

Designing in Nanoscales

Step-and-flash imprint technology moves toward solution that offers lithography that is cost-effective and sub-50 nm

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The challenge of achieving 50 nm lithography, with perhaps 20 nm alignment, requires solving a series of engineering problems and precision mechanical issues. For the engineering team at Molecular Imprints (www.molecularimprints.com) working on next-generation lithography, it's proven to be a multidisciplinary challenge where there is not one single person who can understand the entire problem.

The company's current Imprio 100 product has already achieved high-resolution printing. But for now, the goal is to improve alignment resolution from 250 nm to 50 nm, three-sigma.

"One of our primary strengths is that we can print very small structures and maintain very good fidelity," says SV Sreenivasan, chief technology officer for the company. "But to compete with photolithography, we also must bring in the rest of the features in line with that capability. The idea is to eventually offer 50 nm lithography with perhaps 20 nm alignment, but we're hoping to offer 40 to 50 nm alignment by the early part of next year."

The Imprio 100 uses a step-and-repeat process to lithograph 25 mm² fields. Instead of whole wafer imprinting, the machine imprints up to 8-inch wafers using a low-cost template format. The company's S-FIL technology utilizes a bilayer technique where a low viscosity, UV-curable liquid is dispensed in droplets onto an organic planarization layer that enables imprinting on semiconductor device layers that include metals and polysilicon.

Sreenivasan says the company's tool is unique because "the patterning process puts down low-viscosity liquids, captures the shape of the liquid in a mold, and then cross-link it." The best time to do alignment is just before UV cross-linking it when there is a liquid film between the mold and the substrate.

He says that one challenge was using standard technologies like air bearing stages and noncontact linear motors in conjunction with a fluid/mechanics problem due to the fluid layer on the interface. "The fluid layer is on the order of 100 nm or less, so you are dealing with fluid mechanics in the nanoscale region, which is difficult to understand," Sreenivasan says.

The engineering team needed to understand how the mechanics couples with the positioning stages to solve the alignment problem. "So that was the real problem, and it proved to be multidisciplinary," says Sreenivasan. He adds that stage vendors offer good positioning mechanics, control systems, and system testing expertise, but Molecular Imprints needed to also employ fluid mechanics and materials technology experts to understand all the issues as thoroughly as possible. "Risk assessment becomes a big issue because there is not one person who understands the entire problem," says Sreenivasan.



Printing at a Different Scale: *The Imprio 100 by Molecular Imprints uses a step-and-repeat process to lithograph 25-mm² fields. Instead of whole wafer imprinting, the machine imprints up to 8-inch wafers using a low-cost template format.*

sense something that you need to sense because it was not designed for these nanoscale dimensions."

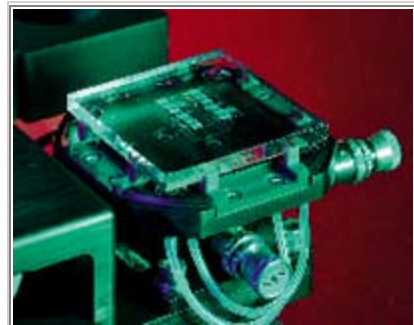
During the in-house integration, development work focused on optimizing the fluid mechanics and materials, plus cooperation between the control engineers and material/ fluid mechanic experts to achieve performance goals.

The motion system in the new machine uses a combination of vacuum preloaded air bearing stages and noncontact linear motors to minimize friction, backlash, and other nonlinear effects. For small motions, small strips of metal called flexures are designed to control motion by literally bending within the elastic limits of the metal.

Achieving the high resolution and repeatability requirements of the system meant addressing problems with in-position stability, since even the best systems have a small amount of jitter or vibration down to 10 nm. Since the machine does alignment with the liquid in the gap, the engineers found ways to take advantage of the liquid to help dampen vibrations and achieve precise alignment before the UV expose process.

Sreenivasan says that part of the challenge with the project is that, if you do modeling or theoretical work, it gets complicated working in nanoscale regime. So the engineering effort had to be experimentally intensive with some modeling and complimentary analysis.

"You need to have tools that allow you to develop an experimental procedure to understand what is occurring at these nanoscales," he says. "It can be frustrating because you have a piece of machinery, and you can't



No Vibrations: *Achieving the performance and repeatability requirements of the motion system meant addressing problems with in-position stability.*