AiR INNOVATIONS

PURSUING PERFECTION

Semiconductors and the Race to Tiny

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To most casual observers, a cleanroom is a contaminant-free environment calling to mind spotless surfaces, ultra-filtered air and workers in polypropylene coveralls and gloves who leave nary a hair or a fingerprint behind. To a semiconductor manufacturer, though, a "cleanroom" is anything but. At a level beyond the realm of human sight or sense, it's a cluttered wasteland where a fleck of dust might as well be a deadly asteroid and the smallest fluctuations in temperature can wreak havoc.

To get an idea of why semiconductor manufacturers live in such fear of infinitesimal hazards, just take a look at the gadgets sitting around your own home. There's your teenager's cell phone with enough computing power to guide a 1960s-era Apollo rocket to the moon and back without skipping a beat on selfies, tweets and texts. Or that freebie calculator someone handed you at a trade show—it crunches numbers at speeds that, just a generation ago, would have required a supercomputer.

Stretch that view beyond the walls of your home to the aerospace and defense industries, which seek to pack ever-greater capabilities into ever-smaller payloads. Or to medicine, where delicate sensors attached to robotic arms probe deep into the human body. It's no wonder that for many years the semiconductor industry has been driven by Moore's Law (named for Intel co-founder Gordon Moore) dictating that the power contained in each square inch of a silicon chip must double every 18 months. For environmental control specialists such as Air Innovations, the challenge and thrill of serving semiconductor fabricators has been to match this "race to tiny" step by step—finding ways to control environments to a degree unheard of in the long history of human manufacturing.

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How Small Is Small?

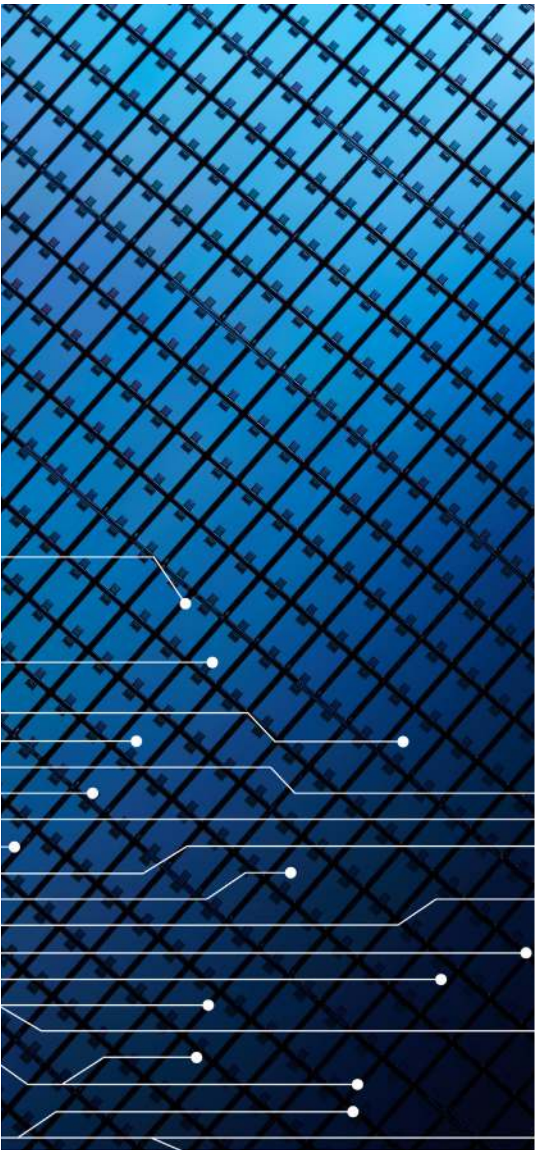
The nanoscale is used to measure the smallest of things. The difference in size between a nanometer and a meter is the same as the difference in size between a marble and the Earth.

ROOMS WITHIN ROOMS

Transistors today are measured in nanometers. That's one billionth of a meter. For perspective, the National Nanotechnology Institute (Nano.gov) tells us the size ratio between a nanometer and a meter is about the same as between a marble and the Earth. To keep driving things smaller, processes have to keep getting better. Machinery has to get more and more precise.

At such tolerances, the smallest nanoparticle landing on one of those connectors would sit like a boulder on a busy road, blocking traffic. Wires that used to carry information from one component to another are no longer wires at all, but minute metallic strips that must be laid with utmost precision to be sure nothing overlaps or disrupts the flow of information.

Complicating matters is the fact that chip manufacturing, even under the best circumstances, is a complex, multi-phase process. Thus, to combat corruptions, semiconductor fabricators no longer manufacture chips in open cleanrooms, as they once did. Today, cleanrooms (or "ballrooms" in industry vernacular) contain a series of separate, fully enclosed mini environments with even finer environmental controls.



PUSHING TOWARDS ZERO

Even in these mini-environments, where lasers and robots guide the assembly and no human sets foot, absolute environmental control remains an elusive goal. At Air Innovations, we partner with fabricators to push their environments as close as possible to that theoretical destination known as "perfect," with customized environmental control units (ECUs) designed to protect semiconductors and equipment across every step of the manufacturing process.

For example, we're being tasked with maintaining precise temperatures during the lithography stage, one of the most vital and delicate parts of semiconductor manufacturing. As the name implies, lithography is where the patterns for semiconductors are etched onto silicon wafers. This involves shining light through an intricate pattern known as a photomask. In a process similar to film photography, the light shining down etches the pattern into a layer known as a "resist," which, when washed away, leaves an exact pattern on the substrate layer—a sort of blueprint upon which the semiconductor is created.

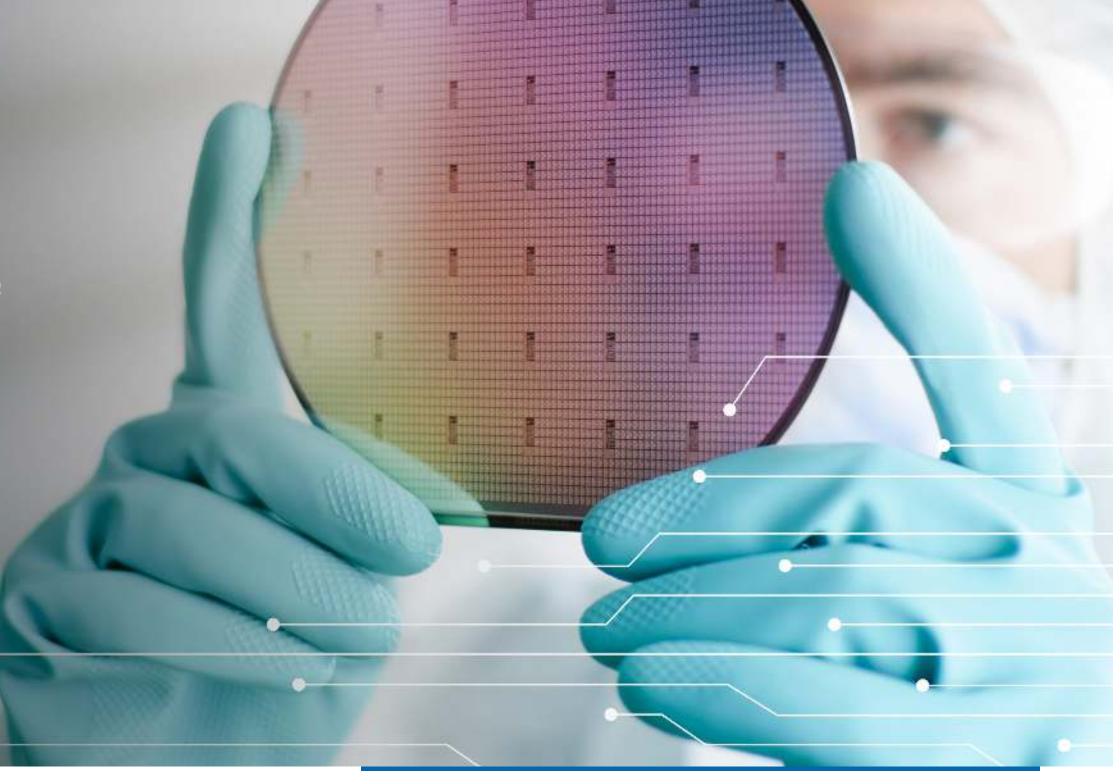
Often valued in the six figures, photomasks are used again and again. Over time, defects may occur along any of the tiny grooves in the mask, either from wear and tear or from nanoparticles landing on the mask.

One of our Air Innovations clients specializes in cleaning and repairing these masks through a process known as nanomachining. Their system involves interferometry, using reflected laser light to scan a mask and scout out defects in need of repair. As the laser light travels over a large silicon wafer searching for defects, even minor differentiation in the temperature of the surrounding environment can throw readings disastrously off target. This client needed us to create an ECU capable of precise humidity control and steady temperatures with less than 0.03 degrees Celsius variation—or, three *one-hundredths* of a degree.

Our Solution:

Working with the client's specifications, our engineers created a customized ECU—a vertical, stainless steel system that attaches to their machines. Using the world's most sensitive and accurate temperature control devices, sourced from a specialty manufacturer in Sweden, we created a system that's not just reliable, but durable and portable. Because this client's own semiconductor clients are located globally, our solution enables the client to communicate directly with its photomask repair machines anywhere in the world, with online access to the ECU's controls and diagnostics through a clear, Windows-based program.

When we look back on the developments over just the last few of decades, our money is on the relentless march of human ingenuity, and on the semiconductor industry's history of steady breakthroughs.



FLEXIBILITY IS A MUST

Other parts of the semiconductor fabricating process command different approaches, each one customized to the specific needs of the manufacturer.

DRY OR WET

Some steps, such as stacking the various layers that comprise the silicon wafer, require an environment close to absolutely dry to ensure that the layers bond properly to one another. Other steps require the opposite: moisture nearly to the point of saturation to maintain certain materials during the delicate manufacturing process.

THE RIGHT SHAPE

ECUs may need to be vertical or horizontal in shape and fit inside or adjacent to the fabrication environment.

PARTICLES AND MOLECULES

ECUs will necessarily use the most advanced ULPA filters capable of removing 99.999% of particles larger than 0.12 microns. But in a world measured in nanometers rather than microns, ULPA filters are just the start. We also incorporate the most sensitive available molecular filtration devices to prevent harmful gases from disrupting key parts of the process.

LOOKING FORWARD

These days, some observers have suggested that the semiconductor industry is reaching the limits of how small they can go, and how much information they can pack into a single chip. When, they wonder, will Moore's Law exhaust itself, and that race to tiny finally reach the finish line?

At Air Innovations, we don't pretend to know where such theoretical boundaries lie. We'll leave that up to the next generation of nanoscientists. Still, when we look back on the developments over just the last few decades, our money is on the relentless march of human ingenuity, and on the semiconductor industry's history of steady breakthroughs. Back in the 1980s, when manufacturing at the level of a single micron (or, 1,000 nanometers) blew people away, few observers would have predicted that by 2010 the community would be debating whether it was possible to break the latest supposedly impenetrable barrier: 14 nanometers. These days, 14 nanometers is looking almost obese, as developers set their sites on 7-nanometer technology.

Frankly, we can't wait to see what happens next. And as the semiconductor industry continues to redefine "small," our mission will be to stay with the industry step-by-step, continually revising the way we define environmental control.

At Air Innovations, all of our equipment is custom designed for particular applications. Unlike other companies who build commercial-off-the-shelf type equipment, we create a solution that's tailored to your unique challenges. If you have an idea you would like to find an environmental control solution for, a challenging environmental control issue that's yet to be addressed, or a project coming up that requires specialty environmental control, we would like to talk to you before you write your specification or release an RFQ—we are climate control experts, after all.

So whether it's an environmental control application for aerospace, the military, a research lab, the pharmaceutical industry, or a medical device—or an out-of-the-box concept you'd like to explore—simply fill out our contact form at airinnovations.com/contact-us or give us a call. We're looking forward to talking to you!

For more information about our semiconductor projects or to learn more, visit us at:
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Or call:
800-825-3268 or 315-452-7400

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