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Application note 2 for the 2008 IC Cost Model – February 19, 2008

Depreciation Calculations in the 2008 IC Cost Model

Introduction

For state-of-the-art processes modeled within a few years of introduction, depreciation will be the single biggest portion of the wafer processing cost. This makes modeling depreciation correctly critical to accurate modeling. We get more questions about depreciation than any other part of the cost model and it is in fact the most complicated calculation in the model. In this applications note we will discuss depreciation, how it works and how it is calculated in the IC Cost Model.

Introduction to depreciation

Depreciation is an accounting tool whereby the cost of a piece of equipment is charged off over time. The idea is that by the time the equipment is no longer useful is will have been completely depreciated and no longer have any asset value on the company's balance sheet. For example, consider a tool purchased for $1 million dollars with a 5 year useful lifetime. If the tool is depreciated using 5 year straight line, then 1/5 of the value of the tool is written off (taken as a depreciation charge) each year for 5 years. The following table illustrates how this works:

Year	Tool value at year end	Tool depreciation charge for the year
1	$800 ,000	$200,000
2	$600,000	$200,000
3	$400,000	$200,000
4	$200,000	$200,000
5	$0	$200,000

After year 5 the tool no longer has any value and no more depreciation charges are taken. If a tool is taken out of service before its value has reached zero, then the remaining value of the tool must be taken as a charge and the tool is "written off" to zero value.

Depreciation rates and methods

Ideally each tools useful life is determined and the tool is depreciated over its useful life. In practice there are a number of constraints on depreciation. In the semiconductor industry tools may become obsolete in only a few years, but in the United States for tax purposes tools cannot be depreciated over less than five years, in Korea 4 year depreciation is allowed and in Taiwan 3 year depreciation is allowed. Practically speaking most companies keep a set of books for tax purposes and another set of books

for reporting purposes. Most semiconductor companies use 5 year straight line depreciation for reporting purposes and that is the default in the model.

There are other depreciation methods beside straight line that are sometimes used with longer or shorter time periods and different schedules such as sum of digits or declining balance. On the '4 Defaults' page in cell D24 a drop down is available that allows the time period and type of depreciation to be changed. For most users you shouldn't ever need to change this setting and you should only do so if you have specific knowledge or needs that require it.

Cell D26 on the '4 Defaults' page also allows the user to directly select the depreciation rate instead of letting the model calculate it based on the depreciation method selected in cell D24 (cell D24 default is 5 year straight line). If cell D26 is set to default the depreciation method selected in cell D24 sets the depreciation rate, if cell D26 is set to a specific rate, the rate selected in cell D26 is then the rate that is used. Once again most users will not need to ever adjust this.

Tools versus facilities

By default tools are depreciated over 5 years in the model, facilities however typically have longer useful lifetimes and are therefore depreciated over longer time periods. Changing the default depreciation method or rate affects the tool set and tool set installation depreciation schedule. Depreciation of the building is set at 15 years in the model and the cleanroom and cleanroom systems at 10 years, both straight line. These settings cannot be changed.

Tool set upgrades

A major complication in the depreciation calculation is a common practice in the semiconductor industry of installing a tool set, running it for 2 or 3 years and then replacing approximately 1/3 of the tools to upgrade to the next smaller linewidth, 2 or 3 year later another linewidth upgrade may also take place. In this scenario three different tool sets of three different ages may coexist in the facility at the same time. The model tracks upgrades and calculates a blended average depreciation rate based on the method chosen and the age of each of the different equipment set groups. The '4 Defaults' page also offers a number of settings for tuning this calculation. The defaults will all fill in automatically based on our best available information about each company, as a user you may override any of the defaults.

- Cell D12 sets the year the current (most recent) tool set came on line.
- Cell D13 sets the number of upgrades. If this is set to 0 the model assumes an entire set was installed at one time and nothing has been changed out.
- Cell D14 does not do anything unless cell D13 is set to 1 or 2 upgrades. Cell D14 is the number of years to the first upgrade. If the current tool set came on line in 2007 and there has been 1 upgrade after 3 years, then the pervious set of tools came on-line in 2004 (2007 – 3).
- Cell D15 is the dollar value of the equipment set replaced in the first upgrade. Once again this only affects the model if cell D13 is set to 1 or 2 upgrades.

- Cell D16 is the number of years to the second upgrade; this only affects the model if cell D13 is set to 2 upgrades. If the current equipment set came on-line in 2007 and upgrade 1 was after 3 years and upgrade 2 was after 3 years, then the original tool set is from 2001, the 1st upgrade 2004 and the current set 2007.
- Cell D17 is the dollar value of the equipment set replaced in the second upgrade. Once again this only affects the model if cell D13 is set to 2 upgrades.
- Cell D18 is a master override that turns upgrades on and off. By default this is set to yes, if it is set to no, none of the above settings affect the model.

If we consider the previous example of a tool set that came on-line in 2001, was upgraded in 2004 and upgraded again in 2007, we can see how upgrades have a huge affect on cost. If we are modeling 2008 using the default 5 year straight line depreciation, the tools from 2001 will be fully depreciated and no longer incur depreciation costs. The tools from 2004 and 2007 will still be depreciating.

In the model we have set defaults for upgrades specific to each company based on our best understanding. For example many 300mm fabs were built at the 130nm or 90nm linewidth and then upgraded to 90nm, 65nm or 45nm linewidths. An upgraded 45nm Fab may have part of its tool set fully depreciated and therefore have a lower cost than a brand new 45nm Fab with no upgrades. This sometimes results in less increase in cost generation to generation than some people expect particularly if the year being modeled is also being changed to a later year.

Partial year depreciation

A new feature in release 0801 is the ability to have a tool set come on-line part way through the first year. In the past the model has assumed that tool sets always came on-line at the beginning of the first year. Cell D25 on the '4 Defaults' page now allows the number of months of depreciation in year 1 to be set. This setting only affects the calculation if cell D24 is set to default. By default cell D25 is set to 12 months so the equipment depreciates for the entire first year. As you reduce the number of months the tool set depreciates you add depreciation into the sixth year. For example, if the tool set depreciates for 10 months in the first year, then 2/12 of the equipment set will depreciate in the sixth year resulting in sixth year depreciation of 0.20 multiplied by 2/12.

This setting has been added to better model transition years where a tool set is becoming fully depreciated causing a dramatic reduction in cost but once again only affects the model is the default five year straight line depreciation is selected.