Innovate

Prepping U.S. Machine Shops for a Semiconductor Production Boom

Kip Hanson | Sep 27, 2022

It goes without saying that modern technology—from computer microchips to light-emitting diodes, transistors and more—relies on semiconductors.

It isn't something most tech users have had to think about very often, however, until chip imports slowed to a trickle in recent years, driving up the cost of manufactured goods from cars and trucks to TV sets and smartphones while delaying product deliveries.

While chips make the world go round, semiconductor manufacturing capacity in the U.S. fell from 37 percent in 1990 to 12 percent today, in large part because other countries' governments have invested ambitiously in chip manufacturing incentives while the U.S. has not, according to the Semiconductor Industry Association.

The trade group, founded in 1977, praised Congress for altering course with passage of the ***CHIPS and Science Act*** of 2022, "which includes semiconductor manufacturing grants, research investments, and an investment tax credit for chip manufacturing."

From Silica to Silicon Valley

Semiconductors are improbable devices, and their production requires meticulous attention to detail. Silicon dioxide found in beach sand—known as silica sand—is first converted into pure silicon, then melted in a furnace and spun in the presence of a "silicon seed" while blisteringly hot.

The molten silicon bonds to the seed crystal, which is slowly lifted out, creating an ingot weighing several hundred pounds and roughly 1 foot in diameter.

A diamond saw is used to cut the ingot into wafers, which are ground and polished to a millimeter or so in thickness. From there, a photoresist coating is applied to the wafers, which are then etched to create the desired electrical pathways. The process is then repeated as needed.

A single wafer might contain tens of thousands of individual chips. Once removed from the wafer, they are often assembled into skyscraper-like stacks several dozen layers high, each performing a different function. The microchip is born.

Machining the Machines

The entire manufacturing process requires hundreds of discrete steps that could take several months to complete. High temperatures are often involved. The tolerances are incredibly tight, the materials challenging, the surface finishes and required cleanliness levels extreme.

Those statements apply equally to the equipment needed to process the chips, which include machines for dicing the wafers into individual chips, electrical probing devices, grinding, shaping; cleaning machinery, furnaces and vacuum chambers, photolithography, coating systems and more.

Now thanks to CHIPS, a big chunk of that complex manufacturing process is on its way back to the United States.

Much of the heavy lifting will be performed by semiconductor equipment giants such as ASML and Applied Materials, who design and manufacture machinery for the likes of Intel, Taiwan Semiconductor Manufacturing Company (TSMC), Micron and others, all of whom will receive financial incentives to build factories in the States.

Impact of Onshoring Semiconductors

That benefits not only current and future workers, but also the industry's suppliers, who can rely on an influx of purchase orders for machined, stamped and assembled components.

The raw materials will range from the free-cutting, like 6061 aluminum and engineering-grade polymers, to the very challenging, 316LVM (low carbon vacuum melt) stainless steel, Kovar (a nickel-cobalt alloy), and molybdenum among them. And as noted, the tolerances and surface finish requirements will be demanding.

Material-specific cutting tools are a wise choice here, especially for the more difficult alloys. Together with high-quality, well-maintained workholding and shrink-fit, hydraulic or mechanical toolholders, they will help deliver the predictable processes that semiconductor customers demand.

Robust quality control equipment and procedures will likewise be needed. Consider using in-machine probing systems and routine calibration of CNC machinery to ensure accuracy.

Detailed documentation and traceability, on par with that required by aerospace and medical equipment makers, are also necessary. It might be time to add a quality management system (QMS) to the company's enterprise resource planning software.

Getting Machine Shops Ready for the Ramp-Up

Shops wishing to jump on the semiconductor bandwagon should prepare accordingly. As with any manufacturing ramp-up, there will be plenty of prototyping and product development.

If your shop hasn't yet invested in *multifunction CNC machine tools* like mill-turn centers, multitasking lathes and 5-axis machining centers, now might be the time.

The same argument can be made for *Industry 4.0* and the Industrial Internet of Things (IIoT). Semiconductor makers will likely want to see in-process manufacturing data only available with sensor-based data collection and remote monitoring.

Such technologies also make the machine shop more competitive, and prone to fewer surprises.

And because semiconductor equipment producers will want a fair price for their machined parts, it

could also be high time to look at automation in the form of machine-tending robots and a flexible manufacturing system (FMS).

Better yet, shoot for lights-out or at least lightly attended manufacturing. By taking some of the steps listed above, you'll find it's not as difficult as you might expect.

While many consider lightly attended manufacturing to be suitable only for high-volume manufacturing, technologies such as quick-change tooling, offline tool presetting, toolpath simulation, and tool life management (including RFID chips)—when coupled with well-engineered processes—bring unattended machining and SMED (single-minute exchange of die) within reach of even high- mix, low-volume shops.

Workforce Training

Robots aside, training remains critical, particularly amid a worsening labor shortage. Shops hoping to cash in on the influx of new business will need to keep existing workers' skills up to date and thoroughly train new hires, especially as they embrace the potentially novel materials and demanding requirements of producing semiconductors.

Such continuous improvement stands to benefit not only those supplying parts to the semiconductor industry, but shops of all kinds.

Successful reshoring might begin with ***supply chain problems*** and congressional spending bills, but it will soon end if U.S. manufacturers don't embrace these technologies as though their livelihoods depend on them. Because they do.