

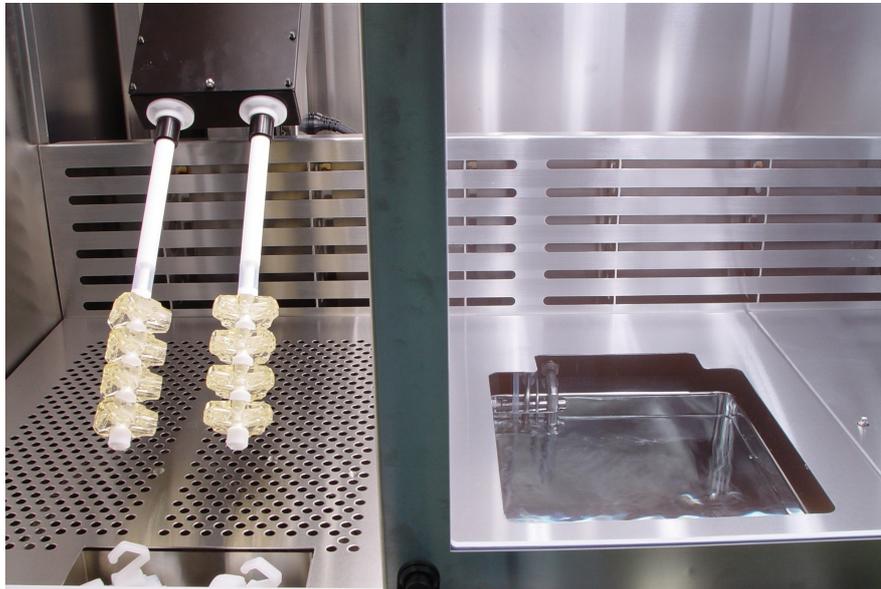
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Cleaning or etching items with unique geometries requires specialised expertise

Feature

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By Jeff Elliott, technical writer based in the US

Cleaning is an integral part of many manufacturing and maintenance processes, and often critical to the performance of a broad range of technologies in the semiconductor, defence, MEMS, photonics and biotech industries.

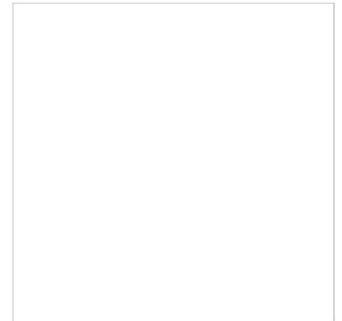
“Cleaning” in this case refers to using agents such as solvents, acids or bases to remove unwanted particulates and other contaminants from products ranging from optics to semiconductor and electronic devices. It also refers to the etching process in semiconductor fabrication, where “cleaning” is precise removal of thin layers of material.

Today, many of these processes are relatively standardised. Semiconductor wafers, for example, are produced in several sizes and processed the same way, no matter the type. However, for products with non-standard geometries, shapes, sizes and, even, weight, cleaning takes on a new dimension that involves determining how to optimally get each item in and out of the equipment at each stage of the processing. Within this category are variety of items such as optical lenses for the world’s largest telescopes and high-energy lasers, crystals used in nuclear sensors or guidance systems, glass substrates, MEMS devices, probe sensors, medical implants, chemically-machined subcomponents, and more. These type items require creative solutions for loading items in and out of what is typically a multi-stage process, which can include automated gantry robots, machined fixtures and loading carts. Careful consideration must also be given to the orientation and, potentially, the rotation of the item after it enters the process baths.

“We are not just concerned with the cleaning equipment, but also how to get the products in and out of that tool,” said Louise Bertagnolli, president of JST Manufacturing in the US, a specialist in wet processing and precision cleaning equipment. “Handling non-standard items of various geometries, sizes and weights is a factor that most customers don’t think about. Instead, they focus almost solely on the cleaning process – temperatures and chemical concentrations, yet, product handling can impact the amount of chemicals required, processing time and even quality of cleaning.”

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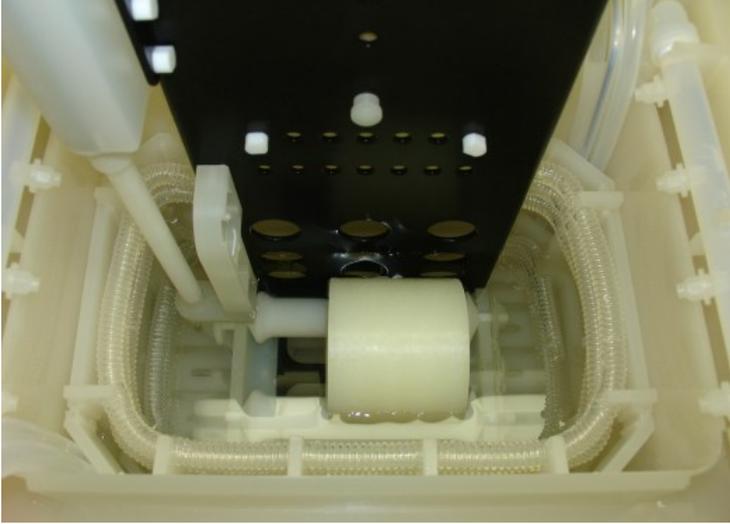
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Using Gantry Robots

Companies that choose to automate a cleaning process usually do so to ensure repeatability of cleaning results. This means precisely controlling the measurement and dispensing of the cleaning agents and rinsing solutions, as well as providing the systems and tools necessary to transport items from one bath to another. For this, robots are often used to lift and transport items to multiple stations or modules. At companies like JST, this necessitates working closely with automation partners such as US-based Bosch Rexroth to develop cleaning stations using linear motion and electric drive and control technology.

In a recent project, the two firms worked together to create an automated system for cleaning silicon chunks to the extreme purity of 11N to meet requirements for the manufacture of semiconductor chips. The project entailed building a 138ft-long cleaning line that incorporated multiple gantry robots. The throughput volume requirement for the chunks was four tons for every 22-hour shift. To accomplish this, JST had to develop a unique basket system to transport the material throughout the process.

To provide for such a long cleaning system, JST built two units; in the 24-ft-long one, baskets of chunks are manually loaded through an auto-door. Then two-axis robots cycle the baskets through five acid-etch baths, and two rinse baths arranged in a single row down the length of the second unit.

In some cases, gantry robots are the only solution, particularly for heavy items for workers to handle safely. Bertagnolli has seen products that must be lifted that exceed 50, even 100lbs.

In a project for Lawrence Livermore National Laboratories' National Ignition Facility (NIF), JST was charged with developing a solution for handling thousands of heavy optical lenses. NIF operates one of the world's highest-energy laser systems, which consists of 192 laser beams that can focus nearly two million Joules of energy. Each of the 192 beams is supported by up to 50 lenses.

"If these lenses were not as clean as possible, then the performance of our laser would be degraded," explains Patrick Williams, NIF optics maintenance manager. "The optics are heavy and rather large, so we don't want to handle them a lot. JST suggested that there might be an easier and more cost-effective way to transport, clean and inspect the optics. They came back with an original design, and then we tweaked it into a system that has worked for over 16 years."

One of the innovations in the NIF cleaning tool, which was a tank-like configuration, was to eliminate the need to move the optics to different locations for washing, rinsing and drying. In lieu of moving the optics, all these functions are done in one tank; effectively, the chemistries move, not the product.

Machined Fixtures

Bertagnolli says another important element to consider is fixturing – the devices that

hold or position the products being processed.

Single or multiple item fixtures are typically designed and machined to fit a specific application. Because precision-cleaning equipment is largely a task involving metal fabrication and machining, suppliers like JST can also provide custom-designed fixtures.

Well-designed fixtures can even accommodate quick-change inserts that allow re-use for other parts.

Attention should also be given to optimising the orientation of the part if it has blind holes or other geometric features facing up, to hold chemistry when lifted out. The same holes, if horizontal, can create unwanted bubbles or air pockets. For these reasons, it might be necessary to design a solution that orientates the part in certain direction and then rotates it later in the process. Even if no blind holes are involved, etching the entire surface of a part may require rotating it whilst minimising surface contact.

One such project JST was involved in needed cleaning silicon “seed rods” that grow the polysilicon ingots from which chucks are made. The seed-rod-cleaning equipment used a gantry robot to move the ingot-carrying cylindrical carriages through a sequence of etch baths. JST designed a custom fixture that rotates the rods to ensure they etch evenly.

“The rotational fixture enables the rods to be cleaned to very high purity,” said Bertagnolli. “We incorporate rotational fixtures quite often for cleaning.”

Early Attention

According to Bertagnolli, sufficient consideration of these factors must be given early in the design phase. Racks and fixtures need to be designed to safely handle parts, and the fixtures themselves must be designed to withstand the chemicals involved.

“With a full engineering staff and 3D modelling, JST can complete a structural analysis and look at the deflection and really have a good idea before anything is ever built,” said Bertagnolli.

In some cases, her company is consulted on handling solutions for other providers’ equipment or when manual loading/unloading is problematic.

“There are many different ways to handle these problems,” said Bertagnolli. “It takes engineering, a manufacturing capability and experience. Given that so much is invested in the cleaning process tool, it makes sense to ensure repeatability with an appropriate product-handling system.”

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