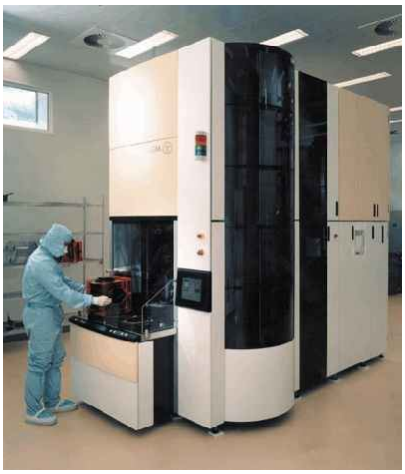
Furnaces

Illustration

- Furnaces for thermal oxidation, but also simply for annealing or for **CDV** processes are complicated and expensive pieces of equipments.
  - While horizontal furnaces dominated the scene for **150 mm** wafers or smaller, with **200 mm** wafers a switch to vertical furnaces took place
  - Below two pictures showing a horizontal and a vertical furncace for **200 mm** or **300 mm** wafer, respectively. Of course, you don't see much; nevertheless, they are big pieces of equipment.

	
Horizontal oxidation furnace; three tubes	ASM A412 300mm twin vertical furnace system for high temperature atmospheric pressure oxidation and LPCVD processing of polysilicon

- Here is a comparison between horizontal and vertical fucnaces, taken straight form the homepage of a major furncae manufactorer.

Comparison Vertical vs. Horizontal Furnaces

Koyo Thermo Systems manufactures numerous versions of vertical furnaces and horizontal furnaces with full automation or manual loading. Smaller versions for pilot and laboratory applications are available.
We are frequently asked for the differences of vertical furnaces and horizontal furnace and for a justification of the higher price of vertical systems. Therefore we worked out the following table sheet. We hope that this overview, this comparison sheet will help you to make a proper planning.
We compare in this sheet a horizontal furnace with a vertical furnace for mass production (VF5300) and with our small vertical furnace VF1000, which is a good alternative to horizontal systems for small companies as well as for research institutes.

Feature	3- or 4-Tube Horizontal Furnace e.g. Model 206	Vertical Furnace for Production e.g. VF5300	Vertical furnace for RD e.g. VF1000

			
Heat up speed	slower	faster	faster
Quartz boat loading time	slower	faster	faster
Cool down speed	equal	equal	equal
Max. temperature using KLL's advanced LGO heaters	1100°C	1250°C	1250°C
Temperature uniformity	lower	higher	higher
Temperature interference between the tubes	1 - 2 °C	none	none
Oxygen concentration tube center (end open)	16%	0,1%	0,1%
Oxygen concentration tube end (end open)	high	500ppm	500ppm
Oxygen concentration tube center (end closed)	0,1%	300ppm	300ppm
Oxygen concentration tube end (end closed)	10 - 30 ppm	10ppm	10ppm
Air tight process chamber (atmospheric process)	no	yes	yes
HCl leak free	no	yes	yes
Cross contamination	possible	not possible	not possible
Process independence	not completely	yes	yes
Particle data	worse	very good	better
Flexibility: Run mixed diameter of wafers in one run	possible	not possible	not possible
Flexibility: Run different diameter of wafers run to run	possible	not possible	possible
Flexibility: Range of wafer diameters that can be processed	3" - 6" (8")	4" - 300mm	3" - 300mm
Stock wafer cassettes	no	yes	no
Automation level	lower	very high	higher
Thickness uniformity wet oxidation 10nm, 8" wafer	no data	± 0.9 %	± 0.9 %
Thickness uniformity dry oxidation 20nm, 8" wafer	± 2.4 %	± 1.2 %	± 1.2 %
Thickness uniformity poly-Silicon 400nm, 8" wafer	± 2.0 %	± 1.0 %	± 1.0 %
Thickness uniformity Nitride100nm, 8" wafer	± 2.5 %	± 1.5 %	± 1.5 %
Capacity	150 wafer	100 - 150 wafer	25 wafers
Power consumption	high	lower	very low

Maintenance independence	no	yes	yes
Maintenance work, necessary	higher	lower	very low
Footprint / tube	2.6 - 3.4 m^2 (partially cleanroom)	3.0 m^2 (grey room)	1.5 m^2 (grey room)
Price	low	high	low

Nowadays, mass production of semiconductor chips happens with silicon wafers with 200mm or 300mm diameter. Vertical furnaces are used almost exclusively. Only in older factories, which still use smaller wafer diameters, horizontal furnaces are still common. For wafer diameters until 150 mm the performance of such systems is in many cases still good enough to fulfil the customer requests. However, the advantages of vertical systems are already evident for this wafer size.
The result of this situation on the oven market was, that almost all large furnace manufacturers stopped the further development of horizontal furnaces. Development work is done today almost only for vertical systems. Therefore vertical furnaces are superior to horizontal ones not only for physical reasons, but also because they are the more modern production tool. Their performance is much higher.
A main issue is furnace automation. Automation for horizontal furnaces means mainly the installation of an elevator system for the loading of the boat on the cantilever arm. The loading area is open to the clean room. Vertical furnaces however are closed system with clean room class 1 inside. The loading happens fully automatically from the cassette by advanced robot systems.
Other technical advantages of the vertical furnaces are the better gas tight sealing of the furnace tube, as well as several options, availabe only on vertical furnaces like improved temperature uniformity by boat rotation or nitrogen load lock chamber.