The Democratization of Chip Design

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The open-source silicon movement with a community-based, open-source platform of easy-to-use, easy-to-access tools is a practical and efficient way to ensure innovation and has the potential to drive exponential semiconductor industry growth.

THE PANDEMIC, AMONG A HOST OF OTHER challenges, affected the global semiconductor supply chain and created a semiconductor shortage just as consumer demand for electronic devices exploded. Shipments of cars and everyday electronics ground to a halt, often for want of a single, sub-$1 chip. Chips were front page news … and for all bad reasons!

Naturally, the focus among the industry, its customers and the public was on the supply of chips and on increasing *fab* capacity and removing supply chain bottlenecks. What was largely missed was the need to position the industry to address a powerful long-term trend toward customized, special-purpose chips and the need to increase *design* capacity.

This is a secular trend and the cure involves addressing three pillars to the solution:

- Expand the designer community
- Reduce the time to design
- Reduce the cost of design

This cannot be done in an incremental way using traditional methods because the barriers are too high. Instead, open source and community are critical to making this happen.

Open source silicon began many decades ago with the advent of open-source EDA tools was kept alive and advanced by a small, enthusiastic cadre of talented professional and academics. It wasn't until recently when (i) open source was applied to the entire stack of chip design and manufacturing, (ii) a simple, scalable, streamlined, cost-effective path was created and (iii) subsidized programs were launched to engage a larger global community of potential designers and chip users, that the value of this new form of ecosystem could be realized.

The numbers of designers and designs are now growing (**FIGURE 1**). Open-source and community are applied to software-style fast, simple and affordable design of chips that are "good enough" to:

- Serve the need for custom solutions for new markets such as IoT, machine learning and automotive
- Prototype novel designs for novel applications
- Educate a new community to address these needs

Software and hardware developers are now empowered to design chips and chip design has become easier and more interesting to learn. This revolution will also bear fruit for the traditional ecosystem as the explosion of designs will applicability to new markets.

Call it the democratization of chip design.

Open-source chips: A full stack

To understand what open-source chips mean, why they are important and what is required for success, it is useful to compare and contrast open-source

Figure 1. The number of designers in the open-source community is growing and those designers embracing an open-source platform are reducing design costs and the time to design. Source: Efabless

chips with their progenitor, open-source software.

In both cases, open source refers to a form of license that allows anyone to freely share, modify, change or use the code or design. Both open-source chips and software are accessible to anyone, anywhere. They reduce cost of design, speed the time of development (and even of starting a project) and make development significantly easier. Taken together, this can put customers and end-users in the center of the development process. In fact, the first movers of open source in both chips and software have been predominantly users, not merchant suppliers.

Both open-source software and chips derive value by enabling new applications or features that would otherwise not be possible with conventional methods based on proprietary technologies. Over time, their openness allows for testing across wide ranges of use cases by a wide range of users, regardless of any previous affiliation. In both software and chips, the value of the ecosystem grows exponentially with the size of users in the community.

This brings us to what is different between open source for chips and that for software. Unlike software, chip design has interdependencies with critical pieces of their creation. These include electronic design automation (EDA) software, other component blocks and the manufacturing processes on which they are manufactured. Any open-source chip must be created with either a full open-source stack or interoperate with and respect the rights of proprietary parts of the value chain.

Finally, software is a virtual product with no production cost allowing for rapid cycles of design/fail/redesign that accelerate the improvement of code and applications. It also has limited interdependencies with other software and the hardware on which it operates. Chips, in contrast, are different. They are a physical product so manufacturing complexity, cost and time are inhibitors to the speed of innovation. Any chip ecosystem will not be complete without a fast, simple and cost-effective path to prototypes and manufacturing. This solution must be scalable to the chip manufacturer to support a large and growing set of designs, many of which will not have apparent or immediate commercial value.

The definition of open-source chips is much like a layer cake that addresses these needs and interdependencies. The top layer is high-level, architectural design of the chip. The layer below is silicon IP, followed by EDA tools with process design kits (PDKs) including standard cell libraries that link design to manufacturing at the bottom. The last is an important and not well understood piece of the solution. Only by open sourcing the PDK, can designers have true open-source designs that can be shared freely without licensing, shortening the time to commence a project from six months or more to seconds. Significant advances have been made on all layers of the cake.

Google and SkyWater partnered with a community-based chip design platform to address the prototyping "last mile" of the open-source chip ecosystem, the integration of design with a complete path to prototyping and eventually volume production. This offering gives designers of open-source intellectual property (IP) and chips a path from design to prototypes at no cost. Google provided funding, branding and energy into promoting the program. SkyWater open sourced the PDK for its 130 nm process. The platform built the infrastructure and automation to make it happen and runs the service. A follow-on program based on the same open-source infrastructure supports design to prototyping of proprietary designs at extreme low cost. For under $10,000, a designer has access to an EDA environment, community support, a PDK and the prototyping of 300 packaged parts and five evaluation boards.

Finally, the full picture has taken shape.

The Open-Source Applications

Various elements of the open-source stack are already seeing applications across the spectrum of semiconductor design (**FIGURE 2**). In particular, the RISC-V Instruction Set (ISA) has been adopted by companies large and small across applications ranging from chips

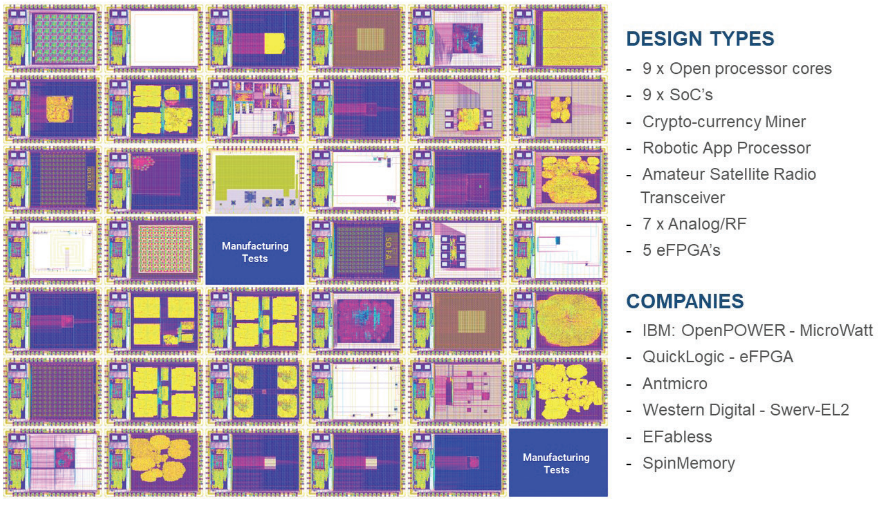

Figure 2. A snapshot of open-source projects highlights the growing number and diversity of designs from designers who work for large companies, startups and those doing it themselves. Source: Efabless

based on near leading-edge processes to those on mature nodes.

Equally interesting are the applications that benefit from the comprehensive open-source stack and related path to manufacturing with adoption. Three examples

of such applications that are early adopters include:

Special-Purpose Silicon: The move to customized hardware for applications like IoT and Machine Learning has created rapidly growing demand for custom (or special-purpose compute) chips. They deliver orders of magnitude lower power consumption or higher performance when compared to general-purpose chips. Custom silicon also reduces the dependency on availability of a wider span of chips in a bill of materials, reducing dependencies on the supply chain.

The current ecosystem is geared to high-volume standard products, not smaller volume or speculative highly customized chips. There are not enough chip designers, the cost of design is too high and the time to design is too slow for these classes of applications.

Apple has solved part of the problem through multiple acquisitions of chip companies, design talent and related IP. *The Wall Street Journal* quoted Carolina Milanesi of Creative Strategies as saying, “Now they (Apple) can line up the design of the silicon, software and hardware to deliver one thought-out product that’s better in power and performance.” Automotive companies are similarly racing to build internal capability. A recent *Economist* article titled “How supply-chain turmoil is remaking the car industry,” notes significant investments are being made by leading automotive companies in building internal chip design capacity in order “to help them semi-tailor specifications to make them, as one car boss puts it, *smarter buyers*. VW is hatching plans to design its own custom silicon, as Tesla does.”

The acquisition and investment path can work for large well-financed companies with large proven markets, but what about everyone else? This is where the open-source solutions shine.

Open-source chips represent the most viable solution to address the market needs: because they can be shared to simplify design, speed time to market and reduce costs. Advances in open-source EDA use automation and novel approaches to expand the community of designers to software and hardware developers, growing the potential pool of designers by perhaps 500X or more. For example, the Open Lane flow built on the DARPA funded Open Road tools offers fully automated RTL to GDS physical design. This turns FPGA developers into chip designers. Frameworks like LiteX offer python-based SoC design.

An open-source platform simplifies, accelerates and makes affordable the critical path to prototypes and early first volumes. They are superior to general-purpose solutions and offer savings in upfront costs to generate a low-cost of ownership chip, enabling designers to inexpensively prototype and address a broad number of applications.

Education: Silicon solutions were prohibitively costly for educators. The low cost of silicon generation is making it accessible to the education field. The academic community now is using open source for both course work and research. In software, students can learn by doing and create their own “apps,” even beginning in high school. In contrast, electrical engineering students would typically not be able to fabricate their own silicon solutions until entering a PhD program or even the workplace.

Prototyping for Startups: For many years, venture funding for startup chip companies had all but disappeared in large because of the high upfront costs of bringing an idea to proof of concept. As a result, overall returns were depressed and such deals were not competitive with other opportunities. In recent years, this has improved, but largely only for high-profile teams undertaking enormous market opportunities.

Open Source with a full prototyping solution speeds the path to proof of concepts (PoCs) at a fraction of the cost of using traditional EDA, IP and prototyping. Once the PoC is developed, follow-on funding can be arranged to fund further development and optimization of the design using traditional methods.

This is democratization of chip design in action.

Conclusion

Governments and the semiconductor industry reacted to the semiconductor shortages by making enormous investments in the supply chain and by formulating plans to build new fabs. Intel plans to spend $100 billion in manufacturing in Ohio and up to 80-billion Euros in Europe over the next decade, assuming government incentives. Governments are responding with capital of their own. In the U.S., the Chip Act allocates over $50 billion to the chip industry with much of it earmarked to capacity and secure supply chains. China has its $170-billion National Integrated Circuit Fund. Europe, India and other countries have similarly ambitious programs.

This is all well and good, but there are big opportunities that also require a new way to approach design to fill fabs and meet market needs. One based in methods proved in software and content creator markets.

The open-source silicon movement with a community-based, open-source platform of easy-to-use, easy-to-access tools is a practical and efficient way to ensure innovation and has the potential to drive exponential semiconductor industry growth. It creates and engages a new community of designers that expands to a far broader community in all countries and offers flexibility for individuals to live and work where they chose.

Editor's note:
Efabless is community-based chip design platform for custom silicon.

Mohamed Kassem will participate in Design Automation Conference (DAC) panel addressing "Is Democratization of Chip Design Already Happening?" Monday, July 11, at 2 p.m. in the DAC Pavilion.

Lucio Lanza leads a panel discussion on " Supply Chain Verification—Critical Enabler for Next-Generation MedTech Innovations" in the Smart MedTech Pavilion during SEMICON West Tuesday, July 12, at 11:35 a.m.

ABOUT LUCIO LANZA

Lucio Lanza is the Managing Director of Lanza techVentures, an early-stage venture capital and investment firm, and a member of the Efabless Board of Directors. A recipient of the Phil Kaufman Award for Distinguished Contributions to Electronic System Design, he previously held executive positions at Olivetti, Intel, Daisy Systems, EDA Systems and Cadence Design Systems. Dr. Lanza holds a doctorate in electronic engineering from Politecnico in Milan, Italy.

ABOUT MIKE WISHART

Mike Wishart has a mult-decade career in investment banking and technology. His resume includes stints at Smith Barney, Lehman Brothers and Goldman Sachs after his Stanford MBA. He

has served as a director at Brooktree, Spansion, Cypress and now Knowles. Wishart is also a venture partner at Tyche Partners, a venture capital firm focused on transformative "hard tech" companies. In 2014, he co-founded Efabless.

ABOUT MOHAMED KASSEM

Mohamed Kassem is a co-founder of Efabless and serves as its CTO. Prior to launching Efabless in 2014, Kassem held several technical and global leadership positions within Texas Instuments' Wireless Business Unit. He joined TI in 2000 at the beginning of the digital telephony revolution fueled by fueled by the integration of analog/RF phone functions on a single SoC. He led the first development of 45nm, 28nm analog/mixed-signal subsystems for wireless applications processors. Kassem holds a Master of Science degree in Electrical Engineering from the University of Waterloo, Ontario, Canada.