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Abstract

We report on the process protocol to cleave wafers using LatticeGear cleaving and scribing tools sets.

Keywords

LatticeGear, wafer scribing, wafer cleaving, silicon fracture

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How to cleave wafers: LatticeGear protocol

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I. Introduction

For a wafer with multiple patterns, it is necessary to separate the chips by dicing techniques, such as thermal stress cleaving and mechanical blade dicing[1,2]. As a dry process, cleaving in nanofabrication can be easily performed and can replace the dicing saw when the pattern's separation satisfies the cleaving resolution. Various of substrates can be cleaved — silicon, glass slides, III-V compound semiconductors and other crystalline and brittle materials[3].

The principle of cleaving is to make a stress concentration line with a diamond scriber and then apply stress at that point to initiate a cleave[4].

The LatticeGear provides the capability of cleaving wafers. This tool basically consists of three independent components: (1) Flexscribe — Front Side Scribing Tool; (2) FlipScribe — Back Side Scribing Tool; and (3) LatticeAx Indent and Cleaving Solutions. We report on the process protocol of all three components along with associated pictures and micrograph.

II. Flexscribe — Front Side Scribing Tool

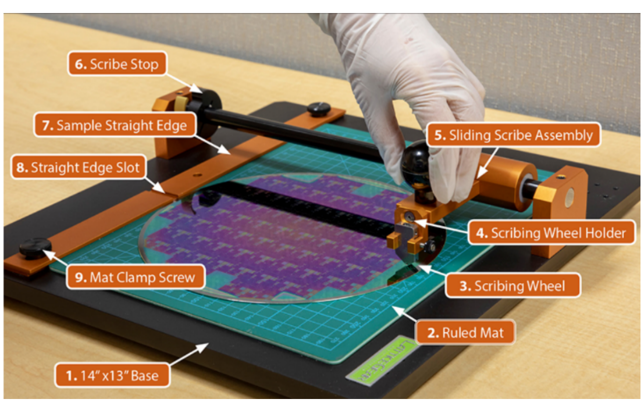

FIG. 1. Structure of FlexScribe[3].

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The Flexscribe and Flipscribe work by using these tools to create the weak point; force is then applied with a plier to cleave the substrate.

Samples may also be more precisely cleaved with the LatticeAx, which acts as a wedge to make the stress point on the surface and then applies a force to cleave the sample[5].

The front side scriber uses a diamond scribing wheel (or a tungsten carbide scribing wheel) to create scribes on the material surface. The scribing is guided by the mat. Each unit square on the mat is 10 mm $\times$ 10 mm.

Fig. 2 shows one of the practical applications. The front-cleaving method is used to make the cross section of the step after the Deep Reactive Silicon Etching process.

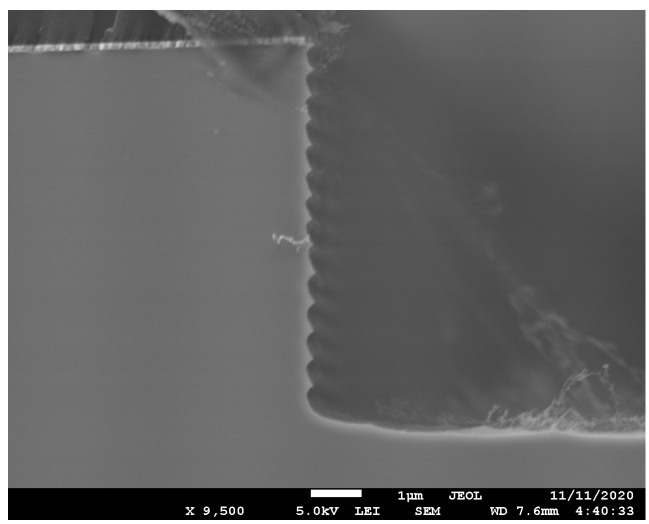

FIG. 2. Representative scanning electron microscopy (SEM) image of the cross-section of a wafer after the deep reactive ion etch (DRIE) using Flexscribe

A. Operation

1. Make a scribe on the front side of the wafer

Place the wafer on the mat (Fig. 3(a)). The scribing wheel cuts along the line of 150 mm.

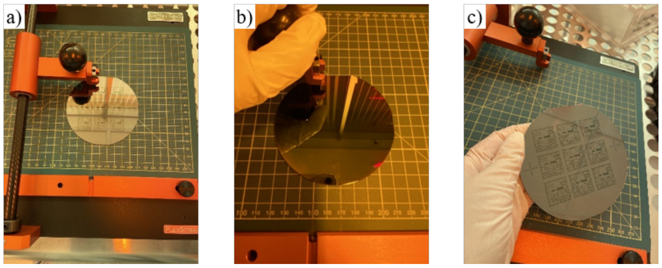

FIG. 3. (a) Align the desired scribe with the centerline (b) apply force on the assembly and pull upward (c) check the position and continuity of the scribe.

Hold the sliding scribe assembly (Fig. 3(b)) and apply force to create friction on the surface of the wafer. Use the right hand to fix the edge of the wafer. Then push the assembly upward. Make sure you hear the sound of the wheel scratching the wafer surface.

The line of the scribe can be short (Fig. 3(c)), for the cracking won't always follow the scratch if you make a long line.

Be careful about the force that applied on the wafer, too much will break the silicon into pieces.

2. Use the CleanBreak plier to cleave the wafer

Put a cleanroom wipe on the platform to collect the debris and pieces that cut from the wafer. Align the scribe with the white line on the plier (Fig. 4(a)). Then slowly apply force, and the wafer can be cleaved along with the scribe (Fig. 4(b)). The CleanBreak Pliers are for samples larger than 20 mm.

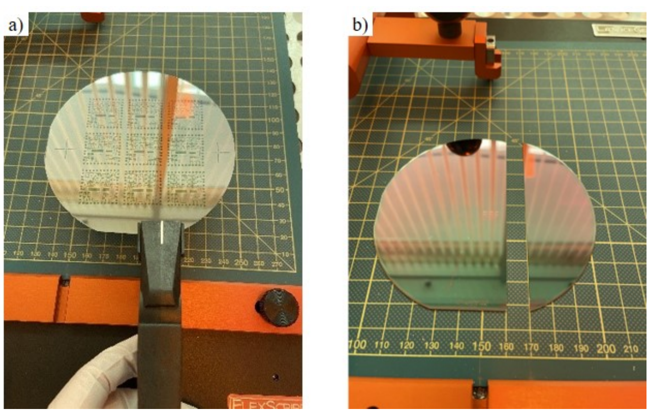

FIG. 4. (a) Scribe aligns with the white line of the plier (b) cleaved wafer.

When the sample diameter is smaller than 30 mm, the Small Sample Cleaving Pliers are recommended to cleave the wafer. In order to not touch the pattern, the tweezers are recommended to hold the edge.

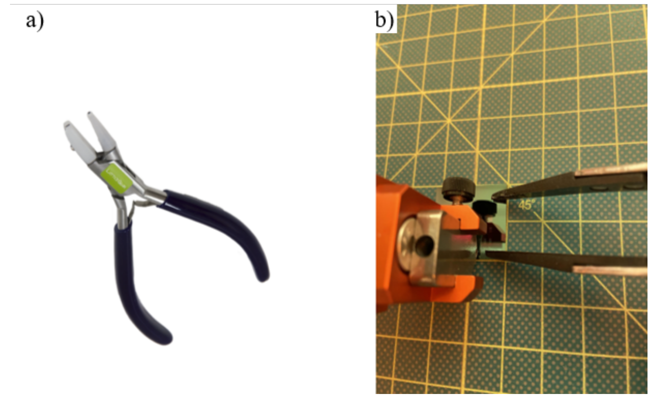

FIG. 5. (a) CleanBreak plier[6] (b) sample fixation by tweezers.

III. FlipScribe — Back Side Scribing Tool

There is a diamond scribe integrated into the platform, which enables the wafer to face up and make a scribe on the backside that protects the frontside pattern. And the scribing accuracy is higher than the frontside scriber, which is ±200 µm. The major unit between the scale lines is 500 µm and the minor unit is 100 µm.

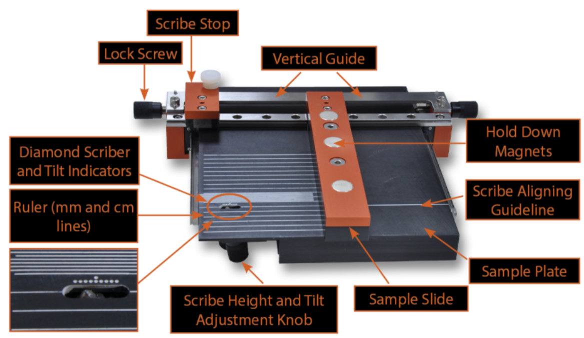

FIG. 6. Structure of FlipScribe[7].

A. Operation

1. Fix the wafer in the holder

Place the wafer face up on the mat, and apply the 100 mm wafer holder (Fig. 7). Make sure the magnet ring is also facing up.

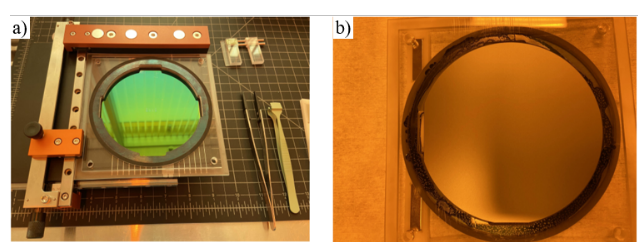

FIG. 7. Front view (a) and back view (b) of wafer fixed in the holder.

2. Define the length of the scribe

Apply the white magnet holder, and the flat of the backside of the wafer should hit against the flat of the wafer. As Fig. 8 shows, use the scribe stop to define the length of the scribe.

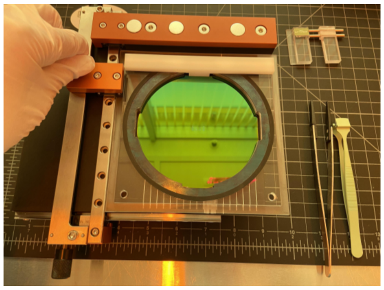

FIG. 8. Use the knob to define the scribe length.

3. Gently pull the holder down and make the scribe

Press the holder and slowly pull it down. Make sure you hear the sound of the diamond scriber scratching the wafer backside.

4. Take the wafer out of the holder

Put a cleanroom wipe under the wafer to collect the debris. Then apply the plier on the scribe to cleave the wafer.

B. Other shapes of wafers

1. For a wafer that is still symmetric after the cutting

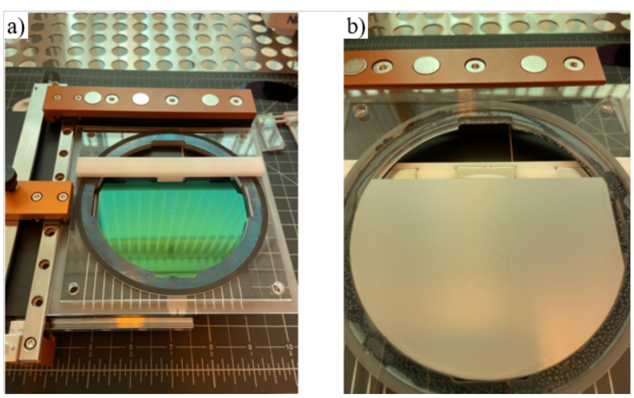

FIG. 9. Front view (a) and back view (b) of wafer fixed by the magnetic holder.

It can be fixed in the wafer holder with the magnetic holder pressed against the flat of the wafer (Fig. 9).

2. For a small sample that has two parallel edges

It can be fixed to the small sample holder (Fig. 10(a)). Load the left side by lifting the holder to make the sample in the groove on the backside of the holder. Then load the right side by moving the gripper to the sample edge.

Put them on the backside scribing platform (Fig. 10(b)) and follow the scribing procedures,

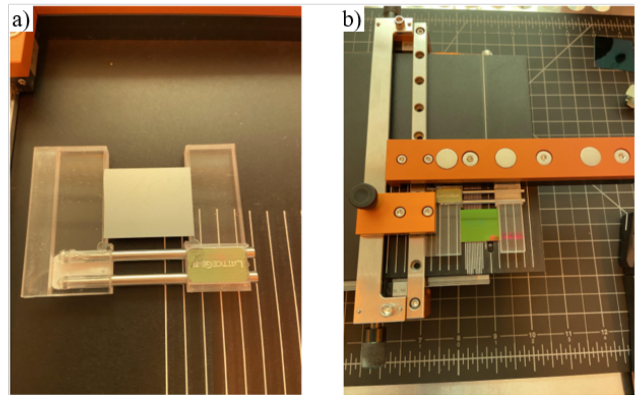

FIG. 10. Small sample holder.

3. Samples can also be scribed directly without holders

Make the flat of the chip hit the vertical (Fig. 11(a)) guide and gently push it down (Fig. 11(b)).

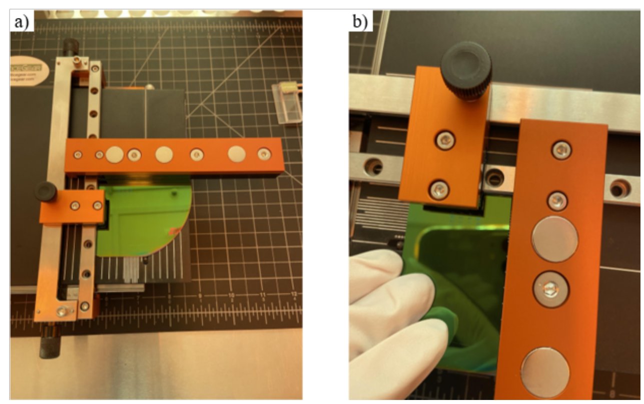

FIG. 11. Direct scribing of the sample.

IV. LatticeAx-Indent and Cleaving Solutions

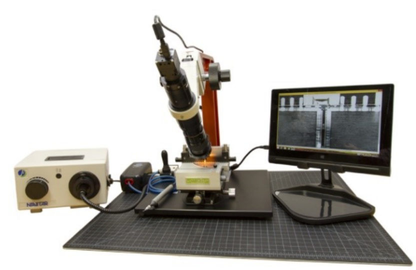

FIG. 12. LatticeAx 420 integrated with LatticeAx 120 on the platform[8].

Lattice Ax420 has the highest performance cleaving solution. It has a cleaving accuracy of 10 µm, assisted by a monocular microscope with 4-µm optical resolution. The indent position is controlled with a 5-µm step size.

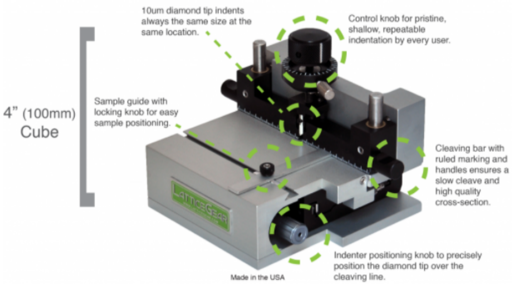

FIG. 13. Structure of LatticeAx 120[9].

A. Operation

1. Connect to power source

Turn on the power source of the microscope (Fig. 14(a)). Open the software named StCamSWare to get the real-time display images (Fig. 14(b)).

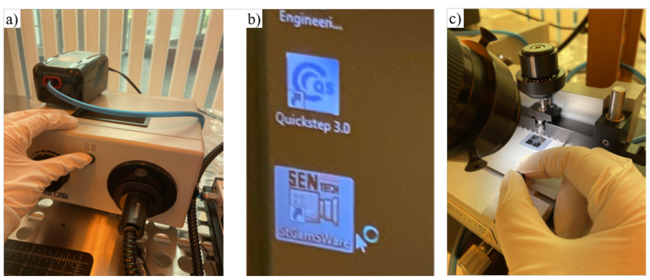

FIG. 14. (a) Power source (b) StCamSWare software (c) sample guide on the LatticeAx.

2. Set the sample and adjust the position

Set the sample on the LatticeAx working station platform. Use the sample guide to lock the sample, which features a locking knob for easy sample positioning (Fig. 14(c)).

3. Focus and adjust the indent point

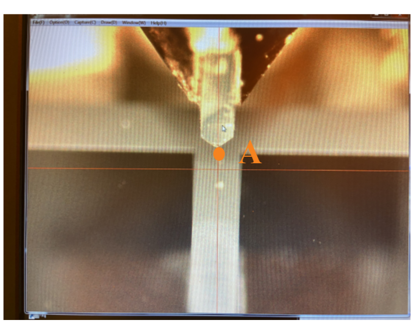

FIG. 15. X stage positioning knob.

Look through the screen and adjust the focus (Fig. 15). Use the x, y stage to position the diamond tip to the area to be cleaved. Point A demonstrates the original position of the indenter.

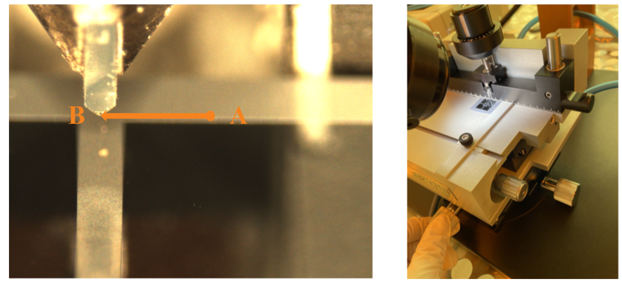

FIG. 16. X stage positioning knob.

Turn the X stage positioning knob counterclockwise (Fig. 16). The indenter and the platform will both move from point A to B along the x-axis of the horizontal plane.

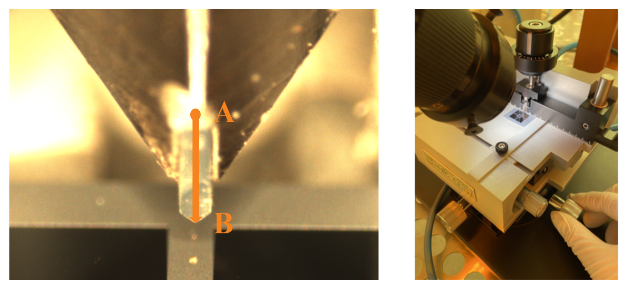

FIG. 17. Y stage positioning knob.

Turn the Y stage positioning knob counterclockwise (Fig. 17). The indenter and the platform will both move from point A to B along the y-axis of the horizontal plane.

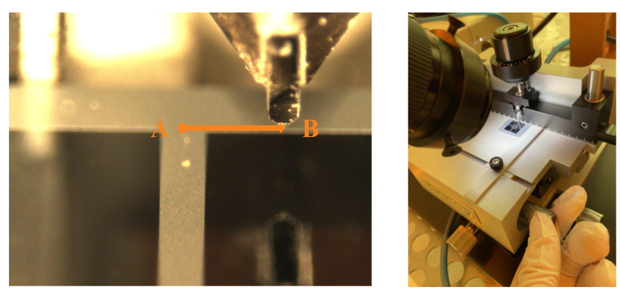

FIG. 18. Indenter positioning knob.

Turn the indenter positioning knob counterclockwise (Fig. 18). Only the indenter will move from point A to B along the x-axis of the horizontal plane. The platform will stay in the original position. This knob is used for adjusting the relative position of the indenter to the platform. It is usually adjusted to make a precise indentation on the sample.

4. Indent

Switch the control knob clockwise (Fig.19) to drive the diamond indenter tip to the surface of the chip.

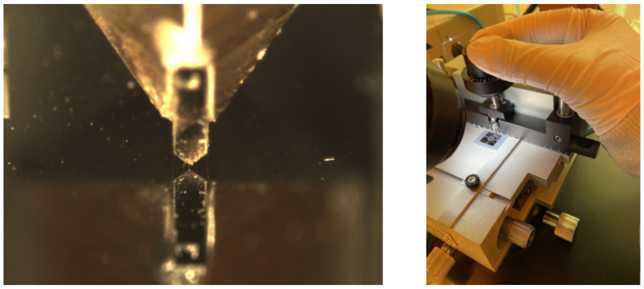

FIG. 19. Control knob of the indenter.

Then use the clock dial (Fig. 20(a)) to calibrate the indent depth.

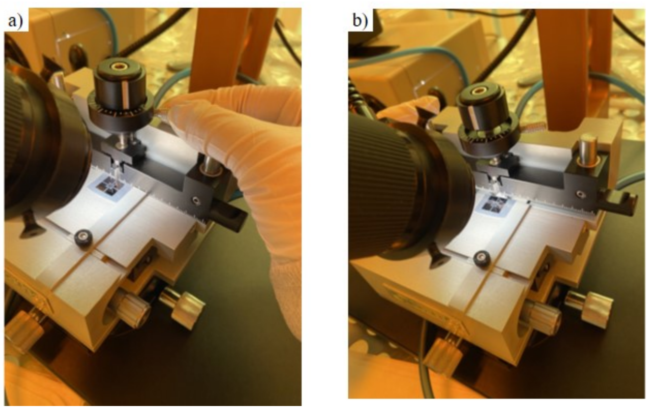

FIG. 20. (a) Clock dial for calibration (b) insertion of the sample.

5. Insert the sample

Turn off the vacuum. Switch the control knob anti-clockwise and move up the cleaving bar. Then insert the sample into the vacuum place (Fig. 20(b)). Turn on the vacuum.

Slowly put down the cleaving bar and make the two tiny vertical tips under the cleaving bar softly touch the surface of the chip and apply uniform force on the left and right hand of the indent.

6. Sample cleaving

Switch the control knob clockwise to cleave the sample.

B. Another method

If you want to protect the surface of your sample, you can skip step 5 and directly use the applied force on the indenter. Use the brush and wipe to clean the platform.

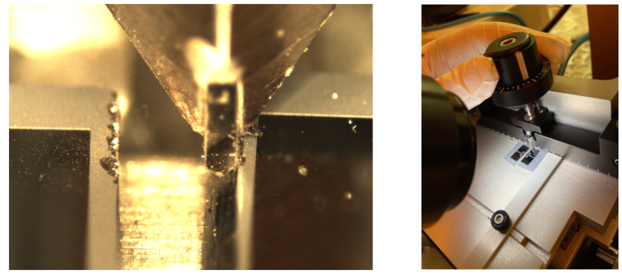

FIG. 21. Switch the control knob clockwise to directly cleave the sample.

V. Acknowledgements

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[1] Takashi Ueda, Keiji Yamada, Keiich Oiso, and Akira Hosokawa. Thermal stress cleaving of brittle materials by laser beam. *CIRP Annals*, 51(1):149–152, 2002.

[2] Dirk Lewke, Mercedes Cerezuela Barreto, Karl Otto Dohnke, Hans Ulrich Zühlke, Christian Belgardt, and Martin Schellenberger. Tls-dicing for sic-latest assessment results. In *Materials Science Forum*, volume 924, pages 547–551. Trans Tech Publ, 2018.

[3] FlexScribe Station - LatticegGear. `https://www.latticegear.com/store/product1.html`.

[4] Moyal, Efrat, Brandstädt, and Ekkehart. Cleaving breakthrough: A new method removes old limitations. *Electronic Device Failure Analysis*, 2014.

[5] Hao Tan, Efrat Moyal, Huei Hao Yap, Yu Zhe Zhao, and Zhi Hong Mai. A controlled, mechanical method for mems decapsulation. In *2017 IEEE 24th International Symposium on the Physical and Failure Analysis of Integrated Circuits (IPFA)*, 2017.

[6] Cleaving Accessories. `https://www.latticegear.com/store/scribing-and-cleaving-kits-accessories/cleaving-accessories.html`.

[7] FlipScribe 100 - Scriber. `https://www.latticegear.com/store/scribing-tools/flipscribe-100-1557316012211.html`.

[8] LatticeAx 420 is a great cleaving tool. Learn about the LatticeAx420 here. `https://www.latticegear.com/store/latticeax-420.html`.

[9] Learn About The LatticeAx 120 - LatticeGear Products - USA. `https://www.latticegear.com/store/product2.html`.