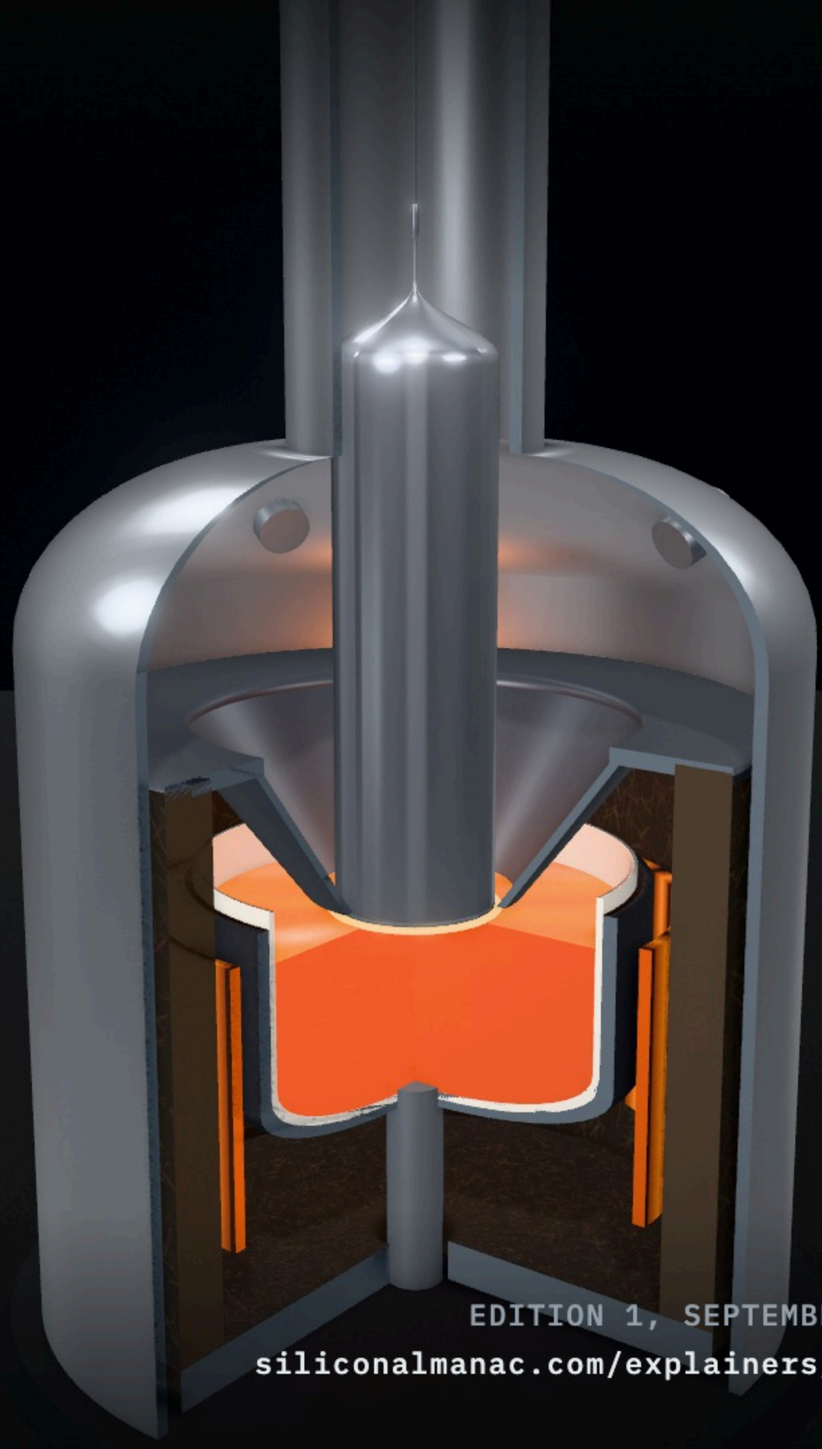
From sand to wafer

Every chip starts as a slice of one perfect crystal: a single lattice of silicon atoms as long as a person is tall, grown slowly out of a pot of liquid silicon.

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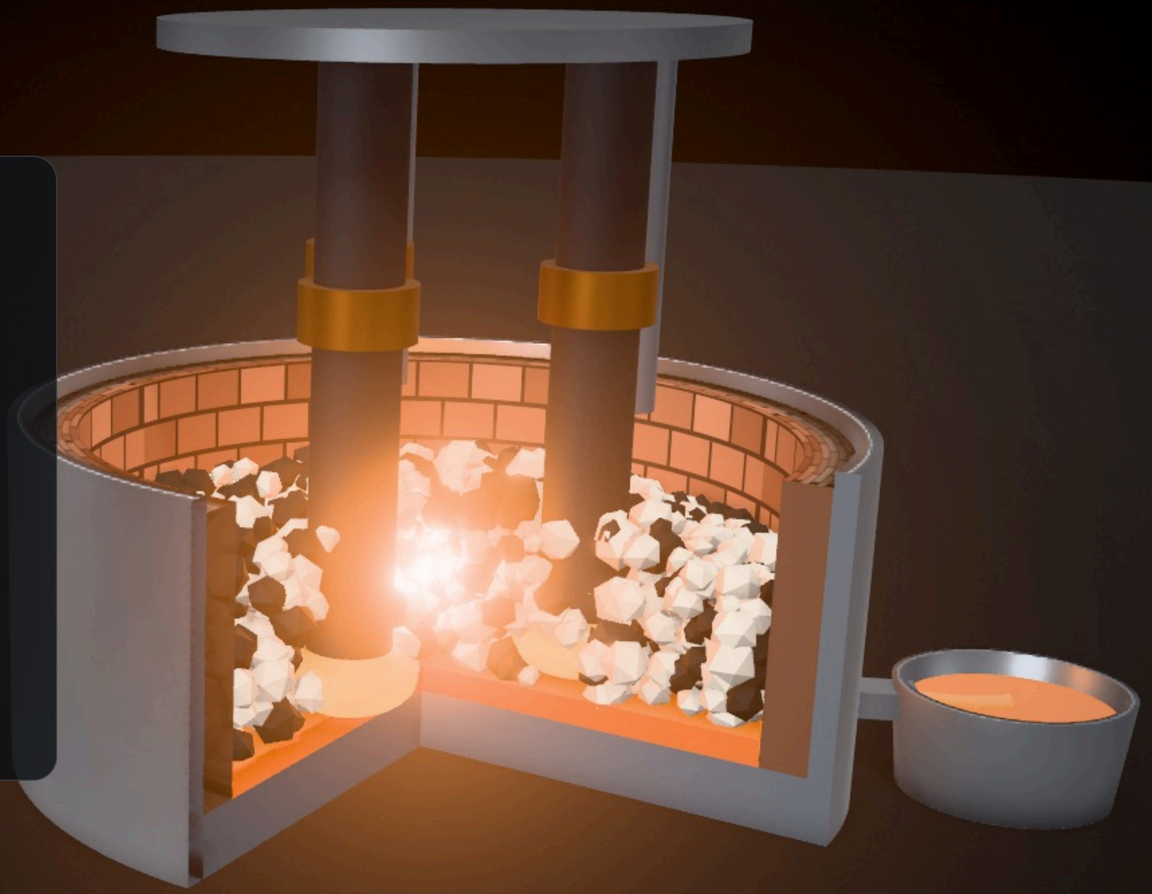
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01 · QUARTZ TO METAL

It starts as quartz rock.

The silicon in a chip starts as quartz or quartzite. Mixed with coal, coke, charcoal or wood chips and heated to about 1,500 to 2,000 °C in an electric arc furnace, the quartz gives up its oxygen, and liquid silicon is drained from the bottom of the furnace. It comes out 98 to 99% pure: metallurgical-grade silicon, which in the United States goes mostly into aluminium alloys and silicones.

Process and temperature: Elkem. The carbon electrodes: Los Alamos National Laboratory. Purity: Wacker. Uses: US Geological Survey, Mineral Commodity Summaries 2026: silicon, for the United States. The furnace is shown opened; it is generic and not to scale.



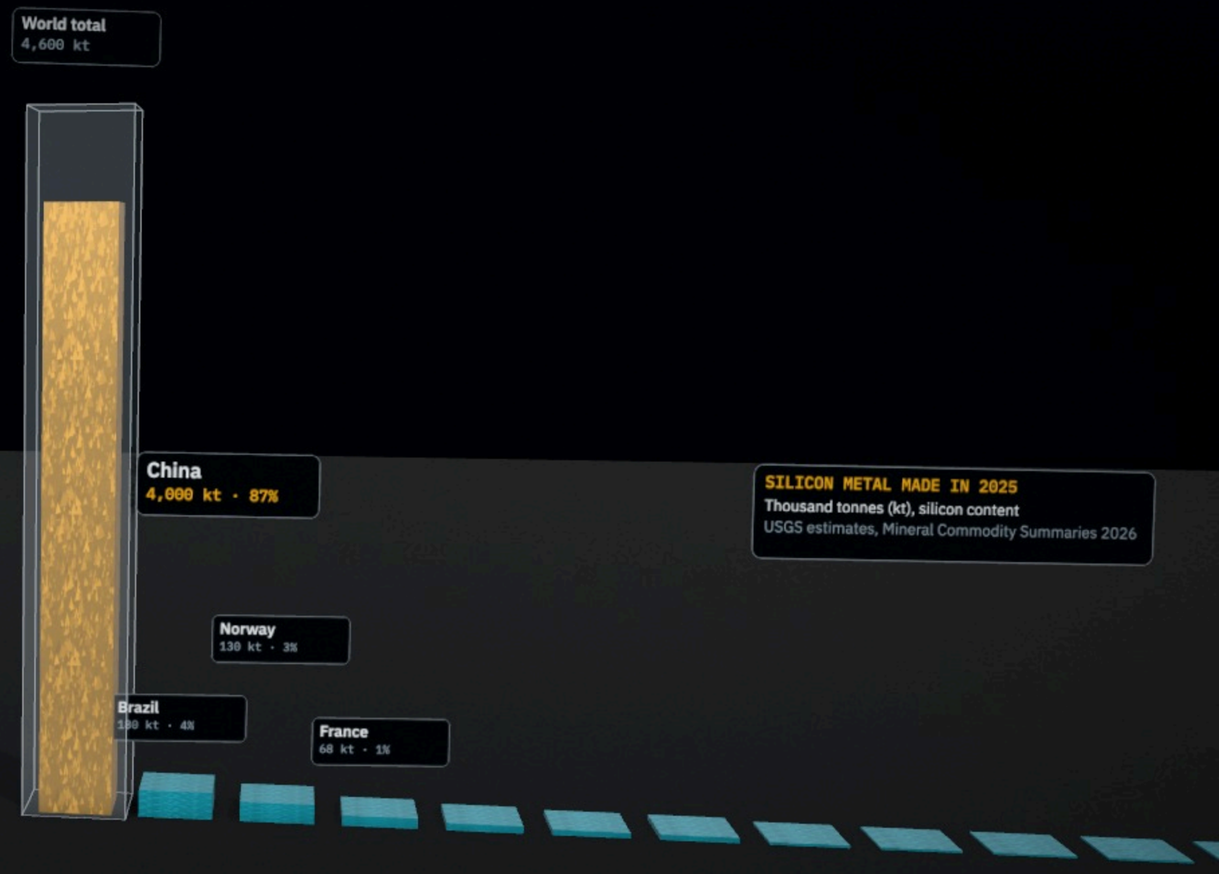
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02 · WHO MAKES IT

Most of it is made in China.

USGS estimates that the world made 4.6 million tonnes of silicon metal in 2025, and China 4.0 million of them, 87%. The next three are Brazil, Norway and France. In Europe, Elkem mines its quartz in Norway and Spain, and Wacker makes its own silicon metal at Holla in Norway. Pick a country.

US Geological Survey, Mineral Commodity Summaries 2026: silicon, world production of silicon metal in thousand tonnes (kt) of silicon content. Every figure in that table is an estimate, the world total is rounded, and USGS withholds the US figure to avoid disclosing company data. The same table is on this record's materials page. Millions and shares are our arithmetic. Elkem and Wacker on their own sites.



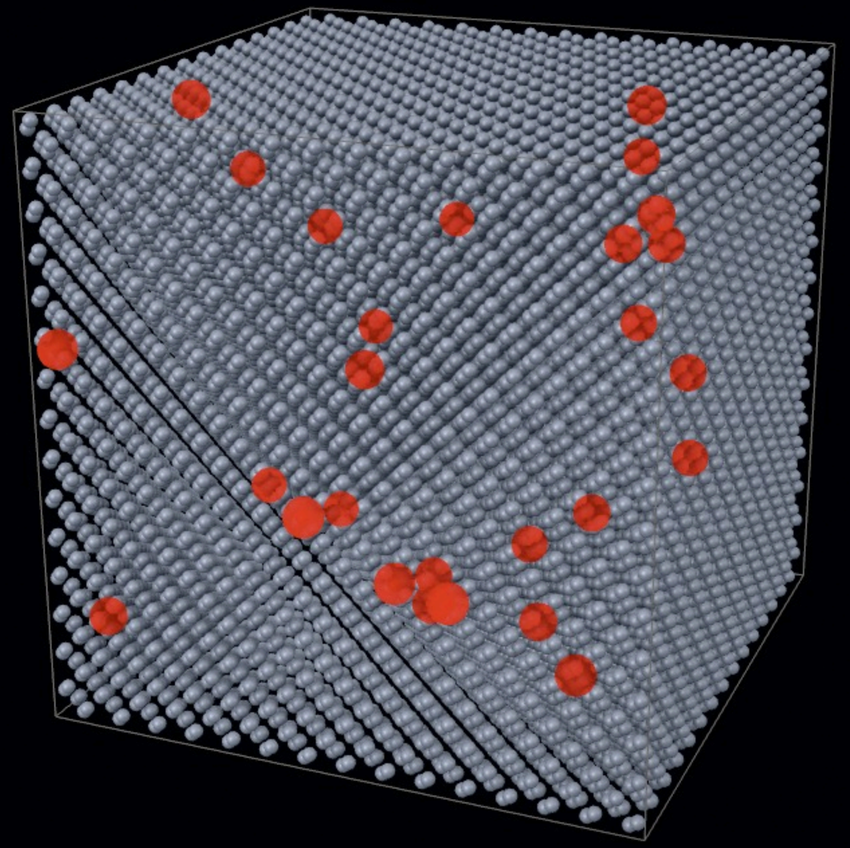
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03 · HOW CLEAN IS CLEAN

Counting the nines.

Purity is counted in nines: 99.999999999% is 11 nines, which the industry writes 11N. Silicon for chips is 11 nines or purer: Shin-Etsu and Tokuyama state 11 nines for theirs, and Wacker 12 nines. Solar silicon is 6 to 10 nines. At 11 nines, one atom in a hundred billion is something other than silicon.

Chip grades: Shin-Etsu, Tokuyama and Wacker, each on its own polysilicon. Solar grades, and the 11N way of writing it: the Semiconductor Industry Association (August 2025). The counts are our arithmetic: 27,000 × 10−N in the cube, and for one 300 mm wafer its volume times silicon's density (Jefferson Lab), divided by silicon's atomic weight (IUPAC), times the Avogadro constant (BIPM).



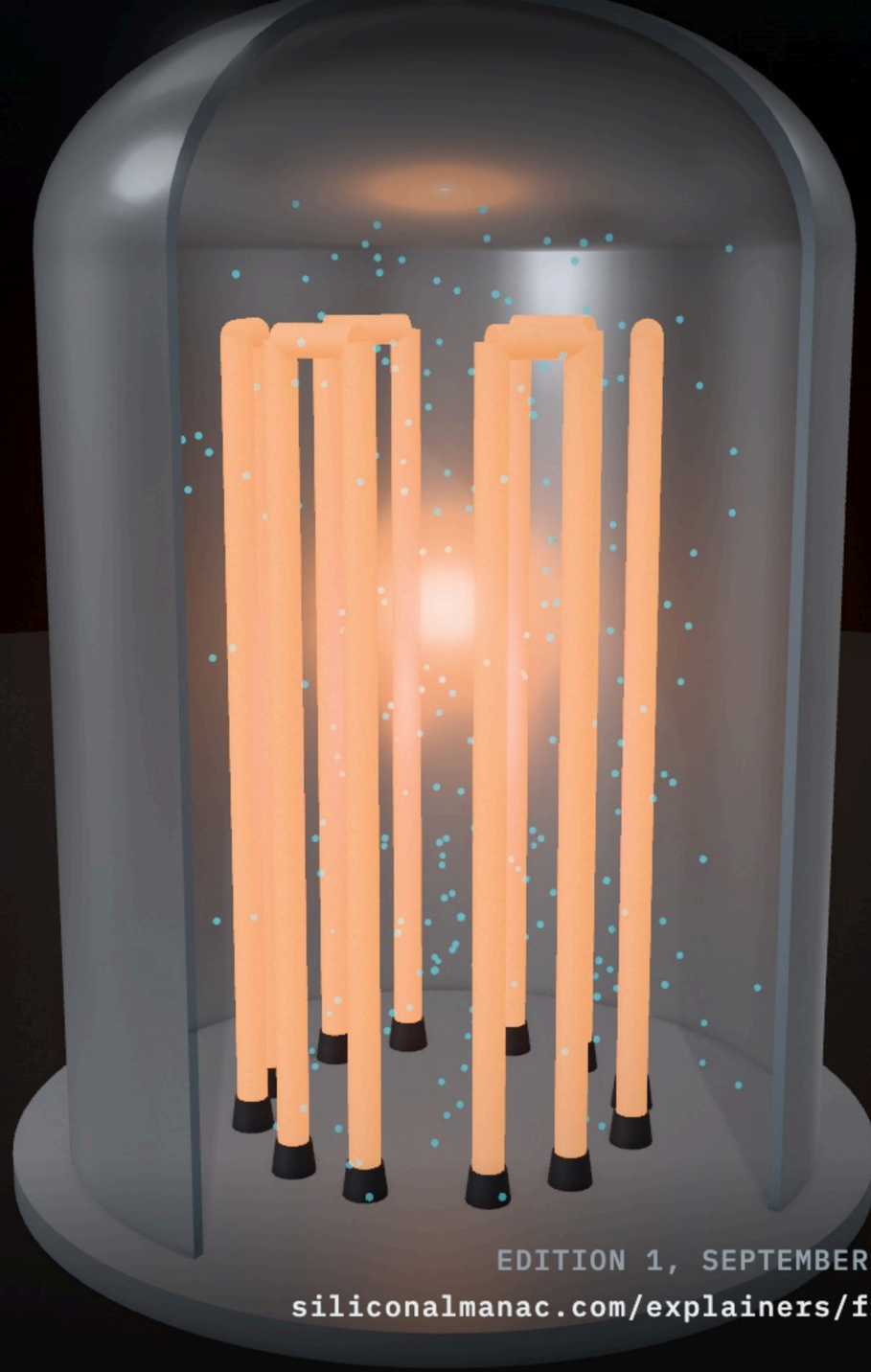
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04 · METAL TO POLYSILICON

Growing rods out of a vapour.

To reach the nines, silicon metal is turned into a liquid, trichlorosilane, distilled, and turned back into silicon. In the Siemens process, thin U-shaped silicon rods in a steel bell jar are heated electrically, up to 1,150 °C, and trichlorosilane heated to over 1,000 °C passes over them. It leaves pure silicon behind, layer on layer, until the rods are 15 to 20 cm thick.

Temperatures: Bernreuter Research (the rods, up to 1,150 °C, growing to 15 to 20 cm) and Wacker (the trichlorosilane, over 1,000 °C). History: Fraunhofer IISB and Wacker. Demand: TECHCET's forecast, as the Semiconductor Industry Association quoted it to the US Commerce Department (August 2025). Bernreuter notes that a fluidized-bed reactor fed with monosilane needs a tenth of the heating electricity. The reactor is shown opened, and its rods grow to 15 cm; the real one is a closed steel jar.



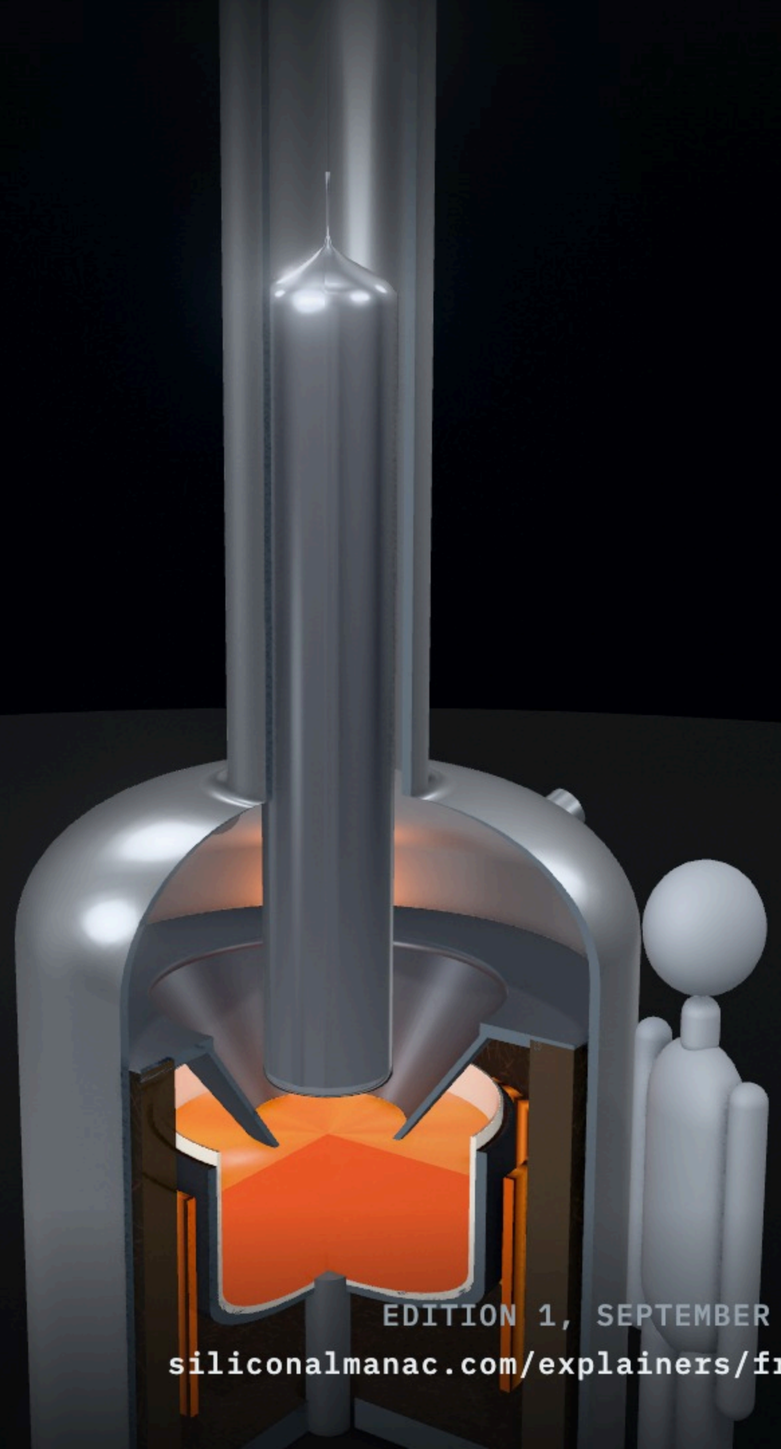
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05 · THE CZOCHRALSKI METHOD

Pulling a crystal from a pot.

The crucible is where the sand is: it is made from high-purity quartz sand. Polysilicon chunks go into it with boron or phosphorus, which set how the silicon will conduct, and melt at around 1,420 °C under argon. A seed crystal touches the surface and is pulled up while turning, and the whole ingot grows as one crystal in the seed's orientation.

Melting, doping and pulling: SUMCO; argon, oxygen and rotation: GlobalWafers, whose oxygen figures are from 200 mm crystals. Crucible quartz: Sibelco and The Quartz Corp. Size, weight and time: Siltronic (September 2023). No wafer maker publishes a length, so the body is drawn at 1.8 m, the height of the person beside the machine, and weighs about 300 kg by our arithmetic. The machine is generic and time is compressed. History: Warsaw University of Technology; Poland's Sejm named 2013 the Year of Jan Czochralski. Float-zone growth makes crystals without a crucible, at low oxygen (SUMCO).



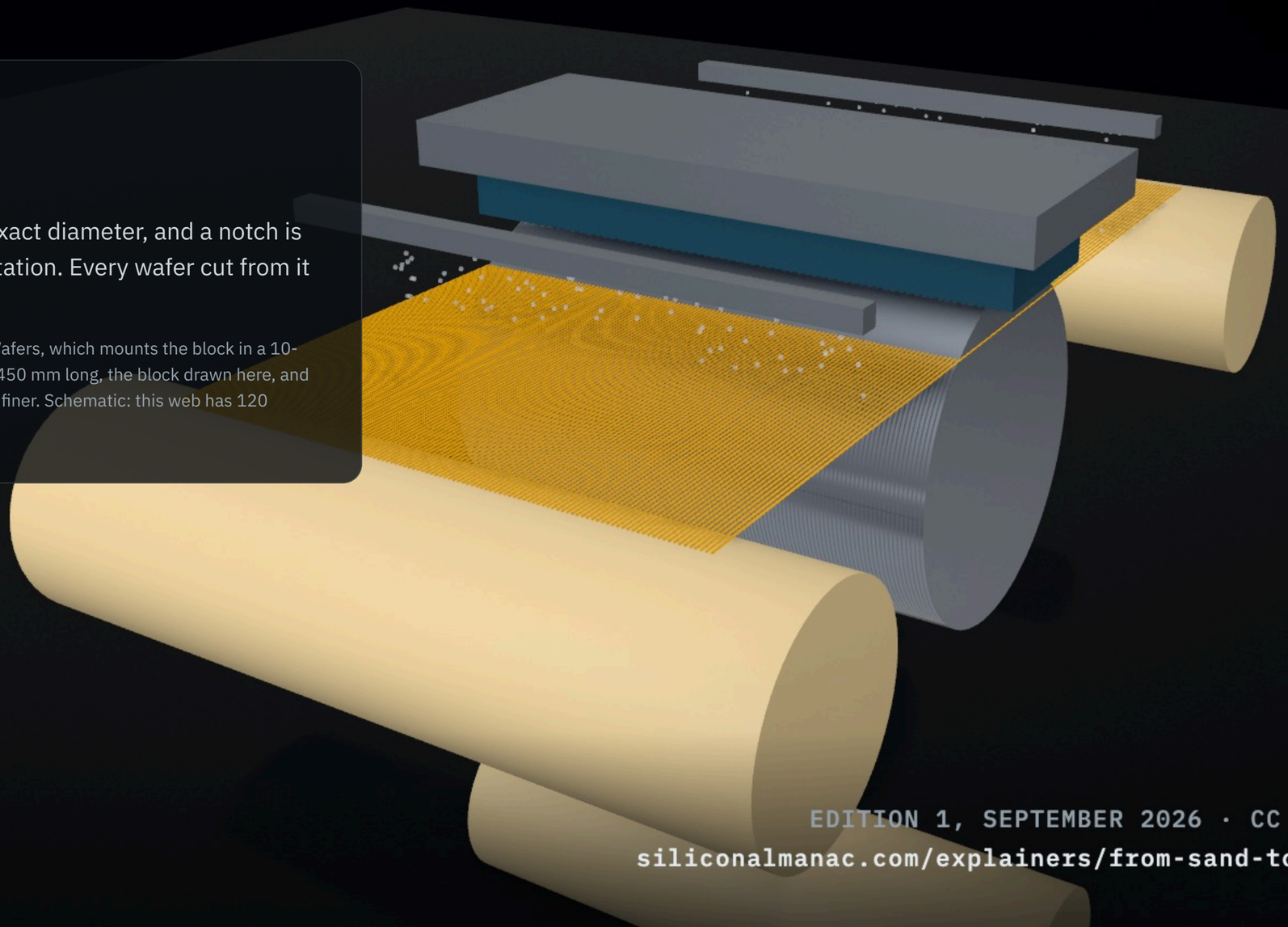
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06 · CRYSTAL TO SLICES

A saw made of wire.

The crystal is cut into blocks and ground to an exact diameter, and a notch is ground along its side to mark the crystal's orientation. Every wafer cut from it carries that notch.

Grinding and the notch: Siltronic. The web and the slurry: GlobalWafers, which mounts the block in a 10-ton saw. Komatsu NTC lists a slurry saw for 300 mm blocks up to 450 mm long, the block drawn here, and says its diamond-wire saws lose less material because the wire is finer. Schematic: this web has 120 wires, where slices of around 1 mm would need hundreds.



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07 · LAP, ETCH, POLISH

Flatter than anything you own.

The slices are rounded at the edge, lapped between two plates turning in opposite directions to take about ten micrometres off each face, and etched to remove the damage that is left. A 300 mm wafer is then polished on both faces at once, held, as in lapping, between an upper and a lower polishing plate, with a slurry between them.

Siltronic: the steps, and why 300 mm wafers are polished on both faces; its 20 nm picture is from its 2020 Factbook. NIST (Griesmann and Wang) on depth of focus, restating the International Technology Roadmap for Semiconductors of 2006: targets, not a shipped specification. The machine is generic, with its upper plate raised so the wafers show.

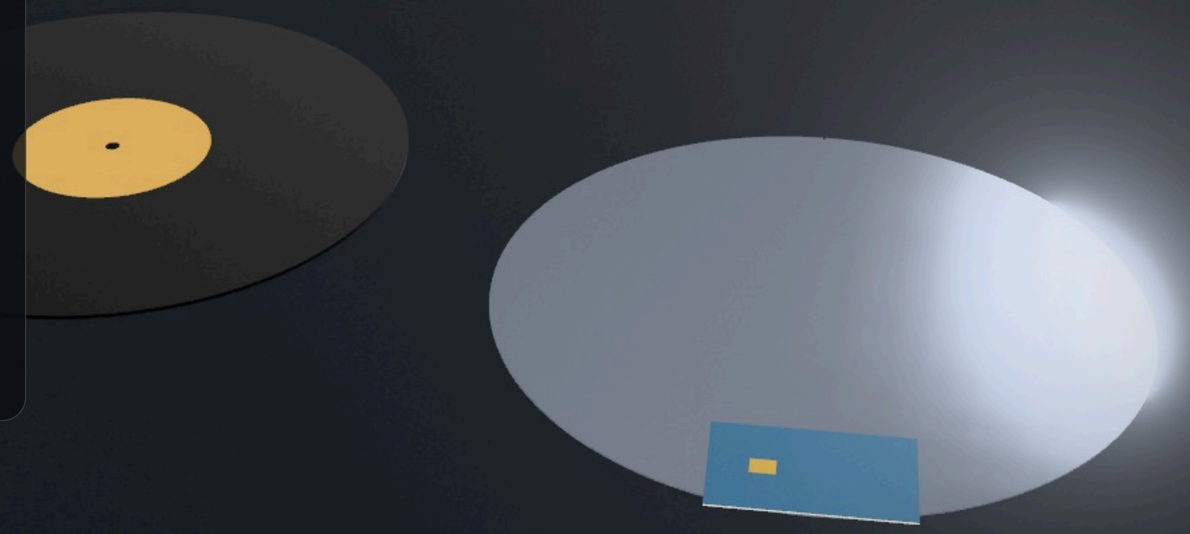
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08 · WHERE TO GO NEXT

Ready for a thousand steps.

The finished wafer is 300 mm across and 775 µm thick. The industry calls it a 12-inch wafer, about the width of a 12-inch record, and it is about as thick as a bank card. It weighs about 128 g, by our arithmetic. It travels to the fab in a shipping box such as ePAK's, which holds 25 wafers 10 mm apart.

Thickness: Wikipedia; no wafer maker we read publishes it. "12-inch": Tokyo Electron. The bank card: ISO/IEC 7810, 0.76 mm thick as Wikipedia gives it. The box: ePAK's 300 mm shipping box, 25 slots at 10 mm. Weight: the wafer's volume times silicon's density.



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Sources

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From sand to wafer

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