Small Volume Technology Fabrication

OPENING THE DOOR TO A NOVEL SOLUTION

Fred Flitsch, PhD, MBA

Chief Executive Officer, Futrfab, Inc.

The semiconductor industry has delivered remarkably consistent improvements in quality, function and cost for more than five decades. However, industry growth has finally brought it to a crossroads. The pace and trajectory of the industry may be pricing out the innovative leadership it needs to continue growing.

One of the great strengths of the semiconductor industry has always been the remarkable consistency of its cost per unit curve. In a principle related to Moore's Law—as semiconductor performance has increased, the price per unit of performance has decreased.

Figure 1 shows how the functionality and cost of products that utilize electronic components has improved steadily and dramatically.

The flip side of that coin, however, is a phenomenon often referred to as either *Rock's Law* or *Moore's Second Law*: "The capital cost of a semiconductor fab also increases exponentially over time." A fab is typically a large building or collection of buildings that houses the equipment, materials, tools and personnel to fabricate semiconductor chips. **Figure 2** shows *Moore's Second Law* in action.

> **Moore's Second Law:**
> **The capital cost of a semiconductor fab also increases exponentially over time.**

State of the art fabricators, such as the "Gigafabs" created by *Taiwan Semiconductor Manufacturing Corporation* (TSMC), cost nearly $10 billion to install. Such a fab, over a potential operating lifetime of 10 years, would need to produce nearly twenty million dollars of gross margin output every week just to cover the depreciation of its building costs.

The exponential growth in expenses is widespread. **Figure 3** illustrates the growth in the cost of lithography tooling—a crucial process performed in all fabs. Lithography tooling is the equipment that "images" or defines features on semiconductor substrates upon which integrated circuits are made. As semiconductors become more sophisticated, the lithography equipment becomes more complex. And more expensive. For example, "extreme ultraviolet," or EUV, lithography tooling is expected to cost over $100M per piece of equipment. In 1980, $100M could build an entire fab.

FIGURE 1

Semiconductor Product
Exponential Cost Trend

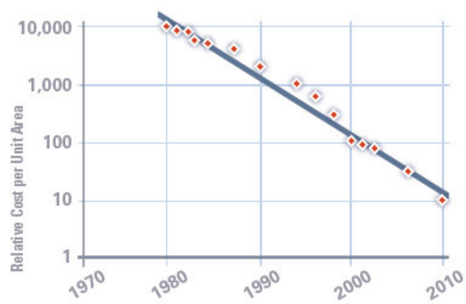


FIGURE 2

Semiconductor Fab
Exponential Cost Trend

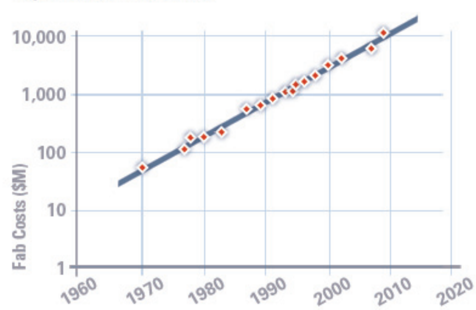
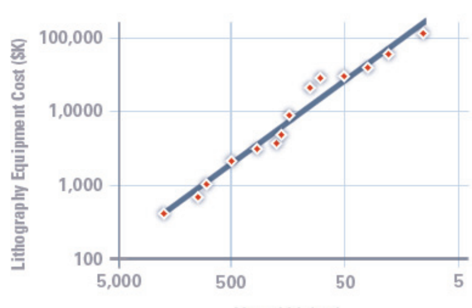


FIGURE 3

Lithography Equipment
Exponential Cost Trend



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The increase in silicon wafer size also contributes to the cost increase. Since 1970, the wafer size has increased from 2 inches to 12 and is expected to reach 18 inches within the next few years.

These conflicting cost trends are already challenging the industry's ability to maintain its momentum. The cost of chips is decreasing. Their functionality is increasing. But the infrastructure to support those trends is starving off virtually all small-volume activity. When fabs cost upwards of $5 to $10 billion, suppliers need to focus on activities that move huge amounts of wafers.

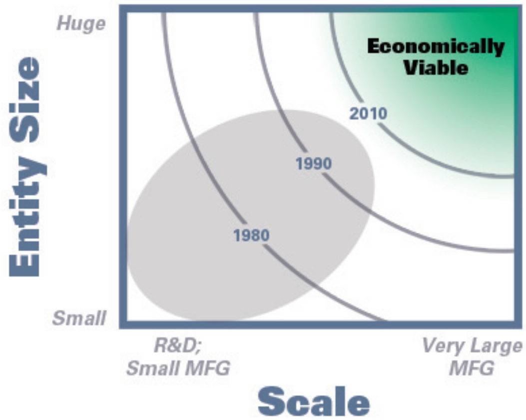

FIGURE 4

In the 1980s, electronics companies commonly owned fabs so they could conduct their own R&D and develop proprietary process flows. Small-scale semiconductor R&D was a possibility for many players. But, **Figure 4** shows the effect of soaring cost structures on the viability of small volume activities. As new tooling and larger wafer sizes began to drive up costs, companies began pooling resources to conduct even small-scale activities. Today, the cost structure is placing small scale activities like R&D and prototyping out of reach for some of the world's largest companies.

The industry has a choice. This conflict in cost trends can either close the door on crucial small volume activities—which would threaten the rate of continued industry improvement—or it can open a door for a novel solution.

[*] Data in Figures 1, 2 and 3 reference information published by IC KNOWLEDGE, LLC.

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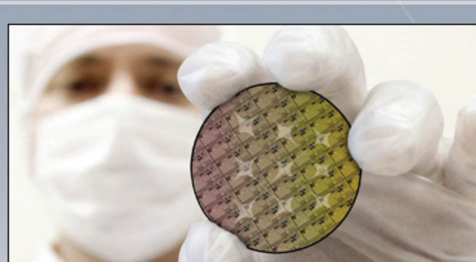

The cost of building a fabrication plant has increased by over 5,000% in the last 30 years. In 1980, a typical state-of-the-art fabrication plant, or 'fab', cost approximately $100 million to build. Today, a truly state of the art fab, costs nearly $10 billion. Given a liberal operating lifetime of 10 years, the fab will need to produce nearly $20 million of gross margin output every week of its life just to cover depreciation costs.

With today's economic pressures, companies face high risks when placing 'novel' designs into large volume production lines. A truly viable small volume manufacturing solution greatly decreases the associated financial risks.

A one-stop resource for R&D, prototyping, production and packaging. Large volume fabrication facilities simply don't support small volume activities well. Research and Development is often done thousands of miles away from the designers. Prototyping is restricted to standardized flows. Packaging is usually performed in far off locations, resulting in weeks of delays due to shipping and customs issues.

A *Futrfab* incorporates every aspect of the manufacturing process into one centralized location for small volume fabrication, and will be the environment of choice for development of new types of components that incorporate or support electronics.

It's the semiconductor fabricator of the future.

Futrfab, Inc.
New York Industrial Plaza
4 Crotty Lane | New Windsor, NY 12553
845.926.4007
www.futrfab.com