inseto	**WHAT IS A WAFER BONDER**	
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- SCOPE: This document overviews the wafer bonder and its use in semiconductor device fabrication.

What is a wafer bonder?

SUSS Microtec 200 mm Wafer Bonder

A wafer bonder is a precision machine tool used in the fabrication of micro-electrical mechanical systems (MEMS) and other similar technologies. A wafer bonder is used to package together two or more substrates on the wafer-level.

Wafer bonders are used on both R&D and industrial scales when the mechanically stable joining, or bonding, together of two substrates is required. This bonding process can either be temporary or permanent, and a number of methods and technologies have been developed depending on the substrates involved and the applications required. For more information on the commonly used bonding methods, see Inseto's knowledge base document Wafer bonding methods.

A wafer bonder works by controllably bringing together the desired substrates and applying some combination of force/pressure, heat or current as required by the bonding method. In some cases, a wafer bonder is required to keep high levels of alignment between the two substrates that are being bonded. As such, the wafer bonder is a complex system requiring high levels of precision and control.

The wafer bonder is required to control the surrounding conditions of the bonding environment to ensure the highest quality of bond can be achieved. The critical environmental factors to control are:

- Bond Temperature
- Ambient Pressure
- Applied Force

To ensure the tightest control over all of these factors, the leading wafer bonders utilise a dedicated bond chamber within which the bonding process takes place.

Bond Chamber
The bond chamber is a sealed region within the wafer bonder that can be evacuated to the user specified pressure and heated or cooled to the required bond temperature. A high quality bonder will exhibit high temperature uniformity and repeatability and precise control over the pressure within the chamber.

The sealed bond chamber, sometimes referred to as the process chamber, should be contamination free to further enhance the quality of the bond interface. The design of the bond chamber is specific to the manufacturer but all good wafer bonders are designed such that the chamber is minimally exposed to the surrounding external environment. This is controlled by the wafer or substrate loading mechanism.

Loading Mechanism
The loading mechanism is responsible for the transfer of the substrates into the bond chamber. As such, the design of this transport fixture is crucial to maintaining the cleanliness of the chamber and thus the quality of the final bond. A loading mechanism, which reduces the opening of the chamber and minimises the number of parts inserted in the chamber, will keep the introduction of contaminants to a minimum.

A further requirement of the loading mechanism is that if the wafers are aligned relative to one another, the precision of this alignment is not lost in the transport into the chamber or in the bonding process. This brings us to the third component required for a quality wafer bonding solution, the alignment of the wafers.

Alignment

The alignment of the two wafers to one another and how this alignment is maintained is crucial to many sectors where wafer bonding is required such as MEMs. There are several methods employed to align the wafers, in some systems the alignment is carried out in-situ (within the wafer bonder), in others, the alignment is carried out in a complementary tool, such as a mask aligner or bond aligner. If processed in a mask aligner, the now aligned wafers, commonly referred to as a stack, must be transferred to the wafer bonder by some form of fixture or carrier that preserves this alignment.

Both approaches, either within the wafer bonder or in an external aligner, have their advantages and disadvantages. However aligning outside the wafer bonder can allow facilities to make use of previous capital investment whilst also reducing the complexity required of the wafer bonder. Furthermore, this separation of alignment and bonding can also lead to an increased efficiency of operator time. As the alignment step is usually a much shorter process than the bond but requires more input from the operator, a number of wafer stacks could be aligned at one time and then all transferred to the bonder. The wafer bonder will then process without any further input from the operator freeing them to complete other tasks.

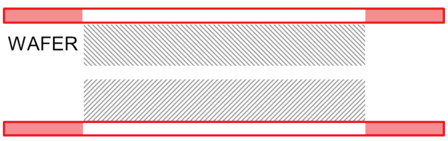
Bond Plates

The final component to be discussed when considering what constitutes a high quality wafer bonder are the plates that transfer the force to the wafers as they are bonded. In some systems these plates can be referred to as wafer chucks. The plates are located within the bond chamber and are crucial to ensuring a uniform bond across the whole wafer.

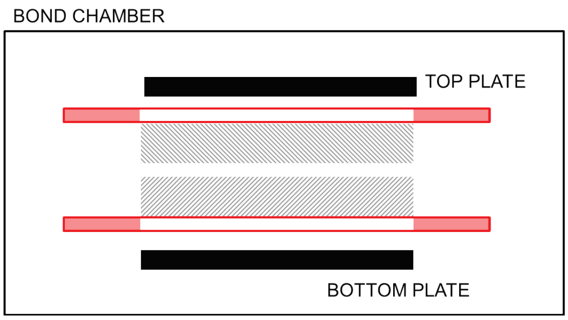
As shown in the diagram below, the bond plates both transfer the force to the wafers but are commonly used to heat the bonded stack, if heat is required for the bond method used. A highly repeatable application of force to initiate the bond across the whole area to be bonded is necessary for all applications. The plates must have high levels of planarity and flatness and depending on the design of the bonder, the force can be applied either through the top, bottom or via both sets of plates.

1) Prepare empty transport fixture and bonder

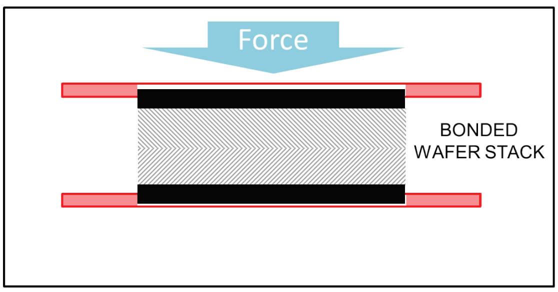
2) Load first wafer to be bonded



3) Load second wafer and align if required



4) Load transport fixture and wafers into bond chamber



5) Apply force to bring wafers into contact & bond