Semiconductor Back-Grinding

The silicon wafer on which the active elements are created is a thin circular disc, typically 150mm or 200mm in diameter. During diffusion and similar processes, the wafer may become bowed, but wafers for assembly are normally stress relieved and can be regarded as flat. Frequently there will be a departure from roundness, with a flat or notch indicating crystal orientation.

The grinding process

A typical wafer supplied from the 'wafer fab' is 600–750µm thick. This thickness is determined by the stresses during processing, and the requirements for handling robustness. However, for most IC assembly uses the wafer thickness is reduced to around 50% of this, partly for mechanical reasons, but also to improve thermal transfer. Dice for other applications are frequently thinner:

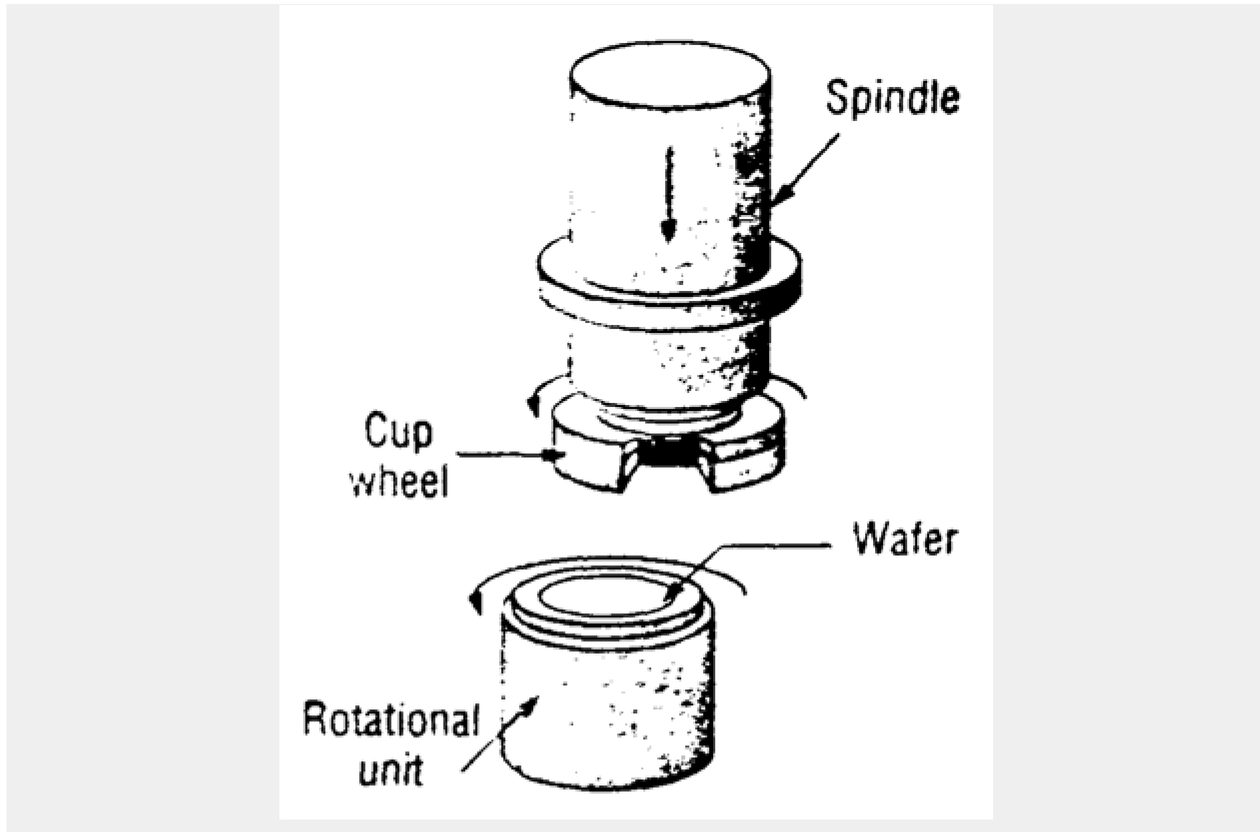
- Integrated circuits for Smart cards are normally 180µm thick, to meet an overall thickness requirement and optimise mechanical strength.
- Small signal transistors are ground to around 150µm, because the die area may be as small as 350µm square.

In the past, the slice would be waxed onto a support, and its reverse lapped. Current practice is to use vacuum or an adhesive tape to secure the wafer to the chuck, and reduce the thickness by grinding.

As illustrated in Figure 1, a standard back grinder has a rotating work chuck, across the centre of which a rotating diamond cup wheel sweeps.

Downward movement of the spindle carrying the cup wheel removes material from the surface of the wafer, creating a flat surface.

Figure 1: Schematic of a rotational grinder



Obtaining uniformity of wafer thickness has become increasingly important. However, it is difficult to measure this in situ, so post-grinding measurements are made using a non-contact capacitative probe. The parameter normally assessed is Total Thickness Variation (as defined in ASTM Standard F533), where a typical target value is <1µm. Whilst the vertical displacement of the spindle is the main determinant of the thickness, fine control of the thickness distribution can be exercised by making very small angular adjustments to the spindle (in the range of 0.0001°).

In a practical machine, water is used to cool the wafer, and the thickness reduction is accomplished in two or three passes. Often the chuck will be

designed to traverse between two wheels, one with coarse and one with fine grit.

Reducing stresses and flaws

Stresses applied during encapsulation may crack the die and cause other stress-related failures. Optimised wafer strength is needed to ensure reliability during both fabrication and packaging. However, grinding anything inevitably leaves flaws on its surface, which can weaken both the wafer and the individual dice sawn from it. Given thermal or mechanical stress, these flaws may then spread into active regions, and may crack the die. Experiments have shown that there are significant differences in the degree of damage between normal grinding practice and an optimised process.

Grinding is a complex process, and Figure 2 illustrates the parameters for a three-pass grinding operation. Lewis ground wafers to constant thickness under different conditions and then, using a three-point bend test mechanism, measured the break strength of dice from different locations on the wafer. His findings were consistent with the theory that, since silicon behaves much like glass, grinding scratches act as cleaving lines for the chip to break along.

Figure 2: The parameters for a wafer-grinding operation

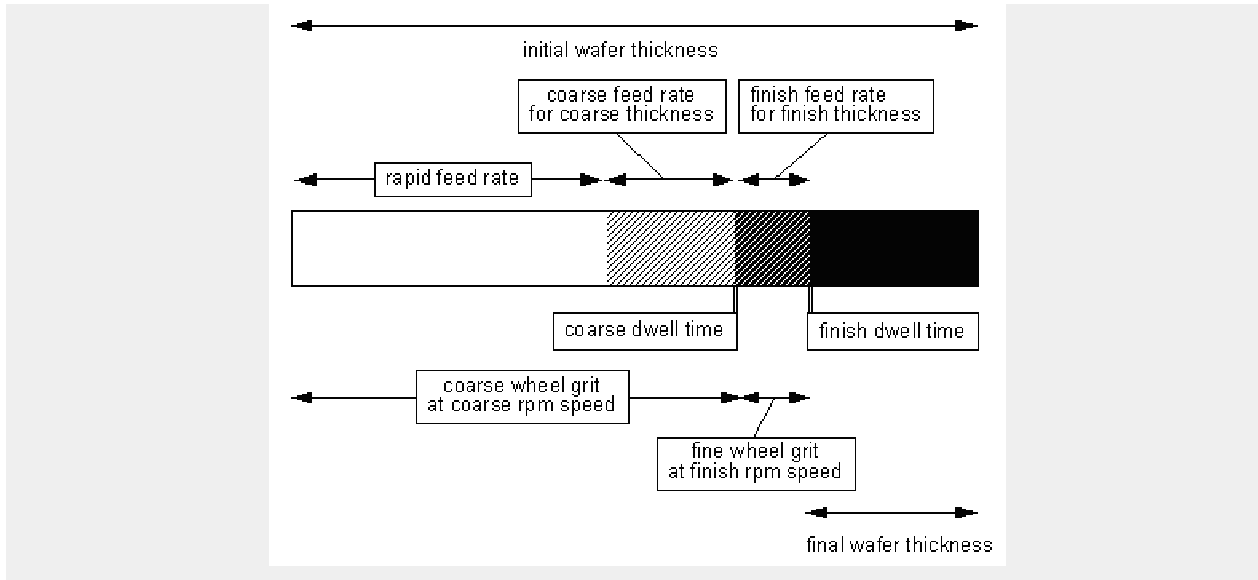


Table 1 summarises the effects that changes in parameters had on the wafer break strength. In general, wafer strength benefited from using fine wheel grits, increased wheel and chuck speeds, and reduced feed rates, even for the first two passes. However, changing grinder settings such as coarse feed rate can have a major impact on machine throughput. A compromise is therefore necessary between throughput and die strength, but Lewis found that a 45% die strength increase could be achieved without putting machine performance outside acceptable limits.

Table 1: Effect of grinding parameters on wafer break strength

The most significant factors are listed first in each column

factors decreasing break strength	factors increasing break strength
increasing coarse thickness	decreasing finish wheel grit
increasing finish feed rate	increasing coarse wheel grit
increasing rapid feed rate	increasing finish wheel rpm
increasing coarse feed rate	increasing work chuck rpm

	increasing finish thickness

Even after careful grinding, there will still be some damage to the wafer. This can be divided into two layers: the top layer, typically 5–7µm thick, is full of micro-cracks, which cause warpage and stress in the wafer; the second layer, 50–70µm thick, contains crystal dislocations, which cause degradation of some electrical properties.

At least the top layer is usually removed by etching away perhaps 10–20µm of material, leaving a smooth but not polished finish, a process often referred to as 'SEZ-etch' after the equipment used.

If possible. probe testing is carried out after the back grinding operation. This ensures that parts damaged by the process are not transferred to bonding.

Source : http://www.ami.ac.uk/courses/topics/0265_sbg/index.html