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WAFER EDGE GRINDING PROCESS (Wafer Edge Profiling) Application Note

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This application note discusses the Edge Grinding of hard, brittle materials that are common to semiconductor, MEMS, LEDs, and other applications. Edge grinding, also known as Edge Profiling, is a process that is common to the manufacture of nearly all semiconductor related wafers and wafers that are used in the manufacture of many other electronic, solar, and nanotechnology devices.

After the boule is grown to diameter and length, it is rounded, and then sliced into substrates that will become wafers. These substrates are ground to specific dimensions and polished to a specular finish. SEMI Industry Standards are quite specific in stating the tolerance allowed for wafer edge profiles.

Explanation Of The Process

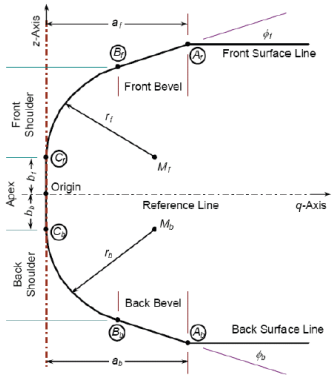
The edge grinding step is critical to the safety of the wafer edge. Silicon in this crystalline state is very brittle and if the edge is not profiled or rounded off, it will flake during handling and certainly during follow-on processing steps both mechanical in nature and thermally dynamic in nature. Edge flaking is not only catastrophic for the individual wafer, it can be a disaster for other wafers that are being processed if the edge flake contaminates the processing equipment or nearby wafers.

Silicon Wafers and Substrates

Classical "Bullet Nose" shape common to most semiconductor silicon wafer applications. (Drawing not to scale).

While other shapes may be used to protect the wafer edge from chipping, what has become generally known as the "bullet nose" shape and variations of this shape are the most common for monocrystalline silicon wafers of all sizes in the semiconductor industry. This shape is common also for polycrystalline applications such as those made in PV (solar) related device manufacturing. The shape of the "nose" may be blunter if the wafers are to be processed farther down the line using the CMP process, or they may be more aerodynamic if the wafers are not going to go through a CMP process. This is because a blunter shape will help hold the wafers more securely within the template seat or the retaining ring of the wafer carrier during the CMP process.

The positive bullet shape that is ground into the edge of the wafer is formed by a diamond grinding wheel which has its grinding periphery manufactured in a negative bullet shape. The diamond grinding wheel can be manufactured in any one of a number of different shapes depending upon the resultant profile shape desired for the wafer's edge.



(Drawing from SEMI Profile-Parameter based Edge Specification, presented by P. Wagner at STEP, San Francisco, July 2011)

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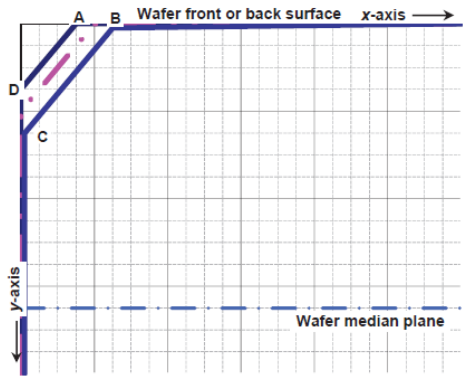
Sapphire, Silicon Carbide, Gallium Nitride Substrates

Classical “Bevel Nose” shape common to most LED substrate applications. (Drawing not to scale)

In certain applications that require the use of ultra-hard and brittle substrates of Silicon Carbide, Sapphire, or GaN materials, such as those associated with the manufacture of Light Emitting Diodes (LEDs), a different type of edge treatment is sometimes deemed appropriate. This type of edge treatment is often called a “Bevel Nose.”

Due to the importance of the critical crystal plane orientation, a rounded edge profile is not used for typical hard, brittle LED substrate materials. Also, to grind a complete bullet shape into the edge of these substrates would require the removal of significant amounts of the ultra-hard crystal material. This would result in the very short effective lifetime of the shaped diamond wheel. Therefore, the edge of this type of material is ground at two angles simultaneously or in a two-step process, in order to form the chamfer. The SEMI specification for the length of this bevel edge is 200 µm ± 50 µm.

This type of edge treatment is achieved by the use of diamond grinding wheels but instead of a positive bullet nose shape formed by a negative bullet nose shaped diamond wheel, usually, the grinding is done by a flat diamond wheel that approaches the substrate from a 45˚ or 60˚ angle depending upon the bevel desired.



(Drawing is from SEMI Document Number: 5265A)

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Challenges

Downstream: Two major issues will occur in down-stream processing if the edge treatment is not performed properly:

1. Edge flaking and edge chipping
    a. Both flaking and chipping will have disastrous consequences:
        i. To the individual wafer
        ii. To other wafers in the process chamber and work area
    b. Contaminates the pristine environment within the clean room
2. Wafer slip-outs from carrier pockets or holding fixtures
    a. The individual wafer will be lost, broken, or otherwise destroyed beyond usability
    b. Other wafers within the process chamber proximity will be significantly damaged

In-Process: There are several challenges associated with the Edge Grinding process itself:

1. Challenges in the Edge Grinding process
    a. Diamond wheels – the choice of grits, bond matrixes, concentration, etc.
    b. Uneven grinding
    c. Uneven wear of the grinding wheel
    d. Improper angle of the profile
    e. Edge flaking during grinding
    f. Edge grinding is a time consuming process – affects total CoO
    g. It is challenging to hold tolerances to SEMI specifications

Axus Technology's Solution

The solution to being able to produce accurate and repeatable wafer edge profiles is to be able to combine the correct processing equipment with optimized consumables and to perform this process with well-trained and experienced personnel.

This is normally a process that is not performed in a state-of-the-art clean room but that does not mean that cleanliness is not important. The wafer is delivered from the in-feed cassette by automation such as a pick and place arm, or transfer belts, and positioned near the diamond grinding wheel. The diamond surface of this grinding wheel is shaped exactly opposite to the desired end result shape of the wafer edge. The wafer is either fed into the diamond wheel, or the diamond wheel is fed into the wafer, depending upon the machine design. This type of machine often has the capabilities to grind a major flat, or a major flat and a minor flat, or a notch, all of which are indicators of the crystal plane position.

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It is important to periodically or constantly (customer choice) monitor the shape of the resultant diamond wheel because this shape is what is determining the shape of the wafer edge profile. As material is being ground from the edge of the wafer by the diamond wheel, the shape of the diamond wheel is also changing due to the abrasive nature of silicon, or silicon carbide, or sapphire, or by whatever material the wafer is made. The wear rate of the diamond wheel is much less than the wear rate of the wafer material but none the less, the shape of the diamond wheel is constantly being affected. These wheels can be "trued" to reshape them back to the original profile, and also to help clean them of swarf in an effort to make them cut more efficiently and effectively. Some can be returned to the OEM for recycling, or refurbishment.

Conclusions

It takes excellent, well trained personnel plus the right equipment and tooling to do the Edge Grinding process well enough to meet SEMI specifications. Years of experience gained in the actual processing of wafers of many types of materials helps Axus Technology have the skill set necessary to perform at this level. We meet and often exceed customer expectations for Edge Grinding because of a unique perspective, some of our people have actually been a part of the design teams during the engineering and manufacturing phases of the development of this type of processing equipment.

How Axus Technology Can Help You

FOR PROCESS SERVICES: If you are looking for a partner company to perform Edge Grinding and Edge Profiling on a contractual basis on your wafer substrates, our Process Services Department is ready to discuss this with you.

FOR EQUIPMENT AND TOOLING: If you are planning to perform this process in-house in your own facilities, we can help with your equipment choice by offering to you a selection of refurbished Edge Grinding equipment and tooling including the appropriate diamond wheels to perform this critical process step with accuracy, repeatability, and dependability.

About Axus

Axus Technology provides surface processing solutions for a range of semiconductor, MEMS, substrate, and related technologies. Along with providing parts and support services for existing tools, Axus Technology delivers economical leading-edge equipment and process solutions that are precisely configured for end-user applications.

Based in Chandler, Arizona, Axus Technology operations include a fully equipped development and foundry processing facility, as well as design, manufacture, and service operations. For more information visit our website at www.AxusTech.com.