Table 1

History of wafer grinders at Disco Corporation [44]

| Year | Model | Application | Grinding type | Wafer size (mm) |
|---|---|---|---|---|
| 1981 | DFG-83H/6 | Back grinding | Creep-feed | 150 |
| 1988 | DFG-82IF/8 | Back grinding | In-feed | 200 |
| 1994 | DFG840 | Back grinding | In-feed | 200 |
| 1995 | DFG830 (DFG840HS) | Flattening | In-feed | 200 |
| 1997 | DFG870 | Flattening | In-feed | 300 |
| 1998 | DFG850 | Back grinding | In-feed | 200 |
| 1998 | DFG860 | Back grinding | In-feed | 300 |
| 2001 | DFG8540 | Back grinding | In-feed | 200 |
| 2002 | DFG8560 | Back grinding | In-feed | 300 |
| 2004 | DGP8760 | Back grinding; polishing | In-feed | 300 |
| 2005 | DFG8360 | Flattening | In-feed | 300 |

Table 2

Progression of silicon wafer size (after [53])

| Wafer size (mm) | Year |
|---|---|
| 12.5 | 1960 |
| 25 | 1964 |
| 75 | 1973 |
| 100 | 1975 |
| 125 | 1979 |
| 150 | 1981 |
| 200 | 1985 |
| 300 | 1991 |

Table 3

Typical TTV specifications for silicon wafers of various sizes

| Wafer size (mm) | TTV (μm) | Reference |
|---|---|---|
| 75 | 25 | [58] |
| 100 | 10 | [59] |
| 125 | 10 | [60] |
| 150 | 10 | [61] |
| 200 | 10 | [62] |
| 300 | 3 | [63] |

Table 4

Impacts of wafer size progression on the role of grinding in flattening of silicon wafers

| Wafer size (mm) | Flattening process | Note |
|---|---|---|
| < 200 | Lapping | |
| 200 | Lapping → Single-side grinding (→ Lapping) | Changing from single-side grinding back to lapping was due to the replacement of ID sawing by wire sawing. (See Section 4.) |
| 300 | Simultaneous double-side grinding | |

Table 5

Effects of slicing on the role of grinding in flattening of 200 mm silicon wafers

| Slicing method | Flattening process | Note |
|---|---|---|
| ID sawing | Lapping | When 200 mm wafers were first manufactured, ID sawing was used to slice ingots into wafers and lapping was used to flatten sliced wafers. |
| ID sawing | Grinding | Due to its significant improvement, in-feed wafer grinding became more cost effective than lapping for flattening and successfully replaced lapping in some cases. |
| Wire sawing | Lapping | In-feed wafer grinding (single-side grinding) could not remove wire-sawing induced waviness, and hence was replaced by lapping to flatten wire-sawn wafers. |

Table 6

Evolution of process flows for manufacturing of silicon wafers

| Year | Process flow |
|---|---|
| < 1990 | ID sawing → Lapping → Etching → Polishing |
| 1990 | ID sawing / grinding → Grinding (SSG) → Etching → Polishing |
| 1995 | Wire sawing → Lapping → Etching → Polishing |
| | or |
| | Wire sawing → Lapping → Etching → Fine grinding → Polishing |
| 2000 | Wire sawing → SDSG → Etching → Polishing |
| | or |
| | Wire sawing → Lapping → Etching → Polishing |

Table 7

Comparison of major machining processes in silicon wafer manufacturing

| Process | Machine | Machine cost ($k) | Typical abrasive | Throughput (wafer/hour) | Flatness | Roughness | Depth of damage (μm) |
|---|---|---|---|---|---|---|---|
| Slicing | Wire saw | 600-800 | Silicon carbide, free abrasive | High | Poor | Poor | 5-15 |
| Slicing | ID saw | 200-400 | Diamond, fixed abrasive | Low | Poor | Poor | 5-15 |
| Lapping | Lapper | 700-900 | Alumina, free abrasive | High | Good | Good | 2-5 |
| Grinding | Grinder | 600-800 | Diamond, fixed abrasive | High | Good | Good | 2-5 |
| Etching | Etcher | 200-1,200 | None | Very high | Poor/good | Poor/good | None |
| Polishing | Polisher | 1,000-3,000 | Silica, free abrasive | Low/high | Very good | Very good | None |