

# Fab Design For Future Technology

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## **Biography**

Michael O'Halloran is Director of Technology for Industrial Design Corporation (IDC). IDC is a global leader in the design of semiconductor facilities. As Director of Technology, Mr. O'Halloran has participated in the design of many fabs in North America, Europe and Asia. His experience includes the design of many types of fabs, including several 300mm facilities. Mr. O'Halloran has also been instrumental in the development of innovative fab design technologies, several of which have received patents.

## **Abstract:**

Semiconductor fabrication facilities being designed today will be expected to have a useful life extending to 2010-2015. These facilities will also be expected to remain efficient during an era that some consider will represent the limits of silicon semiconductor manufacturing technology.

This paper will address critical issues related to current factors influencing the design of semiconductor fabrication facilities, and discuss how these factors can enable semiconductor facilities being designed today to remain efficient for the full duration of what will surely be the most demanding life cycle period in the history of the microelectronics industry. The issues covered will include the impact of 300mm tools, automated material handling systems

(AMHS), and future semiconductor processing technologies. The paper will further discuss how such anticipated technologies can be expected to change the cost and efficiency dynamics of semiconductor fabs in both the near and long terms.

Industry owners are increasingly intent on anticipating the impact of such factors upon their future operating costs and ability to be competitive in this industry. These owners understand that the stakes of miscalculating the cost consequences of key facility design factors pose unprecedented consequences and concerns. The real-world expertise and "lessons learned" from the design of many current semiconductor manufacturing facilities will provide a number of valuable insights to an audience consisting of owners and suppliers integrally involved in this industry.

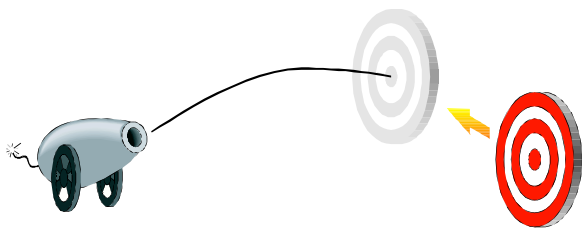
## **Data**

A semiconductor wafer fab being designed today would be expected to offer a production life of approximately 15 years. As show in Figure 1, the ITRS 99 expectation is that fabs will eventually be required to support 35nm micron technology. This is a level of technology considered to be very near the limits of silicon's performance capabilities.

Year	1999	2002	2005	2008	2011	2014
Technology Node (nm)	180	130	100	70	50	35

**Figure 1.** Anticipated reduction of IC geometry widths.

The challenge is designing a fab facility for five or more generations of product. As suggested in Figure 2, future fab technology is a moving target. How do you hit a moving target?



**Figure 2.** Future technology is a moving target

The answer is to aim for the future. Aim not where the technology target is now, but instead where we expect that target to be in the future.

In 1992, IDC developed an approach to this challenge when we produced the Future Factory Design for SEMATECH. Fabs that were designed and built consistently with the principles advocated in this 10-year-old report will soon have their production technologies extended to 300mm capability. To some extent, this efficient evolution of technology in these facilities validates the general steps developed in the Future Factory Design approach, which were:

- Interview technology experts.
- Interview materials suppliers.
- Interview tool manufacturers.

- Assess potential trends and the timing of their probably development.
- Develop facility concepts to support the most probable trends.

In the space allowed in one paper it is not possible to review all of the specific factors involved in each of the above steps. However, we can address a few examples to demonstrate the type of analysis that can greatly improve the long-term viability of a fab’s production value when applied early in the fab planning process.

Figure 3 is a table of concerns or issues which can be expected to have impact on the industry in the next few years. This sample “risk table” of concerns was developed during extensive discussions with industry sources.

Challenges or Issues	Probability of Change	Impact on Facility
300mm Tool Dimension Increase	High	High
Lithography Tools	High	High
AMHS	High	High
Wet Processing	High	Low

**Figure 3.** “Risk Table” showing examples of key concerns associated with fab planning

There are many other concerns and issues in addition to the above. ITRS is a good resource to assist fab owners in identifying and addressing those issues.

The probability of change and impact that each of these factors represents is calculated based on qualitative judgements that vary in

accordance with the unique circumstances that prevail in each fab situation. Each company needs to apply its analytical energy to determine its own specific priority concerns and issues to bring the greatest credibility to its strategic planning for the future.

The following are brief examples of an analysis process for critical future fab planning issues.

*300mm tool dimensions* – Discussion with tool vendors indicates that tool dimensions will continue to increase significantly. Some 300mm diffusion furnaces, for example, reach heights of approximately 3.5m. Certain 300mm lithography tools have maintenance fixtures requiring height clearance of 4.3m or more.

Considering tool move-in requirements, some 300mm lithography tool components exceed the SEMI standard (E72-0299) for component size. They are more than 3m wide and more than 2.3m long, with weights of more than 8,400kg.

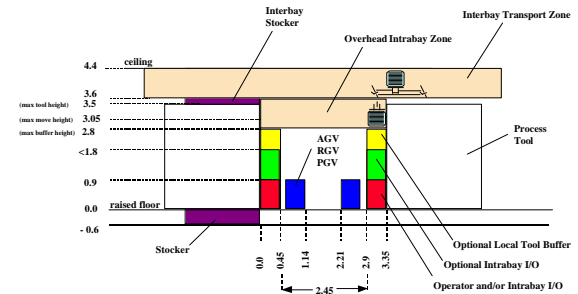
Conclusion: Ceiling heights must rise to 4.4m or higher. Move-in paths must increase to approximately 3.6m in width, and higher floor loading capacities must be applied.

*Lithography tools* – Discussion with industry researchers indicate a migration toward vacuum lithography. The vibration requirements entailed in this change will be accommodated at the tool. Tool throughput

may decrease up to 50 percent, depending on the quality of technology being applied in a given circumstance.

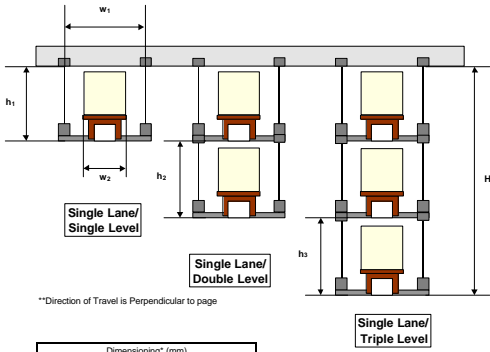
Conclusion: Up to one half of the fab may need to be lithography-capable. No change in fab vibration specifications needs to be made. The subfab must be capable of vacuum pump service.

*Automated Material Handling Systems (AMHS)* – Many alternatives exist for AMHS, including various Automated Guided Vehicle (AGV) and overhead transport (OHT) systems. Figure 4 shows a cross-section of a typical cleanroom bay/work zone capable of accommodating either AGV or OHT.



**Figure 4.** Cross-section of a typical cleanroom bay/work zone accommodating AGV or OHT

Figure 5 shows the height requirements for various AMHS/OHT configurations offered by various vendors. If provisions for all of these options are required, the issues accompanying those provisions must be addressed during fab design.

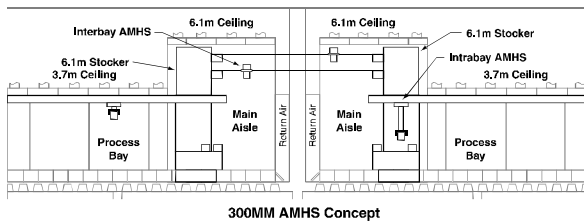


Vendor	Dimensioning* (mm)					
	w1	w2	h1	h2	h3	H
A	609.6		1049	744.22	744.22	2537.5
B	500	390	954	954	CNA	1908
C	500	400	700	700	CNA	1400
D	600	454	1116	1200	1238.4	3554.4
E						0
F	XXXX	XXXX	XXXX	XXXX	XXXX	2000

\*All dimensions have been converted to metric.  
 XXXX = Information not available.  
 CNA = Option Not Available  
 Ormer's 'Sea of Lots'

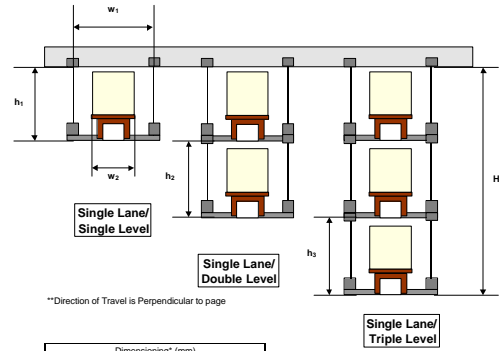
**Figure 5.** Height requirements for AMHS/OHT options

Figure 6 shows one manufacturer's solution to this concern.



**Figure 6.** Example of one manufacturer's 300mm AMHS concept

In collaboration with other manufacturers, we have concluded (and documented) that certain combinations will not be allowed. In these cases, ceiling heights are 4.4m to 4.6m, and only AMHS solutions as shown in Figure 7 are workable.



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	w1	w2	h1	h2	h3	H
A	609.6		1049	744.22		
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F						

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**Figure 7.** Dimensioning of workable AMHS ceiling height configurations

Conclusion: Ceiling heights of 4.4m to 4.6m are acceptable, but certain AMHS solutions must be excluded, or accomplished with high central bays. Bay/work zone widths must be 2.45m.

*Wet processing* -- Wet processing is undergoing changes involving more integration of spray washing and rinse processes. This is a significant change, but it is desirable because of its contribution to the goal of reducing water consumption, which has a significant long-term impact on fab operating costs. There is no significant impact on the fab design.

Conclusion: No response is required.

Given these considerations for a freshly configured facility featuring higher ceilings, larger bays, enlarged tool move-in path provisions, and a larger lithography area, a revised "risk table" would reflect these changes as indicated in Figure 8.

order to achieve the significant advantages that can result in terms of fab productivity and long-term return on investment.

<b>Challenges or Issues</b>	<b>Probability of Change</b>	<b>Impact on Revised Facility</b>
300mm Tool Dimension Increase	High	Low
Lithography Tools	High	Low
AMHS	High	Low
Wet Processing	High	Low

*Figure 8. "Risk Table" reflecting reduced risk resulting from fab reconfigurations*

### **Conclusions**

We are much more comfortable with the ability of our fab to meet future needs with the types of strategic alterations discussed here. IDC estimates that the additional fab development costs necessary to achieve this comfort level, involving the decisions discussed here, is on the order of 2-3 percent.

Of course, many more challenges and issues than those discussed here need to be investigated. IDC has investigated many of these. We estimate that the total cost necessary to achieve a reasonable comfort level for future fabs, when many additional items are included, is approximately 5 percent.

In light of the rapid changes inherent in this industry and the increasing emphasis being placed on flexibility in fabs to accommodate these rapid changes, we believe that the analytical process described here is of critical necessity. We further believe that the added costs for reconfigurations associated with the analytical process are clearly justifiable in