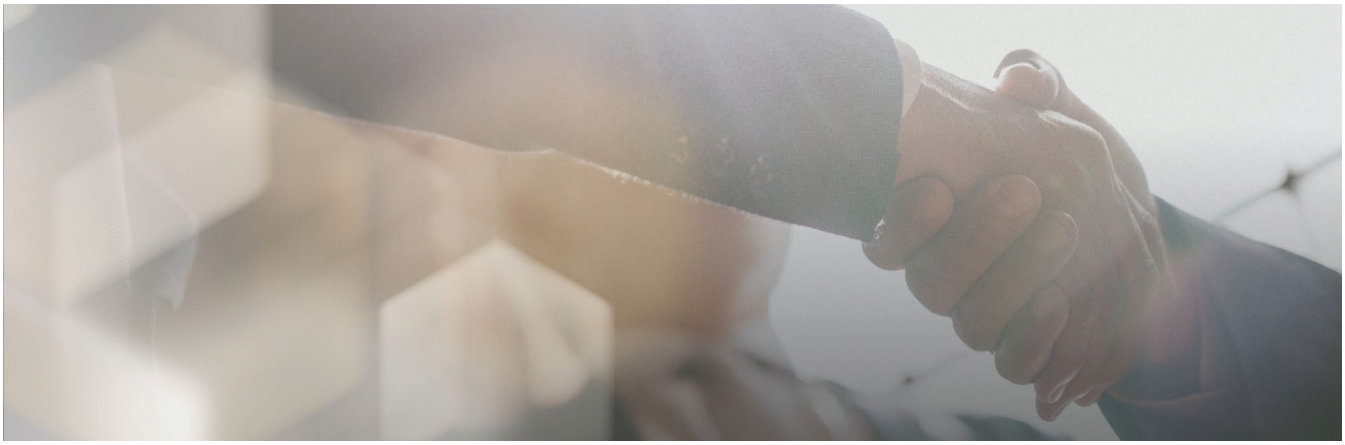


A new era for EUV lithography: How Multi-Trigger Resist technology could redefine semiconductor scaling

Dinesh Bettadapur, Irresistible Materials' CEO, discusses the company's strategic partnership with TOK, the evolution of Multi-Trigger Resist technology, and the future of EUV lithography.

THE SEMICONDUCTOR industry is entering one of the most demanding phases in its history. Extreme ultraviolet (EUV) lithography has become the backbone of advanced chip manufacturing, yet the challenges associated with pushing resolution, reducing roughness, and improving sensitivity continue to intensify. As the industry transitions from low-NA to high-NA EUV - and eventually toward hyper-NA systems - the pressure on resist materials has never been greater.

Against this backdrop, Irresistible Materials (IM), a UK-based specialist in advanced resist chemistry, has taken a bold step. The company recently announced a major strategic partnership with Tokyo Ohka Kogyo (TOK), one of the world's most established photoresist manufacturers. The collaboration combines IM's innovative Multi-Trigger Resist (MTR™) platform with TOK's manufacturing scale and deep industry relationships.

In a wide-ranging conversation, Dinesh Bettadapur - who joined the company 18 months ago - outlined the motivations behind the partnership, the science behind MTR, and the broader implications for the future of EUV lithography.

A strategic partnership built for scale

When Dinesh joined Irresistible Materials, one of the first mandates was clear: secure additional funding and strategic support needed to accelerate the company's trajectory. That search led to TOK, a company with decades of experience in photoresist development and high-volume manufacturing.

The partnership is two-pronged. First, TOK has made a significant investment in IM, providing the financial foundation required to scale the company's technology. Second, the two organisations have entered into a joint development agreement focused on productising and commercialising the MTR platform.

From IM's perspective, the collaboration brings together complementary strengths. IM contributes a multidisciplinary technical team that has spent years developing the MTR platform from first principles, along with a management team experienced in scaling technology companies and navigating successful exits. TOK, meanwhile, brings world-class R&D capabilities, deep expertise in resist chemistry across multiple lithography generations, and manufacturing facilities capable of supporting high-volume production.

The result, Dinesh says, is a "very synergistic relationship" that positions both companies to accelerate the introduction of next-generation resist materials into the market.

Understanding Multi-Trigger Resist technology

At the heart of Irresistible Materials' value proposition is its Multi-Trigger Resist platform - a technology designed to combine the best attributes of chemically amplified resists (CAR) and metal-oxide resists (MOR), while avoiding their limitations.

The best of CAR and MOR - without the drawbacks

Chemically amplified resists have long been the workhorse of lithography, relying on catalytic reactions to

achieve high sensitivity. However, the uncontrolled regeneration of acid in CAR systems can lead to pattern blur, line-edge roughness, and resolution limits.

MOR resists, on the other hand, offer high opacity and small molecular structures that support excellent resolution. But their metal content introduces contamination risks and complicates integration into semiconductor fabs.

MTR aims to bridge these worlds. Like CAR, it uses a catalytic mechanism - but with a crucial difference. IM has developed proprietary molecules that prevent uncontrolled acid regeneration, enabling a more controlled reaction and improved pattern fidelity. Like MOR, MTR is based on small molecules with high opacity at EUV wavelengths, supporting high resolution and strong image contrast. Yet unlike MOR, it is fully organic and metal free.

This combination, Dinesh explains, gives MTR "the best of both worlds," along with unique differentiators that make it a compelling candidate for next-generation EUV processes.

Meeting the challenges of EUV lithography

EUV lithography presents a unique set of challenges for resist materials. As Dinesh notes, the EUV light source produces a sparse photon distribution, making photon absorption efficiency critical. Resist materials must capture as many photons as possible to achieve the required sensitivity.

Beyond photon scarcity, EUV lithography introduces issues such as pattern collapse, thin-film etch transfer limitations, and shallow depth of focus. These challenges become even more pronounced as the industry moves toward high-NA systems, where the depth of focus shrinks further and patterning tolerances tighten.

IM believes that MTR is well-positioned to address these issues. Its high opacity improves photon absorption, while its controlled catalytic behaviour and small molecular dimensions support tighter resolution and reduced roughness. The company has demonstrated the ability to pattern extremely fine pitches - such as 26 and 28 nm - at doses below 30 mJ/cm^2, a level of sensitivity that could significantly reduce cost of ownership for EUV fabs.

Why small molecules matter

One of the defining characteristics of MTR is its use of small molecules rather than polymer chains. This design choice is central to the platform's performance.

Dinesh offers a simple analogy: small molecules act like smaller pixels. Just as a higher pixel density enables sharper images, smaller molecular "pixels" allow the resist to form finer, more precise patterns. Combined with the material's high opacity at EUV wavelengths, this leads to improved signal-to-noise ratio and better pattern fidelity.

This molecular architecture also contributes to reduced linewidth roughness, a critical parameter for advanced nodes where even sub-nanometre variations can impact device performance.

Speed of innovation: A competitive advantage

In the world of EUV resist development, speed matters. The qualification process at major semiconductor manufacturers is long and iterative, often spanning multiple phases of 9–12 months each. Customers provide a set of target metrics - resolution, linewidth roughness, sensitivity, defectivity, depth of focus, and CD uniformity - and suppliers must iteratively refine their formulations to converge on the optimal balance.

This process requires rapid formulation development. Each iteration must respond to customer feedback, address shortcomings, and move closer to the required performance envelope.

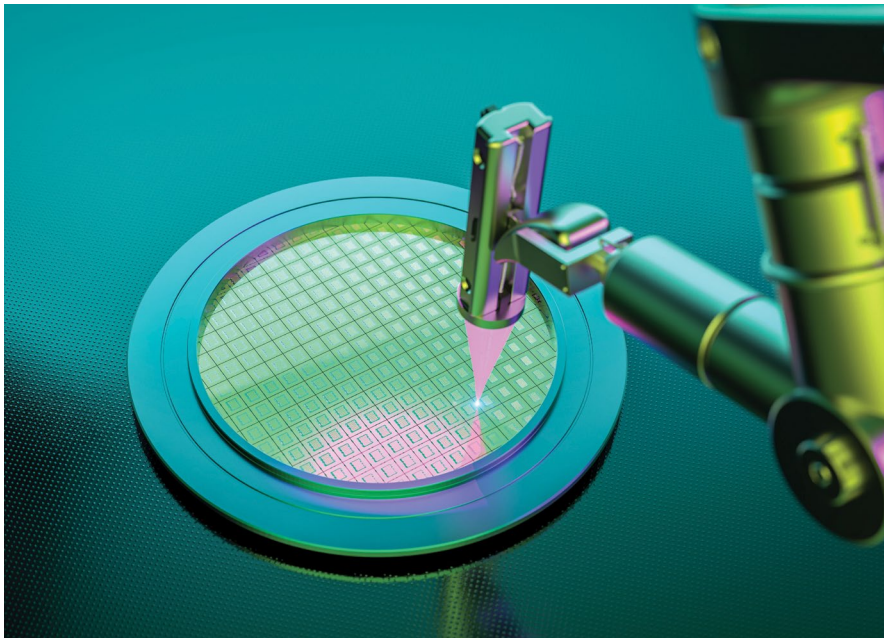
For a company like Irresistible Materials, agility is a strategic advantage. Larger competitors may have more resources, but smaller companies often excel at rapid experimentation and fast decision-making. IM's ability to quickly generate new formulations allows it to progress through qualification cycles more efficiently, improving its chances of adoption.

The role of AI in resist development

While resist formulation has traditionally relied on human expertise and intuition, AI and machine learning are beginning to play a role. IM is already exploring these techniques, using data from its extensive lab/fab testing to identify trends and guide formulation decisions.

Dinesh emphasises that the effectiveness of AI depends heavily on the quality of the input data. Training models requires not only large datasets but also the right kind of data - accurate, consistent, and representative of the relevant chemical and process interactions.

As the company continues to expand its dataset and refine its models, AI is expected to become an increasingly important tool in accelerating



formulation development and predicting performance outcomes.

Accelerating the path to High-Volume manufacturing

One of the most significant benefits of the partnership with TOK is the ability to bridge the gap between research and high-volume manufacturing. TOK's long history in the resist business - spanning i-line, KrF, ArF, and now EUV - gives it deep expertise in scaling materials from lab-scale innovation to production-ready products.

TOK's state-of-the-art R&D facilities and world-class manufacturing infrastructure provide the foundation needed to bring MTR to market at scale. Just as importantly, TOK's long-standing relationships with major semiconductor manufacturers offer a direct pathway to customer adoption.

The response from industry partners has been overwhelmingly positive. Organisations such as ASML and imec, key players in the lithography ecosystem, have expressed strong support for the IM-TOK collaboration, recognising the potential impact of combining IM's innovation with TOK's manufacturing capabilities.

Strengthening the lithography ecosystem

Irresistible Materials has built a broad partnership ecosystem that includes tool makers, materials suppliers, software vendors, and research institutes. The addition of TOK strengthens this network, enhancing IM's credibility and expanding its reach.

TOK itself has independent relationships with many of the same partners, creating a multiplier effect. The combined ecosystem supports faster feedback loops, more robust testing environments, and a clearer path to commercialisation.

In an industry where collaboration is essential, given the complexity of EUV lithography and the interdependence of tools, materials, and processes, this expanded network is a significant strategic asset.

Sustainability: PFAS-Free and Metal-Free by design

Sustainability is becoming a central concern in semiconductor manufacturing. PFAS chemicals - often referred to as "forever chemicals" - are under increasing regulatory scrutiny due to their persistence in the environment and potential health risks. Many countries have already enacted bans or restrictions, prompting the semiconductor industry to seek PFAS-free alternatives.

MTR is inherently PFAS-free, positioning it well for current and future regulatory landscapes.

Metal contamination is another concern. Metal-oxide resists, while effective, introduce contamination risks that can impact yield and profitability. MTR's fully organic, metal-free formulation eliminates this risk, offering a cleaner and more fab-friendly alternative.

These sustainability attributes are not just regulatory advantages - they also align with the industry's broader push toward greener manufacturing practices.

Cost of ownership: A critical metric

EUV lithography is expensive. Tool costs, process complexity, and throughput limitations all contribute to high cost of ownership (CoO). Resist materials play a significant role in this equation, particularly through their impact on sensitivity and resolution requirements.

A high-speed resist with high sensitivity can reduce exposure time, improve throughput, and lower overall CoO. IM's ability to pattern tight pitches at sub-30 mJ/cm^2 doses positions MTR as a strong candidate for reducing EUV manufacturing costs.

Given that cost of ownership remains one of the biggest concerns among EUV adopters, this advantage could be a decisive factor in customer evaluations.

A roadmap for the future of EUV

Irresistible Materials designed the MTR platform specifically for EUV lithography, with scalability in mind. The company believes the platform is extensible across low-NA, high-NA, and eventually hyper-NA EUV systems.

As the industry pushes toward ever-smaller features and more demanding patterning requirements, resist materials must evolve in parallel. IM's roadmap focuses on continuous innovation, ensuring that MTR keeps pace with customer needs and lithography advancements.

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Dinesh acknowledges that challenges remain, but also sees tremendous opportunity. EUV adoption is strong, and the industry is committed to making it successful. With only a handful of leading-edge manufacturers driving demand, meeting the needs of even a subset of device applications could secure significant market traction.

The partnership with TOK provides the resources, scale, and industry access needed to advance that vision.

Conclusion: A platform poised to shape the next era of scaling

As EUV lithography becomes the foundation of advanced manufacturing, the materials that enable it must evolve rapidly. Irresistible Materials' Multi-Trigger Resist platform represents a promising step forward, combining the strengths of existing resist technologies while addressing their limitations.

With TOK as a strategic partner, IM is positioned to accelerate development, scale manufacturing, and engage more deeply with the global lithography ecosystem. The road ahead will undoubtedly present challenges, but the company's innovative approach, strong partnerships, and commitment to rapid innovation give it a compelling opportunity to influence the future of semiconductor scaling.

As Dinesh puts it, the goal is simple: continue to rapidly innovate, align with customer roadmaps, and deliver materials that meet the evolving needs of EUV lithography. If the company succeeds, MTR could become a foundational technology for the next generation of chips and a key enabler of the industry's ongoing pursuit of smaller, faster, and more efficient devices.