Nano-Imprint Lithography (NIL) has already been implemented for some non-semiconductor applications, mostly at the research level. Semiconductor devices mostly require photolithography technology. However, the emergence of new semiconductor devices demands tighter nanoscale resolution, complex shapes and more cost-effective lithography solutions. This has triggered the need for new patterning processes. Producers are therefore regaining interest in NIL, which is based on mechanical replication. The technology is especially relevant to photonic elements, biochips and front-end 3D NAND memory, as it enables nanoscale structures below 20 nm over large surfaces and provides complex patterning capabilities.

On the photonics side, NIL technology realizes complex pattern shapes in a periodic way. For life science, the same technology ensures biocompatibility and solves the challenges of increasing complexity of biotechnology devices while enabling finer feature sizes. In the memory business, NIL could represent a cost-effective solution to achieving high-resolution feature sizes. However, there are still some big barriers that prevent NIL from entering mass production. Generally speaking, the master fabrication process appears to be a critical step that increases the Cost of Ownership (CoO) of the NIL process. Additionally, stamp lifetime and finding a trade-off between overlay, defect levels and throughput are issues that are holding back of NIL in high volume manufacturing.

Solving all these limitations could be a game-changer for NIL in the semiconductor industry. This report offers a technical description of the different NIL technologies, their drivers and main challenges.
change?” and “For which applications will NIL be used?” Currently, the real boost for the NIL equipment market is expected in photonic elements, driven by Augmented Reality (AR), 3D sensing as well as datacom/telecommunication. NIL offers the ability to imprint diffractive optical elements (DOEs) in the nanoscale. This includes optical gratings and photonic crystals to create waveguides, light shaping elements and pattern generators.

Specific to biochips for the life science space, NIL technology has already been implemented for imprinting DNA sequencing devices in the nanoscale regime. Yole Développement (Yole) forecasts further investment in NIL from different players involved in DNA sequencing. Yole also anticipates the breakthrough of NIL processes for point of care and organs-on-chips in the next three years. This is led by a strong trend towards miniaturization and controlled systems delivery with respect to transport and manipulation of biological fluids.

Last but not least, NIL equipment from Canon has been evaluated by Toshiba to replace steppers for the next generation of 3D NAND memories and potentially other front-end memories in a longer term. It would enable a cost-effective process at higher resolution feature size, and is currently in a R&D phase.

This report provides the NIL equipment market forecast for three large-application semiconductor markets: photonics, biochips and 3D NAND memory. In addition, it outlines Yole’s understanding of current market dynamics and outlook on the future evolution of NIL technologies.

**NIL TECHNOLOGY’S BENEFITS WILL ATTRACT MORE MANUFACTURING PLAYERS**

The NIL market is fragmented into different business models and numerous players.

From the equipment perspective, the NIL equipment market for optical photonic elements driven by augmented reality, 3D sensing and datacom applications is highly diversified. This sector is fragmented, with equipment suppliers including EV Group (EVG), SUSS MicroTec and Obducat. By contrast, the biochip and memories markets are effectively monopolies, with EVG and Canon respectively active in those markets. Most companies have developed expertise in optical photonic elements or biochips, but not all of them. Canon is the only system vendor that has developed expertise in the storage memory space.

For each feature size range, there is a clear leading NIL supplier. In the nanometer range EVG is dominant, especially in DOEs. SUSS MicroTec has a strong market share in the micrometer range.

A few material suppliers officially provide resin materials specific to NIL processes, such as Micro Resist Technology and DiC Color & Comfort. However, some vendors come from a different material industry, such as providing temporary bonding material or photoresist. They are currently leveraging their knowledge and capabilities to expand their product portfolios towards NIL materials.

Manufacturers of NIL equipment, materials or processes use different strategies to drive forward in the NIL market for semiconductor applications:

![Nano-Imprint Lithography (NIL) technology: key market drivers](image)

**Nano-Imprint Lithography (NIL) supply chain**

![Nano-Imprint Lithography (NIL) supply chain](image)
Seeking to evolve toward greater diversification, some NIL players have acquired other companies. Magic Leap's acquisition of Molecular Imprint allowed it to explore NIL capabilities and leverage the technology in its products.

In the hopes of acquiring market share in other regions, some vendors have developed turnkey cluster solutions, including coating and baking systems in NIL tools. Some suppliers have remodeled their wafer bonder tool to turn them into NIL systems.

**REPORT OBJECTIVES**
- Detailed analysis of NIL technologies for semiconductor applications
- Give the current status of NIL adoption and the various technologies available on the semiconductor market
- Provide an overview of NIL technological trends for semiconductor applications
- How does the NIL technique differ from the other lithography solutions?
- What are the key NIL drivers for photonics, BioChips and front-end memories (3D NAND)
- Understand what are the remaining challenges to implementation of NIL technology in the field of semiconductor applications
- Offer market metrics at NIL equipment market level for semiconductor applications from 2018-2024
- Evaluate market developments in terms of market volume and value by semiconductor device and end-application
- Provide a competitive landscape by identifying key players in technology development and manufacturing
- Gives an overview of who is doing what, and specifics of each market

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