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Invited

ϕ400mm Large Diameter Wafer -Very High Flatness Polishing in the Nano-Technology Domain

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ϕ 3 0 0 mm wafer are expected to be manufactured on a large scale in a couple of years. To realize the more advanced information society around 2005 to 2010, developing larger-diameter silicon wafers is essential to the industry. Super Silicon Crystal Research Institute Corp. (abbreviated as SSi, founded on March, 1996) concentrates on the establishment of the elemental technologies which will serve as the production platform of super large-diameter silicon wafers. To achieve goals, breakthroughs are required in various field of technology; especially, the MCZ crystal growth technology together with smarter crystal suspending system, the reconstructing wafer shaping technology scientifically, and the low temperature, Cl^- gas compound free, epitaxial growth technology. Meanwhile, as a silicon wafer diameter is becoming large, super flatness is also getting required. The ultra precision grinding based on the principle of motion copying will be suitable as the solution for realizing super flatness.

1. Comparative analysis of wafer shaping methods:

Development targets must meet the severe conditions expected for further advanced devices such as 4G DRAM and greater. For example, flatness of 0.13 μm or less is expected to be achieved. This is a very difficult feat (See Table 1).

Table 2 shows a comparative analysis of shaping methods for super large-diameter wafers according to technical level. Most of the new promising shaping technologies have not emerged from the basic research stage yet. Further improvement is hoped for in Technical Level "C"(Surface Grinding and PACE Technologies) form a practical point of view.

Function	Technology	Drawbacks	Technical Level
Flatness polishing	Lapping	Subsurface damage needs to be decreased. Strict management of plates flatness required.	D
	Surface Grinding	Rigidity and work feed accuracy of the machine need to be improved .	C
	Elid Grinding (Electrolytic In-process Dressing)	Electrolytic properties of bonding material and insulating film characteristics affect grinding conditions.	D
	DMG (Ductile Mode Grinding)	Further study is needed to achieve 0.1μm TTV and less than 0.5μm subsurface damage.	A
	Diamond Fly Cutting	Feasibility of practical application is small due to the cutting edge wear.	A
Mirror polishing	Conventional MCP (Mechanical Chemical Polishing)	Principle of pressure copying hinders high flatness.	D
Local flatness polishing	PACE (Plasma Assisted Chemical Etching)	Low throughput. Shallow sub-surface damage remains.	C
	CCP (Computer Controlled Polishing)	Originally developed for lens polishing. Effectiveness for silicon wafers remains unverified.	A
New shaping methods	Plasma CVM (Chemical Vaporization Machining)	Low throughput. Shallow sub-surface damage remains.	A
	EEM (ElasticEmission Machining)	Effectiveness for large diameter silicon wafers unverified. Feasibility study is under way.	A
	Float Polishing	Polishing rate is too low.	A
	Ion-Beam Processing	Effectiveness for silicon wafers remains unverified.	A

Technical level	A : Basic research	B : Application research	C : Production technology development	D : Mass production

Table 2 Comparative analysis of wafer shaping methods.

	Targets	Present
Wafer diameter, (mm)	400	200
Crystal weight, (Kg)	400	100
Flatness, (μ m)	≦0.13	≦0.35
Particle size, (μ m)	≦0.04	≦0.12
Metal impurity, (atoms/cm^2)	≦10^8	≦10^{10}
Epi layer thickness, (μ m)	2 - 3	2 - 5
Epi layer uniformity, (±%)	≦3	≦4

Table 1.

Research and Development Targets

2. The limitation of Mechano-Chemical Polishing :

Plotting the change of technology in any kinds of industry, it will be given as S-shaped curve. When it approaches the saturated area, it will be difficult to get the profitable results, even if a great deal of money is put in it. Wafer shaping technology is approaching to the turning point, too. (See Fig. 1) Attaining the flatness target of 0.13 μ m is not viable by using the conventional mechano-chemical polishing method. Specifically, the pressure copying method is not capable of achieving the requisite flatness, which is extremely high.

However, attaining 0.13 μ m is feasible if a grinding machine possessing motion accuracy of nanometer order and an etching less process are developed. The current shaping technologies are regarded as precursor to ductile-made grinding technology (Technical Level "A" in Table 2) has a great promise as a leading future Technology.

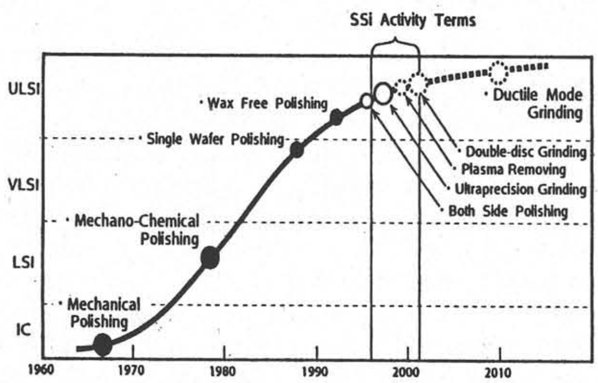


Fig. 1

The History of Wafer Shaping Technology for producing Flatness required from Device Manufacturer

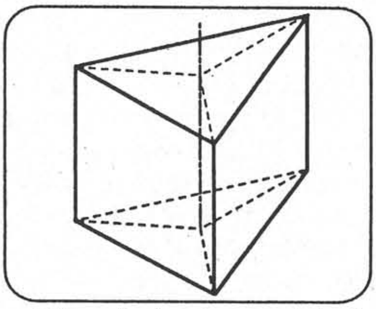
3. Development of an Ultra precision Grinding Machine:

The ultra precision grinding based on the principle of motion copying is suitable as the solution for realizing high flatness and etching-less process. The following new-design concepts are introduced into it.(See Fig.2)

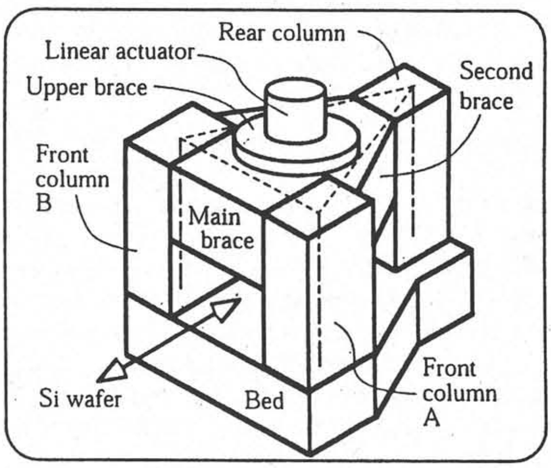
① The trigonal prism structure in three columns.

② The vertical double-V guide way system for guaranteeing 10nm feeding accuracy.

③ The deionized-water hydrostatic bearing system for realizing the extremely high damping performance. The loop stiffness with over 300 N／μ m will be expected. Not only the high flatness and but also the shallower subsurface damage will be obtained at the grinding process.



Trigonal prism type pentahedron consisted of an equilateral triangle



Machine image

Fig. 2 Basic concept of the trigonal prism type pentahedral structure consisted of 3 columns

4. Conclusions:

Vendors' and other organizations' support (including academy) are one of our SSi's essential conditions for ϕ 400mm collaborative development. This ultra precision Grinding Machine based on the above advanced technologies was designed and assembled in cooperation with several organizations. The machine is near its completion. The designed performance will be confirmed around latter half of this year.