone [1]

[1] IMEC

For over a decade, imec has been at the forefront of EUV lithography, shaping the future through its work on tin-based metal-oxide resists (MORs). This journey began in 2014 with the bold step of introducing metal-containing materials into lithography. Key milestones, from fab-compatible processes to 18 nm pitch single-exposure patterning with high NA EUV, reflect a story of innovation, collaboration, and persistence. Along the way, dry-deposited MOR and advanced analytics have opened new frontiers on novel process and material understanding. While challenges remain for high-volume manufacturing, this evolving path continues to redefine what’s possible in resist chemistry and nanoscale patterning.

June Wed 24, 2026 13:00 - 14:40
Room A [Arcrea Himeji, Medium Hall]

E2. EUV Lithography

E2-1-2
Comprehensive Approach of Advanced Patterning Materials and Innovation toward Next Generation Device Architecture

Ethan CB Lee [1], Seungwoo Jang [1], Younhee Nam [1]

[1] Samsung SDI

Upon current big industrial wave of high-performance computing (HPC), artificial intelligence (AI), data storage, communication and automotive, it has been estiamted the semiconductor industry reaches toward over $1T market by coming 2032. This growth is supported from a solid foundation of technology roadmap for computing and data storage, which indicates how to evolve to another degree of structure, performance, and reliability on semiconductor devices. Strong needs for new innovative investigations on materials and process across the entire lithography patterning environment become more significantly important to ensure these essential innovations are integrated effectively. Specifically, the innovation of materials on lithography patterning technology enlarges its impact continuing to expand across key growth fields for supporting new pivotal roles of HBM/PIM in memory technology and CFET in logic architecture. Innovative investigations on optic patterning materials are vital to revolutionize the future of essential lithography technology. In this talk, it will be discussed a comprehensive approach of lithographic patterning materials platforms by reinterpreting materials platform covering powerful EUV and reiterating molecular application, and also addressed strong strategic collaborations to new platform design and implementation among industrial partnerships for patterning toward innovative customized architecture.

June Wed 24, 2026 13:00 - 14:40
Room A [Arcrea Himeji, Medium Hall]

E2. EUV Lithography

E2-1-3
EUV-FEL as a future light source for advanced lithography (II)

Hiroshi KAWATA [1], Yosuke Honda [1], Norio Nakamura [1], Ryukou Kato [1], Kimichika Tsuchiya [1], Masahiro Yamamoto [1], Yoshinori Tanimoto [1], Miho Shimada [1], Takanori Tanikawa [1], Olga Tanaka [1], Takako Miura [1], Takashi Obina [1], Hiroshi Sakai [1]

[1] High Energy Accelerator Research Organization (KEK)

The future light source for advanced lithography should have the following performances: high power more than 1kW to reduce stochastic variation, polarization control, wavelength tunability to realize BEUV and cost reduction of the running cost per scanner. To this end, EUV-FEL is a most promising candidate. At the conference, we will present the trend of the movement in a world and our latest development status.

June Wed 24, 2026 14:55 - 15:35
Room A [Arcrea Himeji, Medium Hall]

E2. EUV Lithography

E2-2-1
Halogenated Triphenyl Amine Additives as Sensitizers for PFAS-free Chemically-Amplified Resists

Fabian Holzmeier [1], James M. Blackwell [2], Robert S. Jordan [2], Kevin M. Dorney [1], John S. Petersen [1], Chien-Hsun Yu [1 3], Danilo DeSimone [1]

[1] imec, [2] Intel, [3] KU Leuven

The incorporation of elements with a high absorption in the extreme ultraviolet (EUV) into photoresists is a common strategy aiming to increase sensitivity. Here, it is shown that the addition of halogenated triphenyl amine sensitizers can lower the dose-to-clear of a PFAS-free chemically-amplified model resist by ~10%. It thus partly compensates for the reduced photoacid strength and lower EUV absorption in a more environmentally friendly photoresist. Using imec’s toolbox of fundamental characterization techniques, the effect that these additives have on the EUV exposure mechanism was furthermore investigated.

June Wed 24, 2026 14:55 - 15:35
Room A [Arcrea Himeji, Medium Hall]

E2. EUV Lithography

E2-2-2
Improvement of non-PFAS biomass EUV resist by optimization of chemical structures

Sotaro Fukumoto [1], Yuki Yoshikura [1], Yuki Yanagisawa [1], Harumi Sunaga [1], Yuki Tamura [1], Ryuichi Saito [1], Daiki Watai [1], Kazuyo Morita [1]

[1] OJI Holdings Corporation

We have been developing biomass resists to meet the increasing demand for High-NA EUV. In our previous work, limited etching resistance and sensitivity were major challenges. To address these issues, we investigated resists with diverse chemical structures and identified five key “knobs” that significantly affect performance. By optimizing these knobs, including the type of saccharide unit, we achieved a 20% increase in etching resistance while enhancing sensitivity by 60% compared with our previous resists.

June Thu 25, 2026 09:30 - 11:30
Room A [Arcrea Himeji, Medium Hall]

E2. EUV Lithography

E2-3-1
Negative-tone Molecular Resist for High-resolution EUV Lithography

Takahiro Maruyama [1], Toshiya Okamura [1], Satoru Mizuno [1], Sin-Fu YEH [1], Youngjin Kim [1], Youngjun Her [1], Hengpeng Wu [1], Kun Si [1], Chenyang Ma [1], Ralph Dammel [1], Jaehyun Kim [1]

[1] Merck Electronics Ltd.

Recent advancements in negative tone molecular resists show significant potential for improving pattern quality and resolution in semiconductor lithography. Innovative molecular designs achieved 20 nm columns with local critical dimensional uniformity (LCDU) under 2.5 nm and demonstrated scalability at 24 nm pitch, with line width roughness (LWR) below 3.0 nm. Contact holes of 32 nm pitch were successfully patterned using bright field masks. Enhanced cross-linking density improves dry etching resistance, achieving LCDUs below 1.5 nm without defects, positioning these materials as viable next-generation photoresists.

June Thu 25, 2026 09:30 - 11:30
Room A [Arcrea Himeji, Medium Hall]

E2. EUV Lithography

E2-3-2

Effect of Organic Ligand Structure on Resist Performance of Inorganic-Organic Hybrid Resist Materials for EB and EUV Lithography

Hiroki Yamamoto [1], Takashi Hamada [1], Takahiro Kozawa [2]

[1] National Institutes for Quantum Science and Technology (QST), [2] SANKEN, The Univ. of Osaka

In previous study, some inorganic-organic hybrid resist materials, which are composed of ligands such as tiglic acid and so on, were synthesized and their lithographic characteristics were investigated to clarify relationship between resist performance and their absorption coefficient with EB and EUV exposure. In this study, we synthesized the inorganic-organic hybrid resist material with other organic ligand such as salicylic acid and examined the effect of organic ligand structure on resist performances using EB and EUV lithography systems.

June Thu 25, 2026 09:30 - 11:30
Room A [Arcrea Himeji, Medium Hall]

E2. EUV Lithography

E2-3-3
Modeling of Tin based MOR Resists

Mark Neisser [1 2]

[1] Tsinghua University, [2] International Innovation Center of Tsinghua University, Shanghai

Model studies and patents suggest that tin based MOR resists are based on tin nanoparticles where each nanoparticle contains 12 tin atoms, each of which has an organic substituent such butyl. The organic substituents are arranged on the outside of the nanoparticle. Reaction with an EUV photon removes an organic substituent and creates some sort of active site that can then cross link with other tin nanoparticles during a post exposure bake (PEB). In this work, the active site is modeled as Sn-OH created by reaction of a tin atom that lost an organic substituent a with a water molecule. These Sn-OH moieties then react with each other during the PEB to form Sn-O-Sn cross links. This mechanism matches known tin chemistry and experimental evidence that tin resists are sensitive to humidity both during exposure and during PEB. Calculating the probability of crosslinks between adjacent particles predicts photospeeds and exposure latitudes by assuming the resist gels at the percolation threshold for crosslinks. The tradeoff between the various model parameters and the resist performance are described. The photospeed is sensitive to the amount of motion of the nanoparticles during PEB. If they are fixed in place and don’t rotate, the probability of Sn-OH moieties on adjacent particles being next to each is so low that photospeeds are unrealistically slow. Allowing rotation gives reasonable photospeeds. In practical terms, it is hard to imagine that nanoparticles only rotate in place and don’t have any other motion during the PEB. More motion than this would be a source of image blur. Given that the nanoparticles are approximately 2nm in diameter, this blur can have a substantial effect.

June Thu 25, 2026 09:30 - 11:30
Room A [Arcrea Himeji, Medium Hall]

E2. EUV Lithography

E2-3-4
Ligand-Dependent Performance in Negative-Tone Organotin EUV Resists

Robert Brainard [1], Moira Niluxsshun [1], Munsaf Ali [1], Jacob Sitterly [1], Ricardo Burke [1], Jordan Greenough [1], Stephen Smith [1], Seungyong (Ryan) Chae [2]

[1] University at Albany, [2] SAMSUNG SDI

Over the past decade, our group has pursued the development of Molecular Organometallic Resists for EUV (MORE), with emphasis on metal-containing systems based on elements such as antimony, bismuth, cobalt, platinum, palladium, tellurium and tin. In this work, we investigate the role of ligand structure in determining lithographic performance by comparing two organotin resists, MA-257 (alkynyl) and MA-258 (alkenyl). Despite their structural similarity, MA-257 exhibits a nonlinear, high-contrast response, whereas MA-258 shows lower contrast. Electron-beam studies further demonstrate improved resolution for MA-257 down to 20 nm. These results emphasize the importance of ligand design in optimizing EUV resist performance.

June Thu 25, 2026 09:30 - 11:30
Room A [Arcrea Himeji, Medium Hall]

E2. EUV Lithography

E2-3-5
Bismuth Complexes for EUV and E-Beam Lithography

Robert Brainard [1], Harry Weinstein [1], Munsaf Ali [1], Stephen Smith [1], Moira Niluxsshun [1], Sukil Kang [2]

[1] University at Albany, [2] SAMSUNG SDI

Since 2011, our group has advanced the development of extreme ultraviolet (EUV) photoresists through the Molecular Organometallic Resists for EUV (MORE) project, focusing on amorphous thin films of compounds containing tin, cobalt, platinum, palladium, bismuth, and antimony. We continue to explore Molecular Organometallic Resists for EUV (MORE) by attempting to synthesize MORE compounds of the form R3Bidi(styrene carboxylate). These compounds are structural derivatives of tri(isopropenyl)antimonydi(styrenecarboxylate) (SH-11), a high photo-speed positive-tone resist. Tri(phenyl)bismuthdi(styrenecarboxylate) (HW-60), was the only compound we were able to synthesize. We show lithographic evaluation of HW-60 using EUV and e-Beam, using a range of process conditions.

June Thu 25, 2026 13:00 - 15:00
Room A [Arcrea Himeji, Medium Hall]

E2. EUV Lithography

E2-4-1
Vertical-Molecular-Wire EUV Dry Resist for 1.5 nm Technology Node

Myung Mo Sung [1]

[1] Hanyang University

This study introduces an innovative extreme ultraviolet (EUV) resist featuring a vertically oriented molecular wire architecture, designed to achieve exceptionally low line edge roughness (LER). This innovative structure achieves an unprecedentedly low LER. The combination of vertically oriented high-aspect-ratio molecular wires and effective lateral cross-linking significantly improves EUV sensitivity and robustness during etching. This pioneering hybrid multilayer EUV resist may satisfy the stringent requirements of advanced semiconductor manufacturing.

June Thu 25, 2026 13:00 - 15:00
Room A [Arcrea Himeji, Medium Hall]

E2. EUV Lithography

E2-4-2
Moisture-Induced Sensitivity Changes in a High-Resolution Zinc Oximate EUV Resist under Post-Exposure Delay

Ying-Lin Chen [1 2], Fabian Holzmeier [1], Roberto Fallica [1], Dowon Kim [1], Kevin Dorney [1], Stefan De Gendt [1 2], Li-Ting Tseng [3], Sarah Seefried [3], Zhongmei Han [3], Juha Rantala [3], Danilo De Simone [1]

[1] imec, [2] KU Leuven, [3] PiBOND

We investigate post exposure delay (PED) effects in a high resolution zinc oximate (Zinc Open-source Nano-Engineered, ZONE) resist processed without post exposure bake. A one day PED under standard cleanroom conditions leads to pronounced pattern degradation. Contrast curve measurements show a clear correlation between PED sensitivity and atmospheric composition. FTIR confirms moisture uptake in EUV exposed films, while EUV induced mass spectra reveal suppressed ligand loss fragment desorption under humid storage. Together, these results demonstrate that atmospheric moisture directly alters EUV activated ZONE chemistry, impacting dissolution behaviour and ultimately limiting pattern fidelity.

June Thu 25, 2026 13:00 - 15:00
Room A [Arcrea Himeji, Medium Hall]

E2. EUV Lithography

E2-4-3
Recent development of new rinse materials beneficial for pattern collapse mitigation in EUV lithography

Takuo Endo [1]

[1] Merck Electronics Ltd.

In EUV lithography with high aspect ratios, pattern collapse caused by the high capillary forces of water has become a significant issue. Applying PFAS-containing rinse solutions during development and drying process is recognized to suppress collapse, on the other hand, there is a growing demand for a PFAS-free solution as regulations become more stringent. In this study, PFAS-free rinse materials were found to be comparable to their PFAS counterparts and additional rinse material was found to improve significant collapse mitigation performance below the 14 nm half-pitch.

June Thu 25, 2026 13:00 - 15:00
Room A [Arcrea Himeji, Medium Hall]

E2. EUV Lithography

E2-4-4
Influence of Underlayer Material Parameters on Pattern Collapse in EUV Patterning

Hyeon Woo Shin [1], Stanfield Lee [1], Jiyoung Hwang [1], Jin Hong Park [1], Jae Hwan Sim [1]

[1] Qnity Electronics, Inc.

As demand for smaller pattern dimensions increases, preserving pattern integrity becomes increasingly challenging, with pattern collapse remaining a key limitation. This work examines how underlayer materials can mitigate collapse through factors such as surface wetting, film rigidity, and interfacial responses within the stack. Through systematic studies, we identify underlayer driven mechanisms that significantly enhance pattern stability. The results show that optimized underlayer design—incorporating targeted material selection and interface engineering—substantially improves collapse tolerance, enabling more robust pattern formation for advanced EUV lithography.

June Thu 25, 2026 13:00 - 15:00
Room A [Arcrea Himeji, Medium Hall]

E2. EUV Lithography

E2-4-5
A Quantitative Framework for Projected-Image Reconstruction Using Resist Contrast, Iso-Focal Response, and NILS Applied to Advanced Photoresist Evaluation

John Petersen [1 2 3], Kareem Pervaiz [1], Yu Chien-Hsun [4], Ivan Pollentier [1], Fabian Holzmeier [1], Kevin M. Dorney [1]

[1] imec, [2] University of Maryland, [3] College Park, [4] imec EX-LIMIT (EUV and X-ray Light Matter InteracTions)

This work applies a quantitative framework for reconstructing the effective projected image recorded by advanced photoresists through combined analysis of resist contrast, iso-focal response, and image-threshold log-slope (ITLS). By interpreting focus–exposure behavior as a nonlinear sampling of the aerial image, the method recovers material-dependent imaging thresholds and chemical-contrast signatures. Iso-focal region mapping and ITLS/NILS extraction enable separation of optical, chemical, and process-induced contributions to critical-dimension bias and pattern fidelity. Application to chemically amplified and metal-oxide resists reveals distinct sampling characteristics, providing a unified basis for material evaluation, process optimization, and hypothesis generation for improving lithographic behavior.

June Fri 26, 2026 13:00 - 14:50
Room A [Arcrea Himeji, Medium Hall]

E2. EUV Lithography

E2-5-1
CD-RSoXS: Chemically Sensitive 3D Metrology of EUV Latent Images and Lithographic Materials.

Cheng Wang [1]

[1] Lawrence Berkeley National Laboratory

As critical dimensions in extreme ultraviolet (EUV) lithography shrink below 10 nm, advanced metrology is required to characterize the three-dimensional structure and chemistry of photoresist systems throughout patterning. We introduce critical-dimension resonant soft X-ray scattering (CD-RSoXS), which combines near-edge X-ray absorption spectroscopy, resonant scattering, and multiphysics modeling to non-destructively probe nanoscale morphology and chemistry across EUV process stages, including latent image formation, post-exposure bake, and development. Complementary resonant soft X-ray reflectivity (RSoXR) measurements characterize underlayer density, thickness, and interfacial structure. Machine-learning-assisted analysis accelerates reconstruction of complex nanostructures, establishing CD-RSoXS as a versatile platform for chemically sensitive 3D metrology of EUV lithography materials and processes.

June Fri 26, 2026 13:00 - 14:50
Room A [Arcrea Himeji, Medium Hall]

E2. EUV Lithography

E2-5-2
Latent image visualization by laser-based photoemission electron microscopy

Hirokazu Fujiwara [1], Cédric Bareille [1], Mario Okawa [1], Toshiyuki Taniuchi [1]

[1] The University of Tokyo

Extreme ultraviolet lithography relies on complex photoresist reactions driven by low-energy secondary electrons, yet the structure of the latent image formed after exposure remains poorly understood. Here we demonstrate direct visualization of latent images in a photoresist using laser-based photoemission electron microscopy (Laser-PEEM). The measurements reveal nanoscale electrostatic potential differences between exposed and unexposed regions, generating lateral electric fields approaching ~100 kV/cm in 10 nm patterns. These results provide experimental evidence that latent images could contain strong local electric fields, which influences secondary electron dynamics and pattern formation in photoresists, offering new insight into the fundamental mechanisms governing resist performance.

June Fri 26, 2026 13:00 - 14:50
Room A [Arcrea Himeji, Medium Hall]

E2. EUV Lithography

E2-5-3
Computational Modeling of Ionic Electrostatic Interactions and Lithographic Outcomes in EUV Photoresists

Geun Seok Lee [1], Jayoung Koo [1], HyunHo Yoon [1], YooRim Jang [1], Jihee Yoon [1], Song Hee Woo [1], Hye Won Lee [1], Jae Hwan Sim [1]

[1] Qnity Electronics, Inc.

Photoresists contain diverse ionic species that generate complex electrostatic environments within the film. To gain further insight, in silico analyses were conducted to quantify how ionic properties, such as charge magnitude, distribution and structure, govern the strength of such interactions and the resulting electrostatic landscape. Subsequent evaluations assessed such these ion-driven environments impact lithographic outcomes including dose-to-size and pattern uniformity

June Fri 26, 2026 15:05 - 16:45
Room A [Arcrea Himeji, Medium Hall]

E2. EUV Lithography

E2-6-1
Evaluation of Resist-Process-Induced Aggregation by RSoXS

Ayumu Tanaka [1], Yuri Ebuchi [1], Shinji Yamakawa [1], Masashi Yoshimura [2], Naoki Hayase [1], Tetsuo Harada [1]

[1] University of Hyogo, [2] SPring-8 service Co., Ltd.

One of the important challenges in EUV resists is the development of resists with low line width roughness (LWR). Factors that worsen LWR include aggregation and phase separation of chemical components within resist thin films, as well as changes in aggregation structures caused by chemical reactions during resist processing. To evaluate these structural variations, resonant soft X-ray scattering (RSoXS) was employed. Using RSoXS, we previously reported that submicron-scale aggregation originating from chemical composition exists in resist films after coating. In this study, aggregation was evaluated for each resist process, and process-induced aggregation formation was investigated.

June Fri 26, 2026 15:05 - 16:45
Room A [Arcrea Himeji, Medium Hall]

E2. EUV Lithography

E2-6-2
NP-SIMS for examining the effect of exposure on hybrid resists

Michael Eller [2], Markus Langner [2], Gregrey Swieca [2], Dan Le [1], Thi Thu Huong Chu [1], Won-Il Lee [5], Shixian Ha [4], Nikhil Tiwale [5], Kim Jiyoung [1], Chang-Yong Nam [4 5], Emile Schweikert [3]

[1] University of Texas at Dallas, [2] University of Mississippi, [3] Texas A&M University, [4] Stony Brook University, [5] Brookhaven National Laboratory

Using NP-SIMS we investigated hybrid resists produced by Atomic Layer Deposition (ALD), Molecular Atomic Layer Deposition (MALD), and Vapor Phase Infiltration (VPI). Samples were examined before exposure, after exposure, and after development. NP-SIMS revealed chemical changes and changes in uniformity that occurred during treatment. Including, loss of organic linker, reengagement of metal aggregates, and chemical changes in the resists

June Fri 26, 2026 15:05 - 16:45
Room A [Arcrea Himeji, Medium Hall]

E2. EUV Lithography

E2-6-3
Effect of Residual Solvent on Exposure Sensitivity under EUV and Low-Energy Electron Irradiation in PHS-Boc Resists

Kuramoto Kouji [1], Yuri Ebuchi [2], Ryuichi Yamasaki [2], Shinji Yamakawa [2], Tetsuo Harada [2]

[1] KH Neochem, [2] University of Hyogo

Line width roughness in EUV lithography is known to be caused by chemical composition distribution within the resist thin film. In this paper, we investigated the effect of residual solvent on composition distribution and exposure sensitivity of PHS-Boc resist. The distribution in the resist thin film was evaluated by resonant soft X-ray scattering (RSoXS), and film density was measured by X-ray reflectivity (XRR). It was found that higher PAB temperature reduced residual solvent and increased sensitivity under EUV and low-energy electron exposure (LEEFET). These results suggested that residual solvent influences photon and secondary electron diffusion behavior in the resist film.

June Fri 26, 2026 15:05 - 16:45
Room A [Arcrea Himeji, Medium Hall]

E2. EUV Lithography

E2-6-4
Investigation of Resist Development under Electron-Beam Irradiation below 400 eV for Short-Wavelength EUV

Ryuichi Yamasaki [1], Shinji Yamakawa [1], Naoki Hayase [1], Tetsuo Harada [1]

[1] University of Hyogo

For further miniaturization of semiconductors, shorter wavelengths of light sources are being considered. The chemical reactions of resists in EUVL are also strongly influenced by secondary electrons generated during EUV irradiation.
Our group has previously compared the resist film thickness after development for resists irradiated with low-energy electron beams corresponding to EUV photon energies and for those irradiated with EUV photons.
In this study, for next-generation short-wavelength EUVL, we compared the resist film thickness after development for resists irradiated with electron beams with energies up to 400 eV (corresponding to an EUV wavelength of 3.1 nm) and investigated the behavior of secondary electrons.

June Fri 26, 2026 15:05 - 16:45
Room A [Arcrea Himeji, Medium Hall]

E2. EUV Lithography

E2-6-5
Resist Sensitivity Evaluation towards Short-Wavelength EUV Lithography at NewSUBARU

Takanari Nishida [1], Ryuta Shiga [1], Masashi Yoshimura [1], Shinji Yamakawa [1], Naoki Hayase [1], Tetsuo Harada [1]

[1] University of Hyogo, [2] SPring-8 service Co., Ltd.

Resist Sensitivity Evaluation towards Short-Wavelength EUV Lithography at NewSUBARU

Products using semiconductor integrated circuits have become essential to daily life, and semiconductor miniaturization is required to improve performance. Currently, EUV lithography with a wavelength of 13.5 nm is being used, and short-wavelength EUV (wavelength 3.1 ~ 6.7 nm) is being considered as a next-generation light source.
The BL-10 at NewSUBARU synchrotron light facility is capable of resist characterization in a wide wavelength range. In this study, we evaluated the resist sensitivity of non-CAR and CAR at wavelengths of 3.1, 4.0, 4.4, and 6.7 nm.

E3

DUV Lithography

ICPST-43 (2026)

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June Thu 25, 2026 16:15 - 17:05
Room A [Arcrea Himeji, Medium Hall]

E3. DUV Lithography

E3-1-1
Progress and Recent Topics of Speckle Lithography

Toshiyuki Horiuchi [1], Masaki Mieda [1], Naoto Masuda [1], Riko Taura [1], Tomoki Iwaoka [1], Hiroshi Kobayashi [1]

[1] Tokyo Denki University

Speckle lithography is a new technology in which traditionally troublesome laser speckles are positively utilized for printing minute random patterns. The speckles are simply generated by irradiating a laser beam to a diffuser. Since sizes and densities are reasonably controllable, it is thought that such random patterns are useful for surface modifications. In fact, hydrophobicity angles of patterned surfaces were improved 20° at maximum. On the other hand, adopting a combination of a hat-top type diffuser and a collimate lens, a large exposure area of 30 mm×23 mm was demonstrated.

June Thu 25, 2026 16:15 - 17:05
Room A [Arcrea Himeji, Medium Hall]

E3. DUV Lithography

E3-1-2
Challenges and progress of PFAS alternatives for ArF resist

Ryosuke Kato [1], Akiyoshi Goto [1], Nishiki Fujimaki [1], Naohiro Tango [1], Hideaki Tsubaki [1]

[1] FUJIFILM Corporation

Perfluoroalkyl substances (PFAS) persist in the environment and cause ecotoxicity, attracting regulatory concern. Widely used in industries like semiconductor manufacturing, PFAS enhance photoresist lithography performance to ensure yield. To promote sustainability, Fujifilm seeks to eliminate PFAS from advanced resists. This paper presents recent developments in PFAS-free photoacid generators (PAG) and immersion additives for ArF immersion (ArFi) resists, advancing eco-friendly semiconductor technology.

E4

Computational / Analytical Approach for Lithography Processes

ICPST-43 (2026)

The 43rd International Conference of Photopolymer Science and Technology

June Wed 24, 2026 16:10 - 18:10
Room A [Arcrea Himeji, Medium Hall]

E4. Computational / Analytical Approach for Lithography Processes

E4-1-1
Advances in control models for scanner corrections of process errors

Wim Tel [1], Albert Li [1]

[1] ASML

Advances in control models of scanner corrections for process errors

Advanced process corrections are needed in any semiconductor fab to compensate for processing fingerprints left by each processing tool. The lithography tool is usually the tool of choice to correct for overlay and cd errors because it can apply different corrections on each wafer and each exposure field separately. This paper will address advances in control models and strategies for optimizing scanner corrections in a factory environment

June Wed 24, 2026 16:10 - 18:10
Room A [Arcrea Himeji, Medium Hall]

E4. Computational / Analytical Approach for Lithography Processes

E4-1-2
AI-Driven EDA: Opening a New Era in Semiconductor Design & Manufacturing

Kazuyuki Yorogo [1]

[1] Siemens Electronic Design Automation Japan K.K.

Semiconductor design is evolving from "humans using tools" to "tools learning and evolving with humans," as AI fundamentally transforms Electronic Design Automation (EDA). This moves EDA beyond automation to intelligent design, inferring intent and optimizing processes.
This session will explore AI's impact on EDA through data, algorithms, and infrastructure. We'll emphasize robust data foundations, intelligent algorithms, and hybrid cloud. AI-driven EDA boosts design efficiency and revolutionizes engineering workflows, enabling faster, more accurate, and creative designs. We will examine the next-generation design environment born from AI and EDA integration and its implications for semiconductor development.

June Wed 24, 2026 16:10 - 18:10
Room A [Arcrea Himeji, Medium Hall]

E4. Computational / Analytical Approach for Lithography Processes

E4-1-3

Dissolution Kinetics of Poly(4-hydroxystyrene) Film in Alcohol/water Mixture -Development Simulation of Polymer Films Using Intrinsic Viscosity and Huggins Coefficient-

Takahiro Kozawa [1], Mikiko Kozawa [1], Yuko Ito [1], Kayoko Cho [1 2], Yuqing Jin [1], Kazuo Sakamoto [2], Makoto Muramatsu [2]

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The concentration gradient between gel and sol layers affects the dissolution of polymer films. Therefore, the diffusion of polymer from dissolution front to bulk solution is important for the resist pattern formation. The diffusion depends on the viscosity of solution and the hydrodynamic radius of polymer. The viscosity of solution is determined by the viscosity of solvent and the intrinsic viscosity and Huggins coefficient of polymer. In this study, the intrinsic viscosity and Huggins coefficient of poly(4-hydroxystyrene) (PHS) in alcohol/water mixture were determined using a quartz crystal microbalance. Using these physical properties, the dissolution kinetics of PHS films was reproduced.

June Wed 24, 2026 16:10 - 18:10
Room A [Arcrea Himeji, Medium Hall]

E4. Computational / Analytical Approach for Lithography Processes

E4-1-4
Probabilistic Numerical Modeling of Component Fluctuations in Chemically Amplified EUV Resists

Soma Tachibana [1], Kenji Yoshimoto [1], Kentaro Taki [1], Makoto Muramatsu [2], Hikari Tomori [2], Kayoko Cho [2]

[1] Kanazawa University, [2] Tokyo Electron Kyushu

In this study, we develop a probabilistic numerical model for chemically amplified EUV resists based on the Stochastic Simulation Algorithm (SSA), taking into account photon shot noise during exposure and fluctuations in the initial resist components. The model enables prediction of the chemical latent image after post-exposure bake process. Resist composition optimization is then performed by defining the contrast, image slope, and variance of the latent image as cost functions. The results demonstrate the potential for systematic evaluation of optimal resist compositions including photoactive compound ratios.

June Wed 24, 2026 16:10 - 18:10
Room A [Arcrea Himeji, Medium Hall]

E4. Computational / Analytical Approach for Lithography Processes

E4-1-5
Fast Stochastic Prediction in Chemically Amplified EUV Resists via Linear Noise Approximation

Kenji Yoshimoto [1], Soma Tachibana [1], Makoto Muramatsu [2], Hikari Tomori [2], Kayoko Cho [2]

[1] Kanazawa University, [2] Tokyo Electron Kyushu

Stochastic effects play an important role in EUV lithography due to photon shot noise and molecular discreteness in resists. Although particle-based simulations can directly capture these effects, they are computationally expensive. In this study, we develop a numerical scheme based on linear noise theory that simultaneously predicts the time evolution of both the mean concentrations and the fluctuations of resist components. Because the method avoids particle tracking, the computational cost is significantly reduced, making it suitable for large-scale systems and parallel implementation. The modeling framework and representative results will be presented.

E5

Directed Self Assembly (DSA)

ICPST-43 (2026)

The 43rd International Conference of
Photopolymer Science and Technology

June Thu 25, 2026 16:30 - 17:10
Room C [Arcrea Himeji, Room 407]

E5. Directed Self Assembly (DSA)

E5-1-1
Molecular Aggregates Capable of Sufficient Disassembly and Reassembly in Response to Light Wavelengths

Mina Han [1]

[1] Kongju National University

Fluorescent molecular aggregates capable of repeated morphological transformation has attracted great interest in various research fields such as photochemistry, biomedicine, and environmental science. A trigonal compound was designed in which three azo-based dyes were connected to a central benzene ring. We investigated how spherical structures formed from the AIE-active trigonal molecule changes their shape and spectroscopic characteristics in response to light wavelengths. <<Due to my schedule, I would appreciate it if you could arrange for me to present on June 23-25. Thank you.>

June Thu 25, 2026 16:30 - 17:10
Room C [Arcrea Himeji, Room 407]

E5. Directed Self Assembly (DSA)

E5-1-2
Linker Length Dependent Photoswitching and Self-Assembly in Azo-BODIPY Based Systems

Jailenn Jannaraine Puray [1], Myo Naing Win [1], Mina Han [1]

[1] Kongju National University

Azo-BODIPY based dyes enable stimulus-responsive fluorescence for sensing and photoactive materials. Three compounds with varying alkyl linker lengths ($AzoC_1BDP$, $AzoC_6BDP$, and $AzoC_{12}BDP$) were synthesized, and their photoisomerization and self-assembly behaviors were studied. $AzoC_1BDP$ hardly reacted to light in polar solvents, while $AzoC_6BDP$ and $AzoC_{12}BDP$ showed switching in both polar and nonpolar media. Microscopy revealed linker-dependent aggregate morphologies, indicating that alkyl chain length influences photoresponse and self-assembly.

keywords: Azo-BODIPY based dye, photoswitching, self-assembly, morphology

June Fri 26, 2026 09:30 - 11:00
Room A [Arcrea Himeji, Medium Hall]

E5. Directed Self Assembly (DSA)

E5-2-1

Advances in Directed Self-Assembly Materials and Processes for Complementing EUV Lithography

Lander Verstraete [1], Rémi Vallat [1], Minseong Jeong [2], Sung Kwan Tae [3], Laurent Souriau [1], Mihir Gupta [1], Hyo Seon Suh [1]

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Directed self-assembly (DSA) of block-copolymers provides a scalable pathway to complement extreme ultraviolet (EUV) lithography. The low variability patterns obtained by block copolymer phase separation offer a valuable route to extend the use of chemically amplified resists for future technology nodes. In this talk we will discuss advances in the materials and processes for DSA of both line/space and hexagonal contact hole arrays. It will be shown how high-chi block copolymers are essential to maximize pattern fidelity, and which challenges these new materials bring. Finally, DSA pitch multiplication will be discussed as an alternative for high NA EUV single patterning.

June Fri 26, 2026 09:30 - 11:00
Room A [Arcrea Himeji, Medium Hall]

E5. Directed Self Assembly (DSA)

E5-2-2

Beyond PS-*b*-PMMA: Directed Self-Assembly Enabling EUV Rectification with Novel High-χ Block Copolymer for Highly Uniform Patterns

Shinsuke Maekawa [1], Shota Iino [1], Ryutaro Sugawara [1], Takehiro Seshimo [1], Takahiro Dazai [1], Kazufumi Sato [1]

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Low-NA EUV lithography faces a serious challenge in fabricating contact hole (CH) patterns with a sub-30 nm pitch due to degraded critical dimension uniformity. Directed self-assembly (DSA) of block copolymers (BCPs) is a promising approach to improve EUV pattern uniformity. Although polystyrene-*block*-poly(methyl methacrylate) (PS-*b*-PMMA) has been extensively studied as a standard DSA material, its limitation in achievable pattern placement error (PPE) has been pointed out. In this study, we developed a novel BCP that enables CH patterns with lower PPE via DSA than PS-*b*-PMMA.

June Fri 26, 2026 09:30 - 11:00
Room A [Arcrea Himeji, Medium Hall]

E5. Directed Self Assembly (DSA)

E5-2-3

Precise Synthesis of Poly(2-vinylpyridine)-b-Poly(dimethylsiloxane) for the Development of Microphase-Separated Structures

Riku Takahashi [1], Haruka Samizo [1], Kan Hatakeyama [1], Yuta Nabae [1], Teruaki Hayakawa [1]

[1] Institute of Science Tokyo

Poly(2-vinylpyridine)-b-poly(dimethylsiloxane) (P2VP-b-PDMS) exhibits strong repulsive interactions between its constituent blocks, enabling the formation of fine microphase-separated structures. Previously reported synthetic approaches to P2VP-b-PDMS have relied on anionic polymerization, which require rigorously inert conditions and hazardous solvents such as benzene. To the best of our knowledge, a facile method for synthesizing P2VP-b-PDMS with controlled molecular weight has not yet been reported.
In this study, two synthetic strategies were adopted: polymer–polymer coupling and reversible addition–fragmentation chain transfer (RAFT) polymerization. Through these methods, P2VP-b-PDMS with a range of molecular weights was synthesized, exhibiting sphere, cylinder, and lamellar microphase-separated morphologies.

June Fri 26, 2026 09:30 - 11:00
Room A [Arcrea Himeji, Medium Hall]

E5. Directed Self Assembly (DSA)

E5-2-4

Influence of Low Surface Free Energy Block Position on Microdomain Orientation in Triblock Copolymer Thin Films

Ryota Uehara [1], Shinsuke Maekawa [2], Takehiro Seshimo [2], Ryutaro Sugawara [2], Takahiro Dazai [2], Kazufumi Sato [2], Riku Takahashi [1], Yuta Nabae [1], Teruaki Hayakawa [1]

[1] Institute of Science Tokyo, [2] Tokyo Ohka Kogyo Co., Ltd.

ABC- and ACB-type triblock copolymers with precisely controlled molecular weights and compositions were synthesized via living anionic polymerization. Subsequent side-chain modifications enabled strategic incorporation of a low surface free energy segment either at the central block or at the terminal positions of the polymer chain. Systematic investigations of the thin films revealed a pronounced dependence of microdomain orientation on the positional agreement of the low surface free energy block. Notably, perpendicular alignment of microdomain interfaces relative to the substrate was achieved exclusively when the low surface free energy block was located at the chain center, and only when the film thickness was independent of the block location. These results demonstrate that precise control over block sequence and interfacial energetics is indispensable for governing microdomain orientation in block copolymer thin films, thereby providing fundamental design principles for advanced nanostructured materials.