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Cost Modeling as a Decision Making Tool

Introduction

Costs play a huge role in the commercial success of any electronics system or device designed for volume production. From cell phones to personal computers to game consoles or even a single integrated circuit a product must hit not only the required performance targets but do so at the target cost to be successful. All too often critical decision makers lack the necessary information to evaluate how their decisions affect the cost of the electronic devices or systems they are responsible for.

Consider these situations:

- An engineer is developing a process to manufacture a part and has to decide between alternate processes.
- A purchasing manager is negotiating a volume purchase of an electronic component.
- An operations manager needs to benchmark their operations for competitiveness.
- A marketing executive is trying to evaluate the relationship between volume and cost to set volume pricing.
- A fabless semiconductor designer is trying to choose between alternate processes.
- A semiconductor analyst wants to understand the manufacturing cost of a product a company they are analyzing has just introduced.

In all of these cases and many others an easy to use tool that provides accurate cost information would help the decision maker(s) make a better decision. The engineer developing a process could understand the cost impact of the various options, a purchasing manager could calculate the margin they are paying for a component and negotiate from a position of greater strength, etc. In some cases the desired cost information exists within the organization making the decision but still may not be easily accessible to the decision maker, in other situations the information is simply not available. Companies purchasing products and services often have no way of knowing what the products or services they are buying cost their supplier to produce.

The commercial availability of easy to use and accurate cost modeling tools empowers the decision maker with critical information and makes decisions easier to make and higher in quality both at the same time. This is the promise of cost modeling as a decision making tool!

The Cost Modeling Challenge

Cost modeling tools need to model the product being modeled at a sufficiently detailed level to capture the elements that significantly affect cost. The cost modeling tools covered in this paper model: Low Power Integrated Circuits (ICs), Micro Electro Mechanical Systems (MEMS), and Discrete Devices and Power ICs. The process flows that produce these devices are very complex and require a deep level of understanding to be accurately modeled. The basic modeling algorithms used in all cases were developed by an individual with nearly thirty years of technical and operational experience manufacturing the devices in question including designing, building and running wafer fabs.

The modeling process begins by building a detailed process flow for each product. The number and variety of process flows modeled has required an extensive network of information sources to produce the required flows. Sources include domain experts, customer and vendor inputs, technical papers, patents, construction analysis and direct experience. The detailed process flows are then distilled down to a list of how many times each of a standard set of unit processes are used in the process flow. The standard unit steps have to be appropriately defined for each modeling challenge. For example, for low voltage IC manufacturing unit steps such as: critical, mid and non-critical lithography, high and medium current as well as high energy implants would be used. When modeling MEMS products thicknesses become more important both in deposition and etches. For steps such as: Deep Reactive Ion Etch (DRIE) or wet Potassium Hydroxide (KOH) etching etch depth becomes relatively more important. Power products require a variety of times at high temperature to achieve the required diffusion depths, etc. These requirements have driven the segmentation into three models to be described later. MEMS may also add the complexity of multiple IC and MEMS devices in the same package.

For each process flow included in a model a background table summarizes the unit steps used. There are additional tables of cost, throughput and footprint for the unit step equipment. The combination of these tables with a designed capacity allows total equipment set cost to be calculated and the required facility size to be determined. These results feed into the critical depreciation calculation that is such a large part of state-of-the-art costs.

Material, direct labor, indirect labor, monitor wafers, consumables, facility costs and equipment maintenance costs are also calculated. There is a vast collection of data required to accomplish this from material costs, direct labor, indirect labor and utility costs by country and other factors. In many cases this data must be provided by year with both historical and future forecast values required. The amassing of the required data has required decades of research.

The resulting mathematical simulation provides a model that correctly accounts for process differences, utilization, capacity, location and all of the other pertinent manufacturing factors.

Usability

In order for a cost modeling tool to be useful it must be easy to use while at the same time modeling the selected process flow at a detailed enough level to provide the required accuracy. The cost models described in this paper utilize a triage model to present a simple to use interface that can be adjusted at a detailed level if required. As an example the IC cost model requires only seven user inputs to model most ICs. The required inputs are: year, process flow, die size, product type, package pins, package type and packaging volume. For many commodity products there is look-up help for die size and package type and pins. For the other settings there are a variety of support options if the user is not certain of what to use including; application notes, direct support and third party analysis.

The seven selections outlined above drive close to one hundred technology specific decisions inside the cost model. Information such as the specific configuration of the fab used by each company to run each process flow drives the fab capacity, country, year the fab came on-line and many other settings. In many cases the default values selected are visible on a defaults page where the user may override the selected value. By removing all of the detail around the defaults to a specific page the user is shielded from much of the model complexity and only needs to visit the defaults page if a special need arises. Many users never need to visit the defaults page or alter a default value.

Similar calculations are utilized for test and packaging costs.

MEMS Cost Calculations can add the additional complexity of multiple ICs and MEMS die inside a single product. The MEMS Cost Model provides the ability to define up to two ICs and two MEMS devices inside a single package. A product level definition is provided for many common products to lead the user through all of the required settings or the user may define their own product. The model supports up to two IC die and up to two MEMS die inside a single package with packaging and test cost.

Model Segmentation

As has been previously discussed, IC Knowledge currently supplies three different cost modeling tools. The following is a brief explanation of the history and segmentation of the tools:

- IC Cost Model – the IC Cost Model was introduced in 2001 and provides modeling for most low power integrated circuits. Commodity logic and memory, ASICs, RF, mixed signal and more can all be modeled. This is the most mature model in the family and is in use at most of the twenty largest integrated device manufacturers, fabless semiconductor and equipment companies, analysts and many others. Feedback from customers and financial models comparing the results of the model to quarterly results at very large foundries are all consistent with single digit percentage accuracy for the model if correctly applied. Licenses to the IC Cost Model include free updates and support for the calendar year the model is purchased in. Discounted upgrades are offered each year to registered users of the previous year's model.
- MEMS Cost Model – introduced in 2004 the MEMS model was originally a wafer cost only model. The limited functionality of the model served only a small portion of the available market. At the end of 2008 the model was completely rebuilt and now includes the capability to model up to 2 ICs and 2 MEMS die in a single product with packaging and test. The IC Capability in the model is sufficient for MEMS devices but will not model the variety of ICs the full IC tool will. The MEMS model is designed to be a complete stand-alone solution but not to substitute for the IC tool for stand-alone ICs. Fully integrating the entire capability of the IC tool was judged to increase the complexity of the MEMS model too much. Since the end of 2008 the acceptance of the MEMS Model in the market has been growing and to-date customer feedback has been very positive with respect to functionality and accuracy. Licenses to the MEMS Cost Model include 12 months of free upgrades and support. At the end of the 12 months discounted renewals are offered to all registered users.
- Discrete and Power Products Model – the Discrete and Power Products Model was introduced in early 2009 at the request of some of our IC Cost Model customers who wanted the ability to model Power ICs in specialty power packages and Discrete devices such as Power MOSFETs and IGBTs. The Discrete and Product Products Model is still rapidly evolving with a great deal of functionality being added to the model with each new release. Initial customer feedback has been positive and customers are also providing a lot of feedback to drive updates. Licenses to the Discrete and Power Products Cost Model include 12 months of free upgrades and support. At the end of the 12 months discounted renewals are offered to all registered users.

Applications

One of the first engagements we had with a customer upon releasing the IC Cost Model provides a particularly interesting example of the model application. As opposed to a customer purchasing the model and making use of it themselves as is more typical today, we were engaged to perform cost calculations for the customer. The customer was purchasing an ASIC that was originally designed for low volume production, they were now buying millions of units a year at several dollars each and they were

interested in examining cost reduction strategies. I remember that at the outset of the engagement there was a great deal of negotiation about our fee that was in the few thousand dollar range.

The first task we performed was to calculate the current manufacturing costs for the device. When we compared the production cost to what the customer was paying we found the gross margin was over 70%. Just armed with this information the customer was able to negotiate a price reduction worth in excess of one million dollars per year!

Today we have many customers using the model in regular negotiations with integrated device manufacturers and or foundries they are purchasing parts or wafer from. Armed with an understanding of the suppliers costs purchasing agents are far more effective negotiators.

We also have engineers at customers utilizing the MEMS Cost Model to evaluate the costs of various unit step processes as part of a designing new process flows. Other customers are using the model to perform internal benchmarking.

We are also aware of at least three cases where the IC Cost Model was used in supplier-customer negotiations and or litigation involving hundreds of millions of dollars! In one case pricing was set by running the model and then adding on an agreed upon margin. This is in comparison to the tool costs that are in the thousands of dollar range or less depending on whether a single seat or enterprise license is required.

Conclusion

The introduction of accurate easy to use commercial cost modeling tools provides decision makers with the information needed to make better decisions. Purchasing managers, development and production engineers, operations managers, marketing mangers, analysts and others can all benefit from accurate cost information. The IC Knowledge cost modeling tools are all designed to be easy to use and come with the support structure necessary to make the user successful. The cost benefit ratio of the model is very high in most applications.

To learn more about the cost models please go to www.icknowledge.com and select IC or MEMS products as required. We may also be contacted for specific questions at info@icknowledge.com or (978) 352 – 7610.