Technological Trends for Future Fabs – Impacts on Ultrapure Media

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Summary

The transition from 200 mm to 300 mm wafers promises a cost reduction of more than 30 % per unit area. However, the overall process cost for a 300 mm wafer can be estimated on a 200 mm basis and is expected to be in the range between 1,400 US $ and 1,800 US $. The price includes personnel, capital and material costs. A capital and material cost splitting will show that it is a tough challenge to meet the cost target. Possible technological trends for Ultra Pure Water, Gases and Chemicals are described..

Transition from 200 mm to 300 mm Wafers

The costs for a 200 mm wafer can be separated in three major groups: the personnel costs (approx. 15 – 25 % for Administration, Facility, Product Engineering, QA/QS, Operator, Process Engineers etc.), capital costs (approx. 40 – 50 % for Equipment, Building and Infrastructure, etc.) and material costs (approx. 30 – 40 % for prime Silicon, testwafers, Auxiliary materials and Utilities) [1)]. Initially the wafer costs are dominated by the capital costs, later on by material costs. (Figure 1).

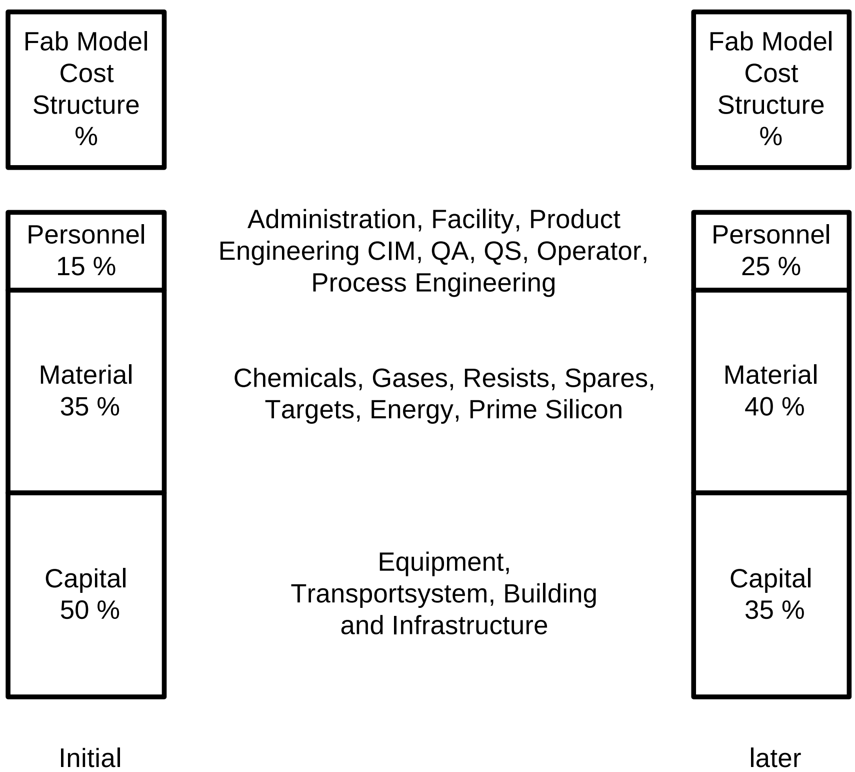

Figure 1: 200 mm Wafer Cost Structure (average market data [1)])

The current 200 mm wafer costs are in the range of about 1,000 US $ for a 0.25 µm or 0.20 µm technology (based on Stock Exchange Reports, published by Samsung and Micron Technology, SEC, NYSE) [2] . Assuming an average cost factor of 1.6 [3), 4), 5)] for 300 mm and transferring the "later phase" cost structure (compare Fig. 1) to 300 mm leads to the conclusion that a 300 mm wafer includes 560 US $ capital costs, 640 US $ material costs and 400 US $ personnel costs (Figure 2).

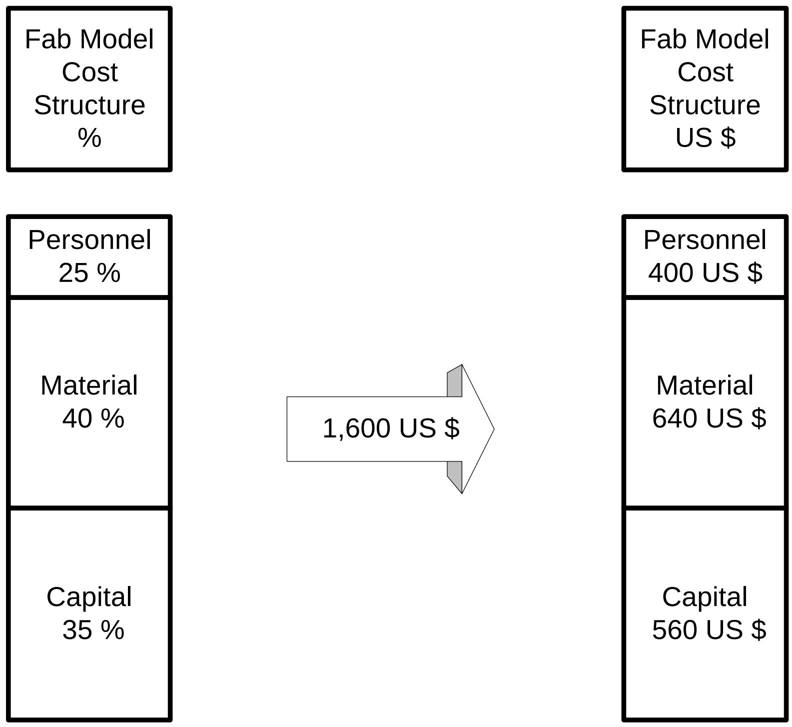

Figure 2: Estimated Cost Structure for a 300 mm Fab

The ratio between capital and material costs may vary and do strongly depend on equipment and prime silicon costs.

To answer the question about technological trends and impacts on ultrapure media it is of interest to split the capital and material costs in more detail (Figure 3 and 4).

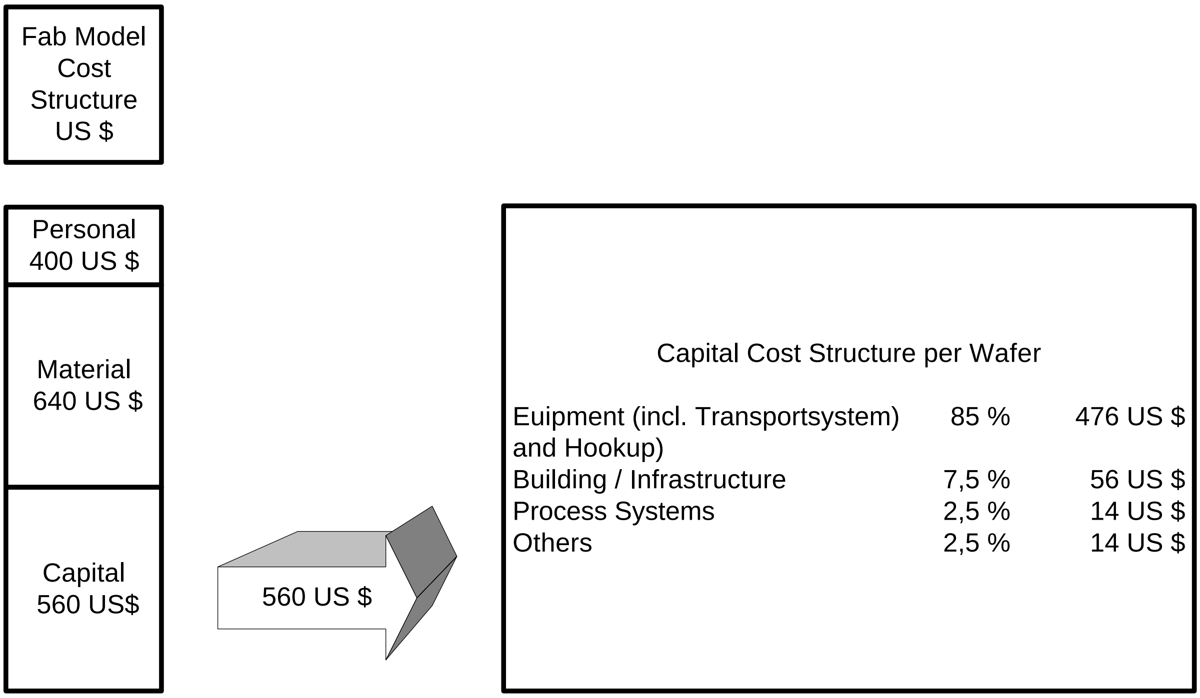

Figure 3: Model 300 mm - Capital Cost Structure [6) 7)]

The comparison between the costs for equipment and for building and infrastructure shows the dominant role of the equipment part [6) 7)] .This is not surprising, because of the high initial tool investment and the shorter depreciation period (5 years instead of 10 years for buildings and facilities).

But it is obvious that the overall budget for the technical infrastructure, which includes facilities for heating and cooling as well as the Ultra Pure Water system or the chemical or gas supply system, is extremely limited.

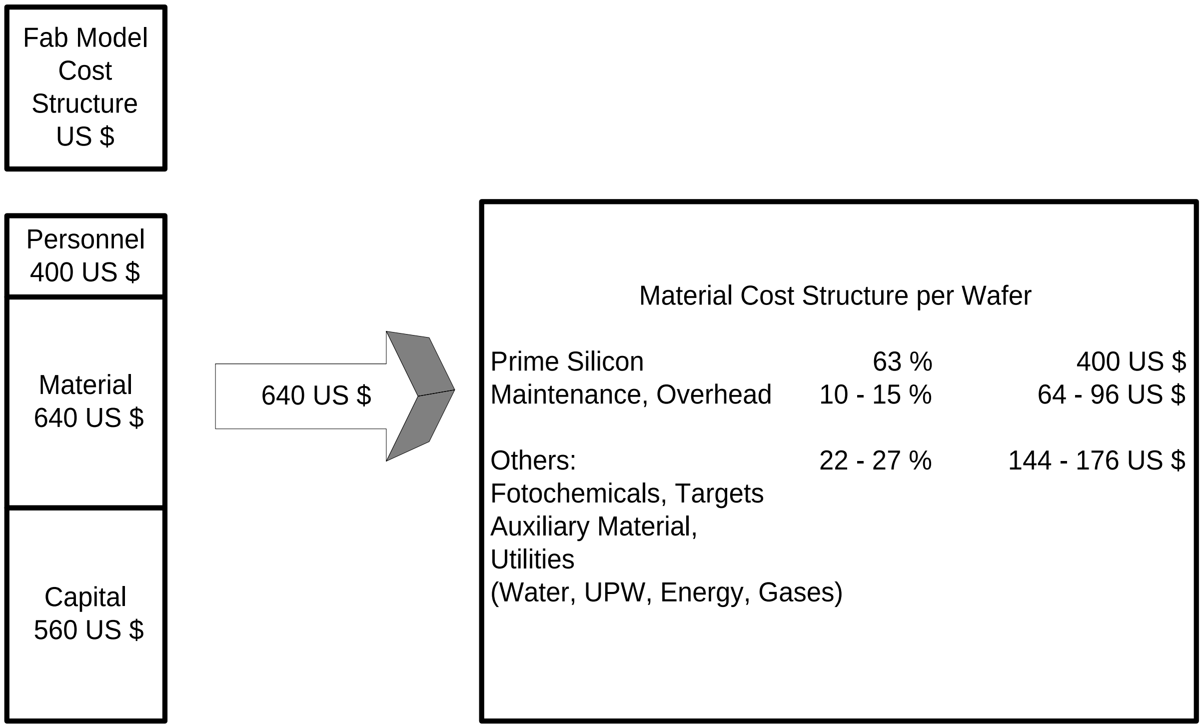

Figure 4: Model 300 mm – Material Cost Structure

The material cost structure strongly depends on the prime silicon costs which are actually extremely high and estimated to be in the range of 400 US $ (non-EPI-wafers) [5) 8)]. Deducting a typical portion of between 10 % and 15% for maintenance and overhead (64 US $ or 96 US $) leads to either 144 US $ or 176 US $ for all other indirect or direct materials. Even when considering a lower price for prime silicon in the future, the cost target for auxiliary materials and utilities is very tight and close to what we would expect in a 200 mm Fab (Table 1).

This result complies with the i300i guideline where the 300 mm process/metrology equipment consumables (production materials and facility utilities) usage per wafer processed per hour must be less than the same ration for similar 200 mm equipment.

		US $ / Wafer	
Auxiliary Material	Bulkgases	11,50	Central Supply Utility Requirements
	Speciality Gases	9,25	Central Supply Local Supply
	Chemicals	31,00	Central Supply Local Supply Utility Requirements
		51,75	
Utilities	Water	12,50	Central Supply Utility Requirements
	Electricity	18,50	Central Supply Utility Requirements
	Exhaust	6,00	Central Supply Utility Requirements
	Others	8,50	e.g. Waste
		55,50	
Total		**107,25**	

Table 1: Auxiliary Material and Utility Costs for a 200-mm wafer (depending on local costs for electrical power, water, waste water etc.)

Capital and Material Cost Optimization

Four major levers can affect capital and material costs: consumption, specification, prices and wafer output, which is not part of this discussion. Each lever will trigger future trends for ultrapure media.

Especially the specifications are a very powerful instrument to reduce capital and material costs. Tight specifications for process materials, system components, installation materials and system startup can add a lot of cost with no additional benefit.

Chemicals and Gases are available in different quality grades with in part significant price differences. Figure 5 shows a price comparison for different speciality gases, which are available as high grade, standard grade or technical grade. The possible savings by downgrading should provoke the question, whether the additional quality is worth the money and whether we add value to the wafer by using higher material qualities. A simple cost structure analysis helps to find cost drivers and is a good instrument to challenge individual tool requirements. Non-added value to the product can be eliminated. At least the procedure helps to get a better understanding about which parameters may hurt the product.

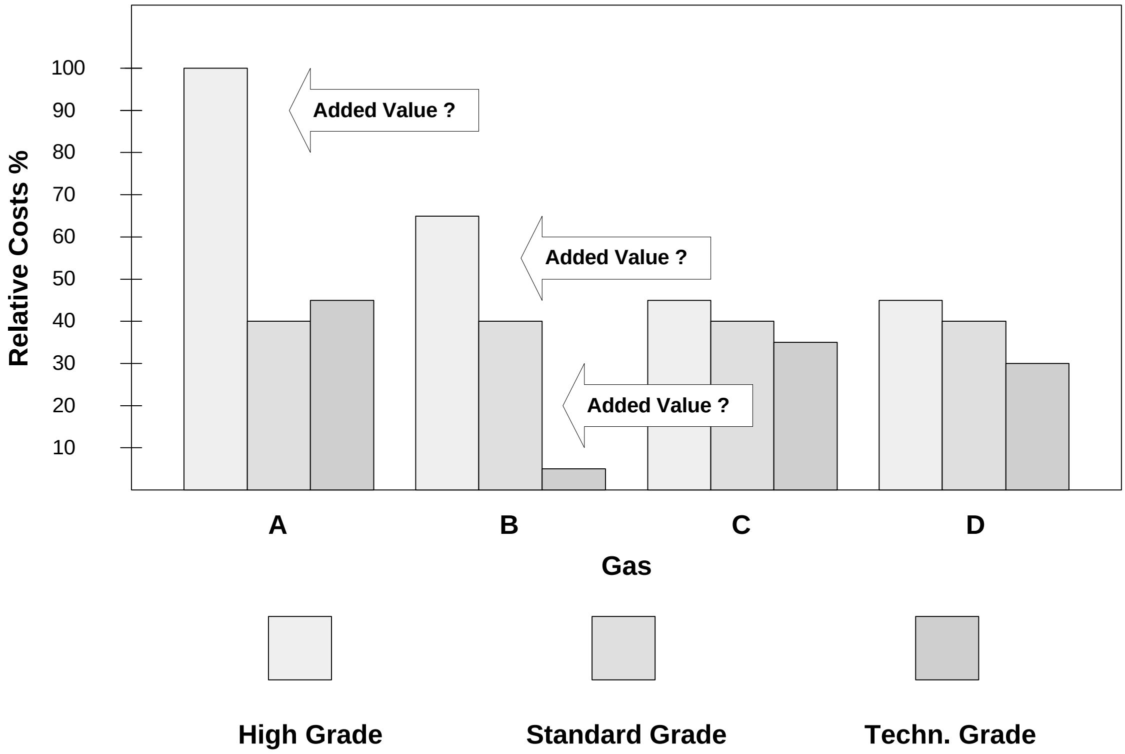

Figure 5: Relative price comparison

An important question for the future will be: “How clean is clean enough?” Of course, this is difficult to answer and there is more to learn about the impacts certain impurities have. But the tremendous pressure on material costs does not permit the use of high-grade materials only for safety reasons.

Tool Optimization

Material consumption optimization starts with the tool design. Therefore a close cooperation between tool supplier and customer is of vital importance. Furthermore a tool mass flow analysis helps to identify cost intensive tools and makes consumption data comparable. Another approach that is well known in other industries is to install recycling capabilities within the tool.

The tool consumption data are also an interesting item for the tool decision matrix during the awarding procedure.

Lower material consumption directly effects the capital costs of all supply systems like Ultra Pure Water, Waste Water Treatment, Gases or Chemical Supply Systems.

Trends for Ultra-Pure Water

Nearly all Ultra Pure Water (UPW) systems are designed to supply one specific water quality. But it is obvious that the process requirements are different (Table 2).

	WQ 1	**WQ 2**	**WQ 3**	**WQ 4**
Particles / Size [µm]	1000/0,05	1000/0,05	5000/0,05	5000/0,1
TOC ppb	< 5	< 5	< 20	< 20
O2 ppb	< 10	< 100	< 100	< 100
SiO2 ppb	< 1	< 1	< 1	< 20
Metals ppt	< 5	< 5	< 5	< 500
Anions ppt	< 20	< 20	< 20	< 500
CMP Polishing				15,2
CMP Ontrak		7,7		
Wet	9,3			
Wet Piranha		27,9		
Wet Semitools			12,2	
Wet SEZ, etc			5,2	
Diffusion CFM	1,8			
Diffusion CFM Nit		0,8		
Etching Wet		0,5		
Polyimide		0,9		
Photo		2,9		
Pre-Assembly				3,0
Quartz Clean			0,8	
Parts Clean				2,9
Plating			0,8	
Labs, Prep Rooms		3,0		
Wafer Inspection			1,4	
Chemical Distribution				3,3
Total (%)	**11,2**	**43,9**	**20,5**	**24,5**

Table 2: Ultra Pure Water Quality Requirements (average figures in %, 200 mm)

It is remarkable, that the highest specification is only needed by roughly 12 % of all users. Approximately 25 % off all applications can accept non-polished water (Water Quality 4, WQ4). The supply of different qualities results in capital savings and reduced space requirements in the expensive subfab (e.g. for the polishing system).

The need for different qualities suggest the installation of user-specific polishing systems with separate UPW tanks. This solution would also reduce the quantity of installed PVDF piping material.

The uncertainty of the total UPW consumption in a future 300 mm fab is very high and it is useful to choose a modular plant design. Advanced treatment units like membrane degasification or electrochemical deionization simplifies this approach. A stronger requirement by certain applications may be adapted with point-of-use purification systems (e.g. membrane degasification for Oxygen).

Water recycling is a well proven process to reduce the material costs. But the economy of a reclaim system needs to be verified and depends on site specific costs for electrical power, raw water and waste water. The reclaim of TOC containing rinse water causes very often problems and the reuse should be evaluated carefully.

The strict separation of worthy reclaim streams directly at the tool is essential for the overall success. All necessary switches for TOC or conductivity should be part of the tool. The separated streams shall be treated individually. An end-of-pipe reclaim systems will never reach a comparable efficiency.

Trends for Chemicals

The use of larger supply containers (IBC, ISO container) can easily reduce the material costs. The chemicals are cheaper, there are less handling activities and analytical checks are reduced.

ISO containers are the most economic solution if the consumption is more or less in the range of 1000 liters per day. If a container is changed only once a month the use of standard IBC containers gets cheaper because of lower rental rates.

A gas to chemical or so-called point-of-use-chemical-generation (POUCG) for NH_4OH is a useful replacement for bulk or standard supply systems. Possible savings compared to a typical supply and distribution system depend on the price for Ammonia gas. Due to the requested process quality the use of a technical grade for Ammonia may be sufficient.

Blending systems especially for high diluted chemicals (e.g TMAH developer) promise huge cost savings and extremely short payback periods. There is no technological reason to refuse this solution and the requested mixing accuracy for developers can be achieved. But negotiations with the chemical supplier are necessary, because they will lose cost benefits.

Trends for Gases

Bulk speciality gas systems (BSGS) have equal advantages as Bulk Chemical systems: the gas is cheaper and less manpower is required for changing gas cylinders.

As for chemicals the chain for material procurement, logistics and disposition should be as simple as possible.

One of the key elements to save capital costs is redundancy. The total number of gas cabinets installed in a Fab varies in a wide range and is obviously more than on flow rates depending on local philosophies and mentalities. A very low number of cabinets is used in Taiwan and often less than 100 cabinets are installed in a typical 5,000 sq.m. fab. The number of cabinets should be based on a risk management decision: What can happen if a cabinet fails?

Other trends like bulk gas mixing skids for N2/H2 mixtures, cryogenic purifiers or point-of-use purification systems instead of bulk purification systems are also of interest. The user has to evaluate the advantages depending on quality and quantity requirements.

Literature

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