

ICKNOWLEDGE LLC

White Paper – Forecasting the 450mm Ramp Up

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Introduction

The introduction and ramp up of 450mm wafers represents a huge transition for the semiconductor industry. Based on a detailed analysis of historical wafer size transitions, silicon usage trends, technology transitions and silicon demand by product a forecast of the 450mm ramp has been produced. The analysis suggests a set of constraints that produces a single unique forecast that meets all of the assumptions. Furthermore an examination of the initial 450mm fab announcements is consistent with the forecasted initial ramp.

Previous Wafer Size Transitions

At each of the 150mm, 200mm and 300mm wafer size transitions a single wafer fab was initially built and then a period of time passed before additional fabs were built. At 150mm Intel drove the transition and built the first fab, at 200mm IBM was the driver and built the first fab, at 300mm we saw two consortiums drive development and then Siemens and Motorola jointly built the first fab. In each case the ramp-up in terms of the percentage of total silicon area represented by the new wafer size versus time has been similar, for example figure 1 illustrates the 200mm and 300mm ramps (150mm is not shown but was similar).

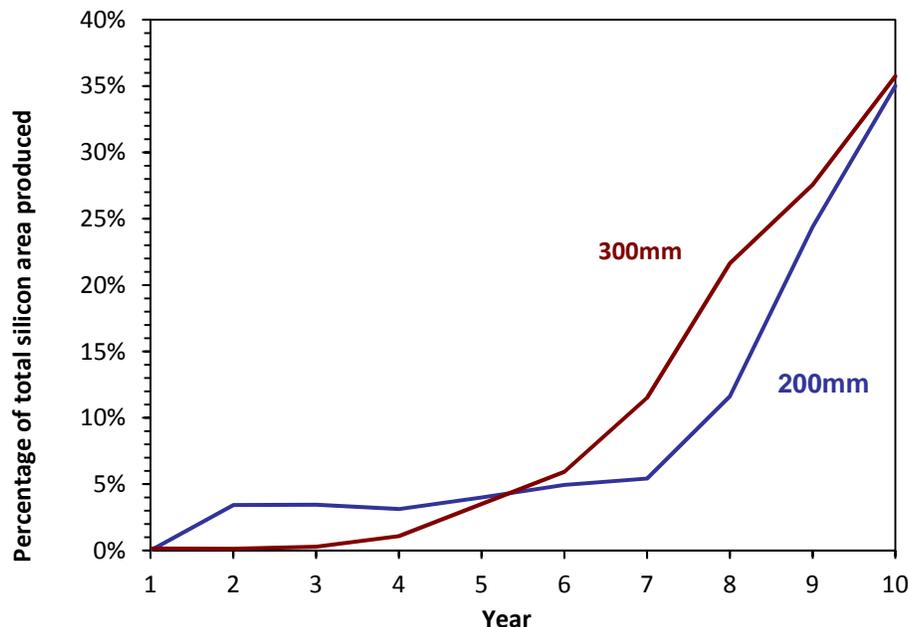


Figure 1. New Wafer Size Ramp Up as a Percentage of World Wide Silicon Area Versus Years Elapsed Since the New Size Was Introduced [1].

Since the last three wafer size transitions have all shown a similar ramp-up it would appear to be reasonable to expect that the 450mm ramp would also be similar.

Silicon Demand Forecast

An x-y plot of worldwide silicon demand versus semiconductor revenue can be fit with a linear equation with a 0.9807 R squared value, see figure 2.

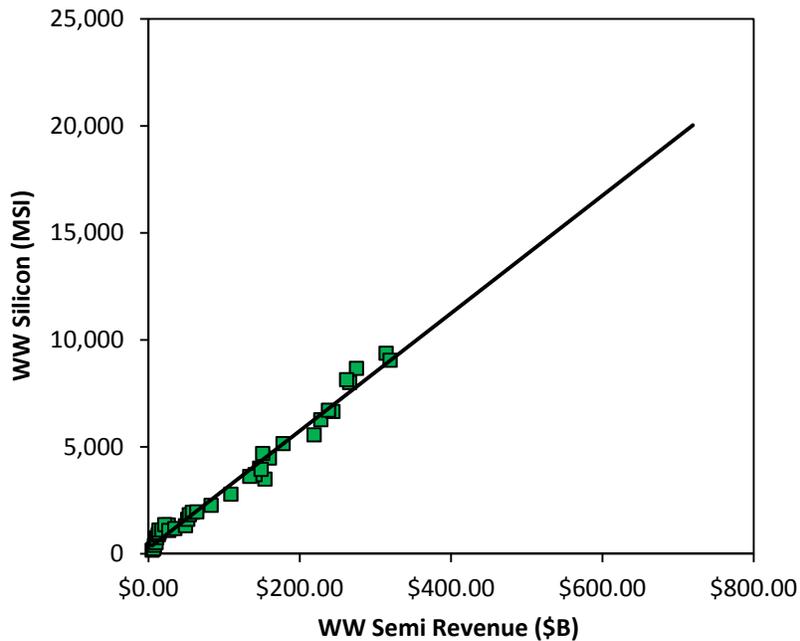


Figure 2. Worldwide silicon demand versus semiconductor revenue [2].

The combination of the data plotted in figure 2 with a long term semiconductor revenue forecast can be used to produce a long term silicon forecast.

It is well known in the semiconductor industry that year-to-year semiconductor revenue is highly volatile and forecasting revenue growth for any given year is difficult at best, however, longer analysis terms smooth out the yearly fluctuations in growth rate.

Figure 3 presents actual worldwide semiconductor revenue by year from 1960 through 2011 (solid green diamonds) and forecast revenue for 2012 through 2030 (open green diamonds). The calculated average growth rate for each decade is also shown, for example 1960 to 1969 - 15.83%, 1970 to 1979 - 13.87%, etc.

From figure 3 it can be seen that the CAGR has been declining over the last two decades falling from the mid-teens prior to the 1990s to approximately 12% in the 1990s and approximately 4% in the 2000s. The 2000s were particularly challenging with two very severe down-turns. With the strong start to the 2010s seen in 2010 we believe we will see some recovery in CAGR for the 2010s but the industry is maturing and a return to a long term double digit CAGR is in our opinion unlikely (although likely over shorter one to two year periods). Based on a detailed forecast through 2013 and trend analysis for 2014 through 2019 we are forecasting a CAGR for the 2010s of 6.28%. For the 2020s we are forecasting a relatively conservative 5% CAGR.

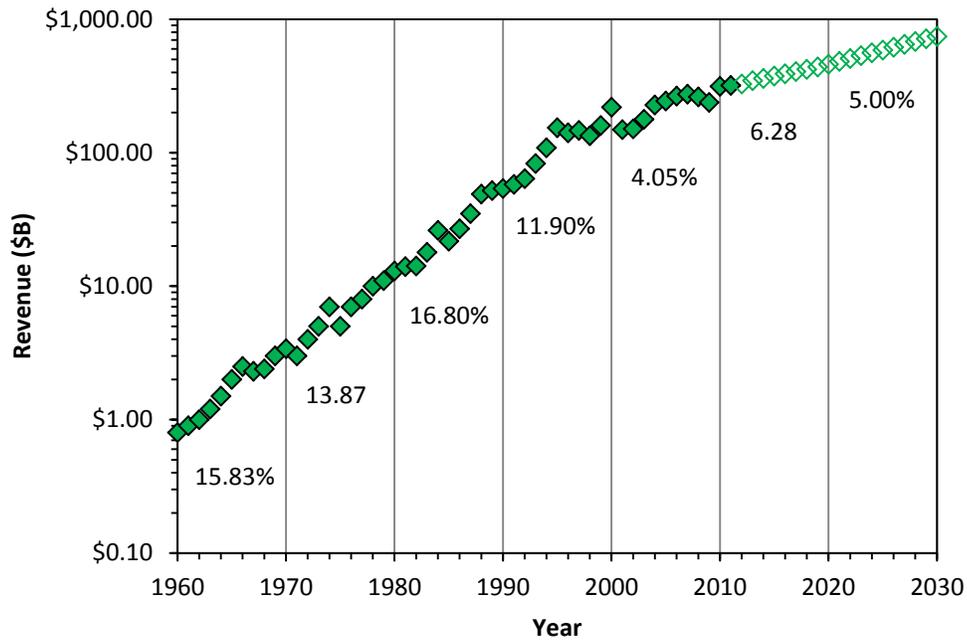


Figure 3. Actual and Forecast Worldwide Semiconductor Revenue [2].

450mm Ramp

Combining the data from figures 2 and 3 produces a forecast of silicon required by year (figure 4 black line). Furthermore with a few reasonable assumptions a forecast of silicon demand by wafer size including the 450mm wafer ramp can be produced (figure 4 colored lines). The underlying assumptions are:

- Wafer sizes smaller than 300mm will decline as a percentage of total silicon demand at a rate consistent with historical declines in older wafer sizes.
- 300mm demand will meet all future demand growth plus lost smaller wafer size capacity until 450mm enters production.
- 450mm will enter production in 2018 and ramp as a percentage of silicon demand at the same rate seen for the three previous wafer size transitions.

The resulting actual and forecast wafer demand by wafer size is presented in figure 4.

Silicon Demand by Product

The data presented in figure 4 includes test wafers as well as prime starting wafers; it is also a total for all semiconductors and therefore includes other products in addition to the integrated circuits that will be the drivers for 450mm (as they have been for 300mm to-date). Using historical data and trend analysis similar to the analysis presented in this paper we have broken out demand to produce an integrated circuit silicon demand forecast [2]. Furthermore an analysis of all of the 300mm wafer fabs in the world from 1998 to the present day can be used to produce a break-out of silicon demand by product type [1],[2].

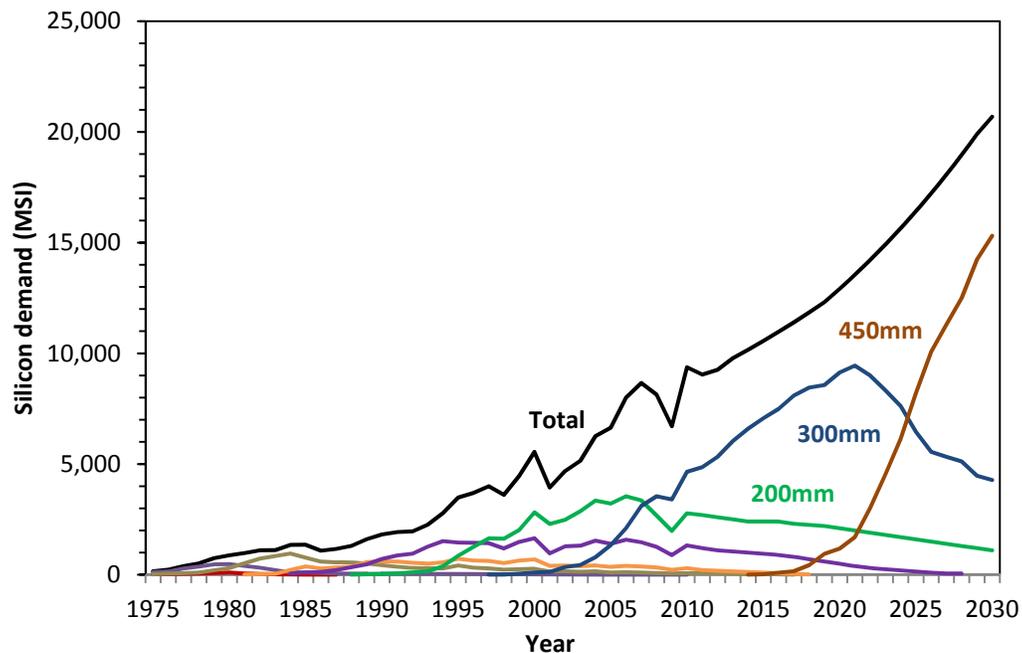


Figure 4. Worldwide Silicon Demand by Wafer Size [2].

Combining the preceding analysis with some reasonable assumptions about future trends we can produce an actual and forecast breakout of wafer starts for 300mm and 450mm by product type.

The key assumptions for a 300mm and 450mm product type forecast are:

- NAND Flash will grow as a percentage of 300mm and 450mm silicon demand for the next several years before beginning to level off.
- ASICs (Foundry and in-house SOC, the term ASIC is used to be consistent with the ITRS [3]) will maintain a steady percentage of 300mm and 450mm silicon demand.
- Other will not migrate to 450mm during the forecast period but will increase as a percentage of 300mm wafers as analog and discrete devices ramp-up on 300mm and ASIC, DRAM, Flash and MPU migrate to 450mm (there is one 300mm analog fab currently operating and one 300mm discrete fab currently announced).

The resulting silicon starts for 300mm and 450mm wafers by product is illustrated in figure 5.

Technology Transitions

The addition of technology transitions to this discussion provides another constraint on the 450mm ramp by product. At 300mm the transition began while 150nm was in production, 130nm was split between 200mm and 300mm, by 90nm – 300mm was the leading wafer size and at 65nm – 200mm production was very rare. Once 450mm enters production, equipment companies will focus their leading edge technology development on 450mm and the introduction of new technologies on 300mm will likely slow and then cease within a few generations.

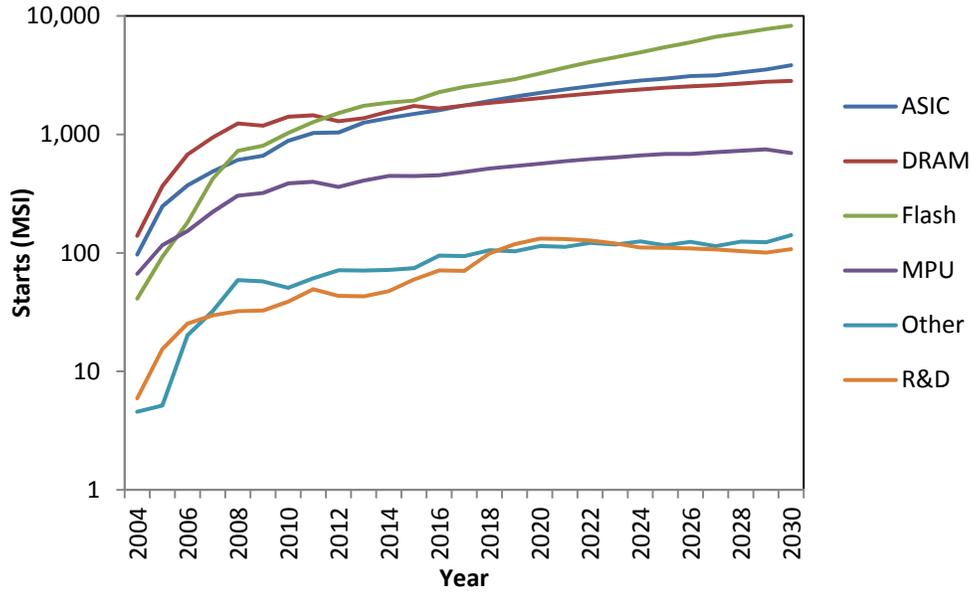


Figure 5. 300mm and 450mm Wafer Demand by Product Type [2].

Fab Forecast

Combining the silicon demand by product from figure 5 with the available total 450mm silicon from figure 4 and technology transition curves for the different product types creates a highly constrained scenario in terms of required fabs at 450mm by product type. The resulting forecast of 300mm and 450mm fabs versus time is presented in figure 6.

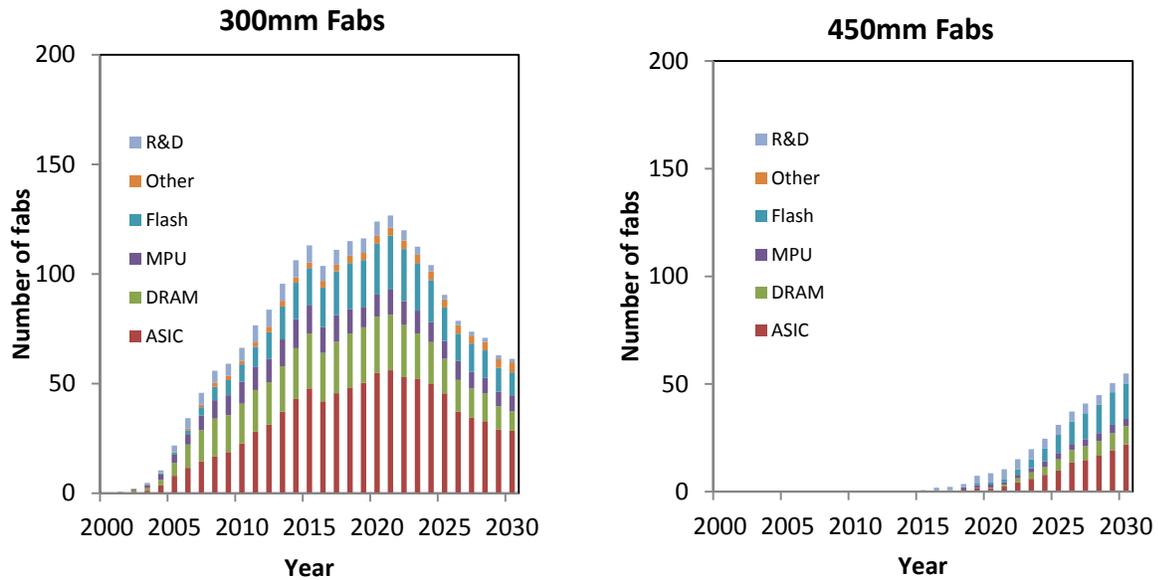


Figure 6. Wafer Fabs Forecast [2].

This forecast of 300mm fabs is based on ASIC and MPU fabs at 30,000 wpm, DRAM at 60,000 wpm, Flash at 100,000 wpm, other at 25,000 wpm and R&D at 5,000 wpm> these numbers were determined by analyzing all of the 300mm fabs in the world currently in production. For Foundry fabs included in ASIC each fab phase is considered a separate fab. For the 450mm fab analysis the average fab size has been assumed to be 1.5x the wafer output in wpm of a 300mm fab for the same product. This is the ratio seen for the last three wafer size transitions. For example, at 300mm the average Flash fab is 100,000 wpm and for 450mm we are forecasting 150,000 wpm.

Please note that up until 2015 the 300mm fabs are based on actual and announced fabs and from 2016 forward the forecast is mathematically derived based on demand. This results in a drop in number of fabs in 2016 suggesting that current fab construction and planning is running ahead of our forecast demand.

To-date TSMC has announced a 450mm R&D fab and a production fab, Intel has announced two 450mm “capable” fabs and Samsung is believed to be working on a 450mm fab [1]. The forecast capacity and timing of these fabs is consistent with the projections in figures 4 and 6.

Conclusion

A detailed long term silicon forecast has been produced. An analysis of historical and predicted future trends produces a highly constrained forecast for 450mm with a single unique solution to the assumption set. This detailed forecast is available as a forecast model where the user can see the calculation details and assumptions as well as modify the assumptions. The model is available as the IC Knowledge – 300mm and 450mm Forecast Model – silicon edition available at www.icknowledge.com. A companion product extending the silicon forecast to forecast equipment demand is also available as the IC Knowledge – 300mm and 450mm Forecast Model – equipment edition, also available at www.icknowledge.com. A similar materials forecast is in development.

About IC Knowledge LLC

IC Knowledge is the world leader in Cost Modeling of Semiconductors and MEMS. We provide Cost Modeling software as well as Cost Modeling services. We also offer Database, Forecast and Report products. Our customers include many of the leading producers of Semiconductors, Equipment and Materials for the Semiconductor industry, Electronics companies and leading Consultants and Consortia. We have several Strategic Partners and Subcontractors we work with to provide a wide range of services to our customers. For more information please go to www.icknowledge.com or contact us at info@icknowledge.com

References

- [1] “300mm and 450mm Watch Database - 1203,” IC Knowledge LLC (2012).
- [2] “300mm and 450mm Forecast Model – silicon edition - 1202,” IC Knowledge LLC (2012).
- [3] “International Technology Roadmap for Semiconductors,” www.itrs.net