



Patent # 6187134
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Reusable Wafer Support for Semiconductor Processing

1a. GENERAL PURPOSE

This invention provides a reusable support for physically transporting wafers in semiconductor processing equipment. The invention will be referred to below as a wafer support. The wafer that sits on the wafer support and is being processed in the machine will be referred to below as the process wafer.

1b. TECHNICAL DESCRIPTION

This wafer support is a rigid disk which supports a process wafer. Its design and material is compatible with the wafer clamping mechanisms found in most etching tools. It consistently aligns the wafer to the chuck and has the option for providing direct backside cooling. A schematic drawing of the device is given in figure 1.

The wafer support can be made of any material compatible with the processing equipment. If the equipment generates a plasma, for example, the material should not react or sputter in the presence of the plasma, as this would contaminate the chamber and degrade the wafer support. The material should also be stiff enough to withstand the pressure of the wafer clamp and robotic transfer mechanism.

The fabrication material also depends on the type of wafer clamp the processing equipment uses. Wafer clamps can be divided into two categories; mechanical and electrostatic. In mechanical clamps fingers contact the edge of the wafer and apply pressure to keep the process wafer fixed against the wafer chuck. In electrostatic clamps, a charge is induced in the process wafer and electrostatically held to the chuck. Thus the wafer support needs to be made of an electrically conductive material (such as a metal) when used for electrostatic clamps. Wafer supports for use in mechanical clamps do not have this requirement.

The wafer support has a physical border which aids in alignment of the process wafer. Processing repeatability depends on the ability to place the wafer flat in the same place for each new process wafer. For example, the wafer support can have mechanical pins extending above the process wafer or a ridge. This border needs to be physically compatible with the clamping mechanism.

The wafer support also provides for process wafer cooling if necessary. In some processing equipment it is important to cool the process wafer from the bottom side, which is in contact with the chuck. For efficient cooling, the process wafer should be in direct contact with the coolant. In the case of gas pressure cooling, a hole in the wafer support permits direct contact between the process wafer and the coolant gas. To prevent this backside coolant gas from leaking through the support wafer, around the process wafer, and into the process chamber, a vacuum seal is maintained around the bottom edge of the process wafer. An o-ring compatible with the process environment placed underneath the wafer can be used to create this seal.

1c. ADVANTAGES/IMPROVEMENTS

The wafer support helps eliminates many problems associated with very deep to through-wafer etching. It also provides greater process flexibility because of the fewer restrictions on the condition of the backside surface of the process wafer.

Challenges of through-wafer etching

There are numerous problems associated with very deep to through-wafer etching. Very deep to through-wafer etching refers to processes which etch holes all the way through, or nearly through, a process wafer. Holes reaching through to the backside of the wafer expose the chuck and possibly the backside coolant to the process environment. This can cause damage to the chuck and contaminate the process chamber. To prevent this, thin film layers which stop the etch and protect the chuck are placed on the bottom side of the process wafer. Thus, to protect the chuck and process chamber, the etch needs to be carefully monitored such that it does not punch through this stop layer. The thickness and fabrication requirements for this thin film can place severe design restrictions for process wafers.

Very deep to through-wafer holes also make it more difficult to unload process wafers. Typically pins rise out of the chuck beneath the wafer, to lift the wafer up so that a spatula can reach underneath the process wafer to take it out of the process chamber. During this motion the mechanical integrity of the wafer needs to be such that the pins can smoothly lift the wafer. This can severely limit design of the holes and places surface requirements on the back surface of the process wafer. For example, holes need to be out of the path of the pins and large holes are dangerous because of weak structural integrity. Similarly, the backside surface of the wafer needs to be such that the process wafer will not stick to the chuck and interfere with the pin lifting action of the unload. This places severe design requirements on the permissible materials used on the backside of the wafer. For example, photoresist, a common semiconductor processing film, can not be used on the backside of the wafer because it can easily overheat and stick to the chuck.

The precarious and restrictive backing wafer solution

A common solution to the above problems is the backing wafer. A backing wafer refers to another process wafer which has been adhered underneath the original process wafer. Photoresist is commonly used to adhere the two wafers. This wafer is typically used only for the very deep/through wafer etch, and is removed after completion of the etch. The physical bulk of the backing wafer protects the chuck in case of possible puncture through the stop layer. Also, because the backing wafer is not part of the original process wafer device, it is not a design restriction to have to keep its underside smooth and clean. As described above, a sticky or bumpy process wafer could have load/unload problems.

This backing wafer solution is precarious and severely restricts process flexibility. When photoresist is used to adhere the process wafer to the backing wafer, physical pressure typically needs to be applied between the two wafers to aid adhesion. This is a very unusual semiconductor wafer processing step which involves physically touching the top surface of the process wafer. Contamination and disruption of the thin film patterns on the top of the process wafer are critical concerns which this adhesion process. Once the wafers are attached, they are often baked to harden the adhesion layer of resist. This extra heat step complicates processing for the thin films of the processing wafer. Once the wafer is ready to be inserted in the semiconductor processing equipment, other problems can arise. Delamination of the process wafer from the support wafer can occur because of heating during the long etch and/or poor initial adhesion. Such problems are often catastrophic, leading to broken process wafers and costly equipment maintenance.

Advantages of the reusable support wafer

In light of the backing wafer solution problems, the advantages of the reusable support wafer are significant.

The support wafer permits increased flexibility of the backside surface of the process wafer. For example, rough and sticky backside layers are now able to be used without the loading, clamping, and unloading problems associated with backing wafers. The fabrication plan for process wafers, in certain cases, is greatly simplified.

The support wafer permits increased flexibility in the physical design and construction of process wafers for very deep etching. The physical integrity of the wafer is less of a concern because the support wafer protects the equipment chamber and its chuck from damage due to wafer chips (pieces of a process wafer which become freed during processing.) The possibility of leaving residue on the wafer chuck is greatly reduced, reducing maintenance and chance of declamping for the next process wafer.

1d. Possible Variations and Modifications

Model A.

This model is designed for use in mechanical clamps. It consists of a disk with four locating pins, a topside o-ring groove, a cooling hole, and a ring (guided by alignment pins) above the process wafer. The topside ring is not required if protecting the outer radius of the process wafer from the etch process is not required. The fingers of the processing equipment's mechanical clamp hold the process wafer firmly against the support wafer. This ensures that coolant gas from below the process wafer does not leak into the process chamber.

Model B

This is the simplest model. Like model A, it is designed for mechanical clamps. It is essentially Model A without the o-ring and and/or without the cooling hole.

Model C

This model is designed for use with electrostatic clamps. Because there is no mechanical clamp, a method of physically holding the process wafer firmly against the support wafer is needed. Model C is similar to Model A, with one modification; the edge support ring is secured to the wafer support with adjustable connections. Screws or spring clips attached on the edge of the wafer support are possible ways to secure the process wafer.

All models have a backside relief cut to aid in aligning the wafer support to the loading mechanism of the tool.

1e. Features Believed to be New

We believe the following features are new:

A reusable wafer support can be used to process wafers for semiconductor processing.

The reusable wafer support can have direct cooling gas contact.

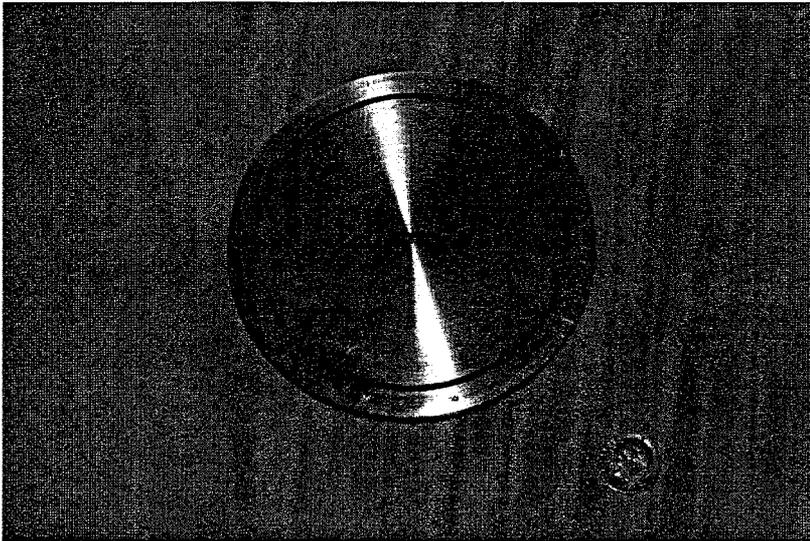
The process wafer can be secured with a ring so that the wafer support can be used in electrostatic, as well as mechanical, clamps.

1f. Close or Related Patents

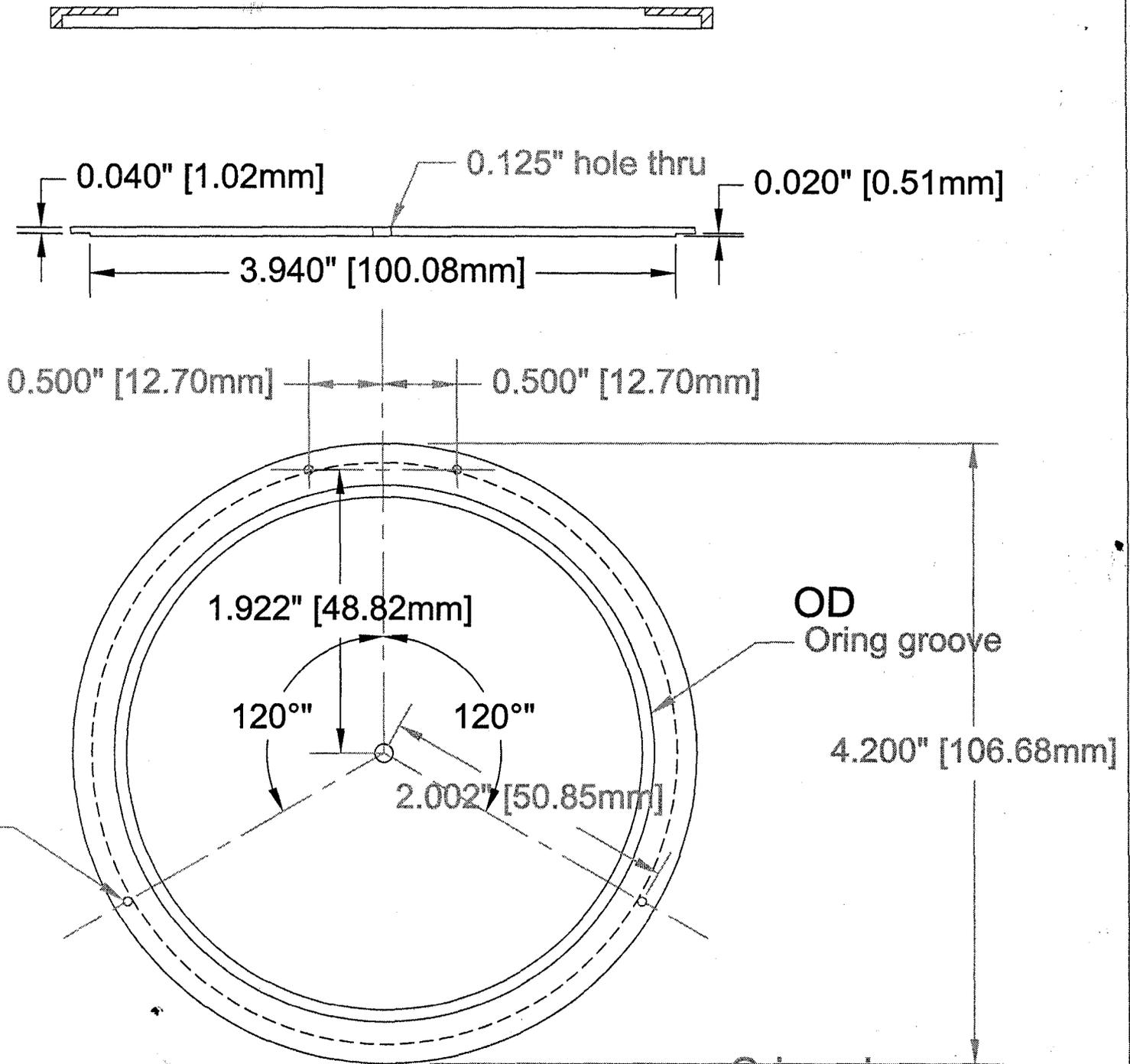
A related patent is #5703493 describing a wafer support for use in device testing (not wafer processing.)

7a. Conception

By May 1998 or earlier the idea was conceived. The inventors were trying to create a way to etch through wafers without having to use a bonded support wafer. The first reduction to practice (of model A), pictured below, was performed in August 1998.



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