

## VentureWire

### Start-Ups Race To Complete The All-Silicon Cellphone

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As smartphones and tablets surge in popularity, the last remaining cellular chip largely made from material other than silicon is motivating several venture-backed start-ups to apply a makeover.

The various semiconductors within a cellphone that handle critical functions like microprocessing, memory, GPS and Wi-Fi are all made from low-cost silicon, one of Earth's most abundant materials. But the power amplifiers, which amplify the device's radio signal, are still made from gallium arsenide, a compound that has some electronic properties superior to those of silicon but is far costlier.

The equipment used to produce silicon chips is standard in semiconductor fabrication plants around the world, while the tools for building chips with exotic materials like gallium arsenide are rare by comparison, making such chips more expensive and the supply chain fragile.

If a start-up can figure out how to effectively develop these power amplifiers using silicon, the market potential is vast. Besides smartphones, tablets and electronic readers all need multiple amplifiers. Research firm Strategy Analytics expects sales of these chips to increase 5% to 10% a year to reach \$3.7 billion by 2015.

"The promise of silicon power amplifiers has been around for a while," said Tim Wilson, a general partner with Partech International, an investor in ACCO Semiconductor Inc., one of several start-ups chasing this opportunity. "If you can get it right, you can expand in a market that's large and growing."

But the technical challenge is difficult to overcome for these start-ups, many of which have tried and failed in the past. Gallium arsenide chips have been used as power amplifiers for decades, and cellphone makers are comfortable using them and understand the performance metrics of the chips. Simply matching the capabilities of gallium arsenide isn't likely to be enough to bring success to the newcomers pushing for a switch to silicon.

Phone makers "have a long history of how [gallium arsenide] products work, and they won't accept compromise," said Brad Fluke, chief executive of Javelin Semiconductor Inc. For those start-ups trying to sell power amplifiers with incremental performance improvements, cellphone companies like Apple Inc., HTC Corp. and Motorola Mobility Holdings Inc. will be too busy to talk to them, he said.

With \$12 million in revenue from its 2G chip last year--its first year of revenue--Amalfi Semiconductor Inc. of Los Gatos, Calif., is one of the first companies to generate substantial revenue from a silicon power amplifier for cellphones. Its path to market is littered with fallen competitors. When Amalfi started in 2003, another start-up, Axiom Microdevices Inc., and a larger company, Silicon Laboratories Inc., were also developing similar technology.

Silicon Labs gave up its effort and sold the intellectual property last year to Black Sand Technologies Inc., a start-up building silicon power amplifiers. Axiom Microdevices sold for about \$10 million to Skyworks Solutions Inc., a maker of gallium arsenide amplifiers that still develops silicon products based on Axiom's technology for use in the most inexpensive cellphones. Another venture-backed company, Star RF Inc., quietly shut down about a year ago after three years in business.

Even for Amalfi, getting the technology right took time. "The reason it took two extra years to get to market is that it's a really tough problem," said Pete Moran, a general partner at DCM, which co-led Amalfi's Series A round in 2003. The company has now raised \$56 million in venture funding.

Aside from lower prices and a firmer supply chain, silicon chips also benefit from the ability to be designed with more smarts--meaning that the amplifier and all the components that operate it can be put on a single chip. This becomes a more attractive option for companies making smartphones because those phones need multiple power amplifiers for different frequency

bands. With silicon, all those could be on one chip.

Though gallium arsenide is well-suited to amplifying power, it isn't possible to build smarts directly into the chip that would enable it to work across a range of power levels, support multiple radio frequencies or reduce interference generated by the chip. To solve those issues, gallium arsenide companies package the power amplifier with multiple chips to regulate its performance.

Building all those capabilities into a single chip is possible with silicon, but it is a very tough technical problem to get a silicon product to match or improve on the performance of current gallium arsenide amplifiers.

Investors are placing bets on which company will be the one to break through.

Austin, Texas-based Javelin, which has developed samples and expects to have revenue by the middle of the year, has raised \$12.5 million over two rounds from Sevin Rosen Funds and Silverton Partners. Another Austin-based company, Black Sand Technologies, which has just released its first samples, is backed by Austin Ventures and North Bridge Venture Partners. Sunnyvale, Calif.-based ACCO Semiconductor, which is staying quiet about its progress for now, has attracted Foundation Capital, Partech International, Pond Venture Partners and Siparex Ventures as investors.

Unlike Amalfi, those companies are building chips specifically for smartphones, though Amalfi plans to follow with a product for that market as well.

One reason for all the activity is that several companies have built major chip businesses by being the first to convert different electronic components to silicon. Atheros Communications Inc. built silicon power amplifiers for Wi-Fi equipment, and Silicon Labs developed telephone modem chips to replace systems built with exotic materials. Both companies, which were founded in the late 1990s and have since expanded their product lines, now have market capitalizations in excess of \$1 billion.

More recently, companies such as MaxLinear Inc., which went public last spring on the strength of its silicon tuners, and InvenSense Inc., a maker of silicon-based gyroscopes that has filed for an initial public offering, have performed well for their venture investors.

Though it is tempting to speculate which start-up will be the first to sell silicon power amplifiers, investors say the real competition for those companies comes not from other start-ups, but from the established gallium arsenide companies, like Skyworks and RF Micro Devices Inc.

Both of those companies use discrete silicon components to add smarts to their power amplifiers. Though neither is convinced of the need to build single-chip silicon-based amplifiers, they both say they have the capability to do so if customers begin demanding it.

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