the Institute for Local Self-Reliance, a nonprofit advocacy organization.

Once a fiber-optic line is in place, the hardware to transmit Wi-Fi costs very little. When Reid began researching options for transmitting Wi-Fi outdoors over long distances, he found that the transmitter was the cheap part, costing maybe CAN $1,500. It would cost 10 times as much to lay the concrete and raise a tower, even with volunteer labor.

The Lawrencetown cooperative has since installed four of these towers–including one on a farmer's silo–and is building a fifth. The high-throughput Wi-Fi he tested early on "kind of blew us away," he recalls. "I could see 600 megabits per second," or about 7 times as fast as Nova Scotia's average fixed broadband speed in 2018.

If government agencies such as the FCC are willing to open up unused licensed spectrum in rural regions, community networks could offer even better service, says telecom engineer Carlos Rey-Moreno of the Association for Progressive Communications. "The breakthrough will be at the regulatory level in the U.S. and other countries when they open up 6 gigahertz [and other bands]," he says, to take advantage of technology that can transmit more data than existing Wi-Fi.

Cooperatives have already shown that they can be popular and profitable with today's technology. At first, the Lawrencetown cooperative, which began offering services in 2017, charged its 150 or so members CAN $60 per month, based on what a neighboring private ISP charged, but the cooperative soon found that it was generating a profit, which it had to repay to members, minus taxes. It has since lowered its prices to CAN $40 a month, and grown its membership to 350, but Reid says it could go lower.

RS Fiber Cooperative, which built fiber-optic service for 6,000 households, farms, and businesses in rural Minnesota, has a similar story. Both RS Fiber and the Lawrencetown co-op relied on municipal loans or backing to build the initial infrastructure. They've both since become self-sufficient.

And being first with fiber is always an advantage, Mitchell says: "It's a hard business plan to make work, but if you can make it work…[you'll] probably have an effective monopoly for many years." The only difference, Reid says, is that the community owns this monopoly. –LUCAS LAURSEN

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ANOTHER STEP TOWARD THE END OF MOORE'S LAW

Samsung and TSMC move to 5-nanometer manufacturing

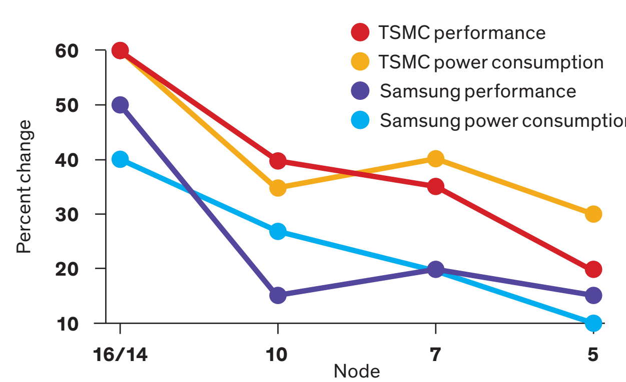
Two of the world's largest foundries—Taiwan Semiconductor Manufacturing Co. (TSMC) and Samsung–announced in April that they'd climbed one more rung on the Moore's Law ladder. TSMC spoke first, saying its 5-nanometer manufacturing process is now in what's called "risk production"–the company believes it has finished the process, but initial customers are taking a chance that it will work for their designs. Samsung followed quickly with a similar announcement.

TSMC says its 5-nm process offers a 15 percent speed gain or a 30 percent improvement in power efficiency. Samsung is promising a 10 percent performance improvement or a 20 percent efficiency improvement. Analysts say these figures are in line with expectations. Compared, though, with the sometimes 50 percent improvements of a decade ago, it's clear that Moore's Law is not what it used to be. But judging by the investments big foundries are making, customers still think it's worthwhile.

Why is 5 nanometers special?

The 5-nm node is the first to be built from the start using extreme ultraviolet lithography (EUV). With a wavelength of just 13.5 nm, EUV light can produce extremely fine patterns

PERFORMANCE AND POWER-CONSUMPTION IMPROVEMENTS



SOURCES: SAMSUNG; TSMC (COMPARISONS TO ORIGINAL VERSION OF PREVIOUS NODE)

NEWS

on silicon. Some of these patterns could be made with the previous generation of lithographic tools, but those tools would have to lay down three or four different patterns in succession to produce the same result that EUV manages in a single step.

Foundries began 7-nm manufacturing without EUV, but later used it to collapse the number of lithographic steps and improve yield. At 5 nm, the foundries are thought to be using 10 to 12 EUV steps, which would translate to 30 or more steps in the older technology, if it were even possible to use the older tech.

Because the photomasks that contain the patterns are so expensive and each lithography machine itself is a US $100 million-plus investment, "EUV costs more per layer," says G. Dan Hutcheson, at VLSI Research. But it's a net revenue gap on a per-wafer basis, and EUV will form the core of all future processes.

Who will use it?

The new manufacturing processes aren't for everyone. At least not yet. But both companies identified some likely early adopters, including suppliers that make smartphone application processors and 5G infrastructure. "You have to have high volume and a need for either speed or power efficiency," says Len Jelinek, a semiconductor-manufacturing analyst at IHS Markit.

Whom you're competing against counts too, explains Kevin Krewell at TIRIAS Research. Graphics processing units, field-programmable gate arrays, and high-performance microprocessors used to be the first to take advantage of the bleeding edge of Moore's Law. But with less competition in those markets, it's the mobile processors that need the new tech to distinguish themselves, he says.

Is it okay that there are only two companies left?

Only Samsung and TSMC are offering 5-nm foundry services. GlobalFoundries gave up at 14 nm and Intel, which is years late with its rollout of an equivalent to competitors' 7 nm, is thought to be pulling back on its foundry services, according to analysts.

Samsung and TSMC remain because they can afford the investment and expect a reasonable return. Samsung was the largest chipmaker by revenue in 2018, but its foundry business ranks fourth, with TSMC in the lead. TSMC's capital expenditure was $10 billion in 2018. Samsung expects to nearly match that on a per-year basis until 2030.

Can the industry function with only two companies capable of the most advanced manufacturing processes? "It's not a question of can it work?" says Hutcheson. "It has to work."

"As long as we have at least two viable solutions, then the industry will be comfortable," says Jelinek.

What's next?

Chipmakers' pipelines have traditionally had 5 nm following 7 nm and 3 nm following 5 nm. But analysts say to expect foundries to offer a variety of technologies with incremental improvements that fill in the gaps. Indeed, both Samsung and TSMC are offering what they're calling a 6-nm process. Foundries will need those intermediate products to keep customers coming to the edge of Moore's Law. After all, there aren't many numbers left between 5 and 0.

—SAMUEL K. MOORE

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ABB AND SIEMENS TEST SUBSEA POWER GRIDS

Putting a power-distribution station on the ocean floor could allow more raw materials to be processed down there

Slowly but surely, oil- and gas-drilling technology is migrating from floating platforms to the seafloor. Pumps moved down there decades ago. More recently, compressors (which boost pressure in a well to keep gas flowing) and separators (which isolate oil from water and silt) have relocated to the murky depths.

Putting this equipment closer to wells makes them more productive and energy efficient. Some oil and gas companies even aspire to build subsea factories that extract and process oil and natural gas directly on the seafloor. These factories would be safe from hazards such as icebergs and hurricanes. They would be controlled remotely, reducing labor costs. Eventually, some believe, offshore platforms could be phased out entirely.

However, all of this sunken gear requires electricity. Today, operators typically string power lines from power plants or diesel generators aboard nearby oil rigs to every piece of subsea equipment they install. That works for a few machines, but it's impractical to string dozens of umbilicals, as they're known, to the ocean floor.