QNFCF

Quantum Nano Fabrication
and Characterization Facility

Standard Operating Procedure (SOP): Gatan Tuned Piezo Cutting Tool [GATAN-cutter]

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Summary:

This document summarizes the safe operating practices to be followed when working with the Gatan Tuned Piezo Cutting tool for cutting both thin (<1 mm) and thick samples (1 mm < to < 5mm).

Important:

1. TABLE OF CONTENTS

2. EQUIPMENT DESCRIPTION

This SOP will describe the basic operation of the Gatan Piezo Cutting Tool for cutting both thin and thick samples from hard materials such as semiconductors, glass and metals.

2.1. GENERAL LAYOUT & FEATURES

The Model 601 Tuned Piezo Cutting Tool from Gatan Inc. is an effective method for rapidly cutting precision shapes from brittle materials. A piezo crystal is mechanical coupled to a shaped tubular cutting tool vibrating in a fine grain boron carbide slurry. The high-frequency vibration causes particles in the slurry to impact the specimen, eroding away the impression of the cutting tool. The sample platform is spring-loaded for maintaining a constant pressure between the cutting tool and sample.

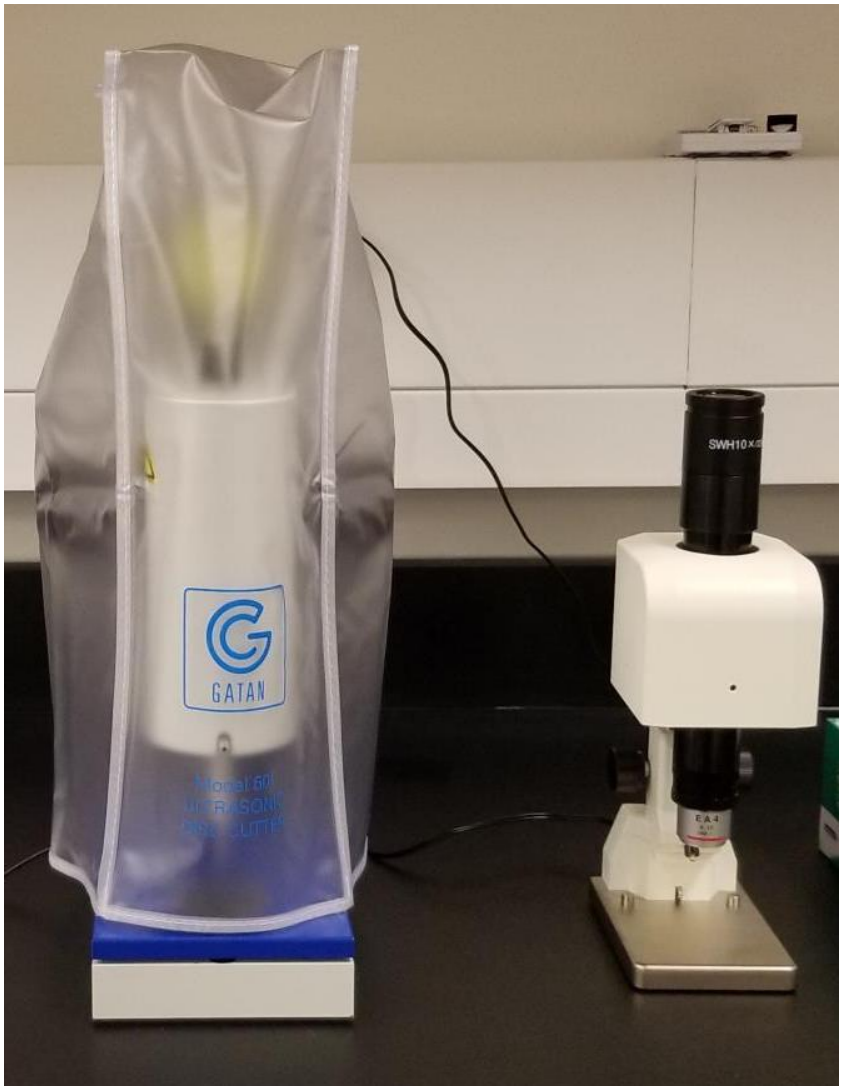
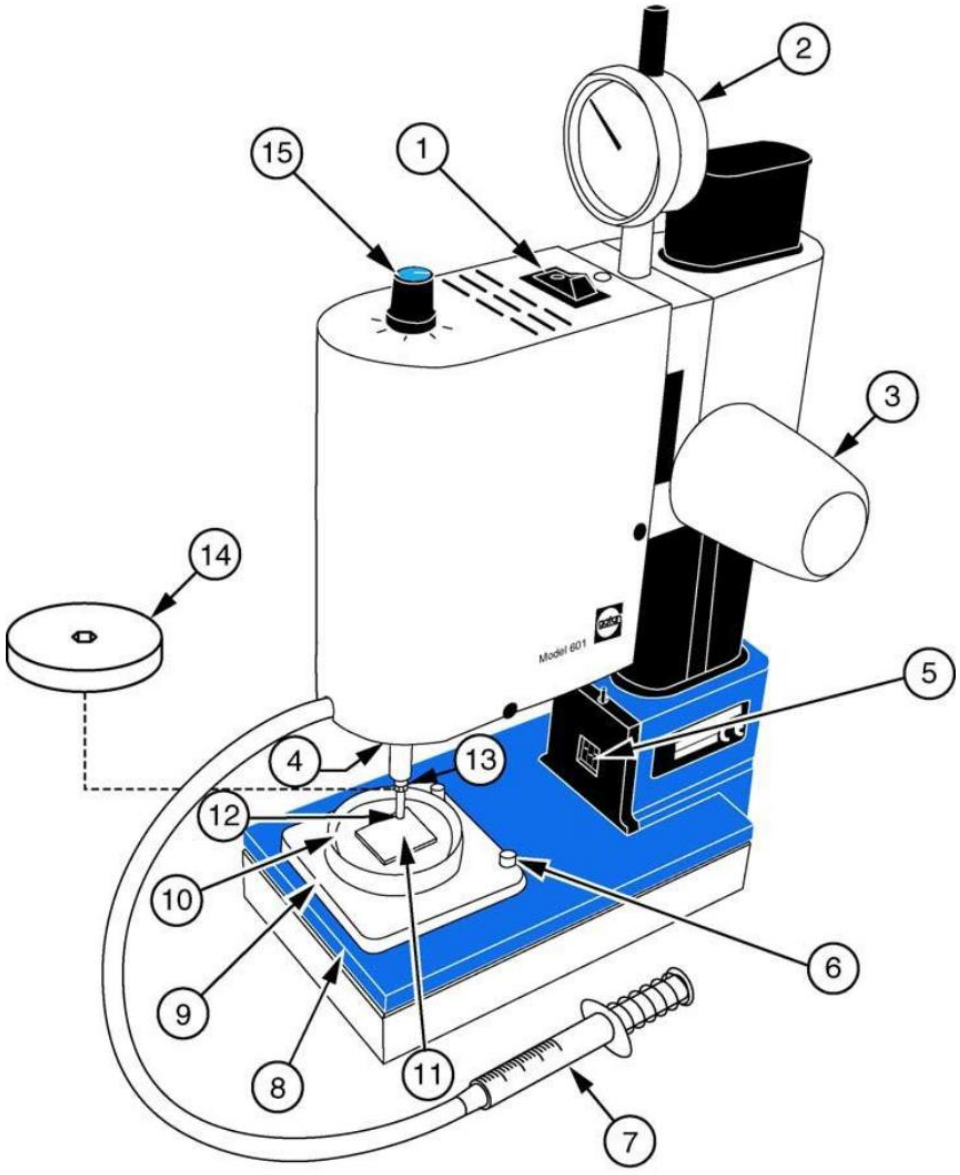


Figure 1: The Tuned Piezo Cutting tool and the alignment microscope.



1	Power switch	9	Magnetic base
2	Depth-of-cut dial indicator	10	Specimen table
3	Cutter height control	11	Glass slide
4	Specimen illumination LED	12	Cutting tool
5	Horizontal indicator	13	Copper washer
6	Locating pins for magnetic base	14	Cutting tool wrench
7	Syringe kit	15	Manual tuning knob
8	Hinged platform		

Figure 2: The Model 601 Tuned Piezo Cutting Tool and its basic components.

All the accessories which are used with this equipment are stored in the drawer labeled 'Tuned Cutting Tool'.

Figure 3: Accessory drawer for the Tuned Piezo Cutting Tool. Items are stored in labeled sections.

3. REFERENCE DOCUMENTS

- Safety data sheet (SDS) for chemicals to be used. SDS are located in the labeled binders by the cleanroom entrance. Electronic copies are also available in the QNFCF website (login required) https://qnfcf.uwaterloo.ca/data/safety-data-sheets
- Emergency contact numbers listed online (login to your account first): https://qnfcf.uwaterloo.ca/data/general/safety-policies/emergency-phone-list

4. MINIMUM REQUIREMENTS BEFORE USE

Before using this equipment independently, you must have completed the "*Becoming a Lab Member*" requirements listed on the facility website, the major elements of which include:

- Completing and passing all required Safety training
- Submitting a *Process Review Request* (one for each of your unique process flows)

- Submitting an *Equipment Authorization Request* (one for each equipment needed)
- Receiving one-on-one equipment training by an authorized staff member

Additional requirements specific to this equipment:

- Reserve time on this equipment through the facility's Badger scheduler well in advance of your session. When you arrive to use the equipment you must remember to "enable" the tool prior to beginning work and "disable" the tool when you are done.
- Review and become familiar with the risks and the emergency response procedures listed in the *safety data sheets* (SDS) for the chemicals you plan to use.

5. HEALTH, SAFETY & ENVIRONMENT

It is important that the safety and environmental requirements and guidelines listed below be followed without exception to ensure the safety of yourself, others and the environment.

5.1. MANDATORY PERSONAL PROTECTIVE EQUIPMENT (PPE):

The following equipment **MUST** be worn when using this equipment:

1. Nitrile Gloves
2. Lab safety glasses
3. Heat resistant gloves (required when using the hotplate)

6. CHEMICAL WASTE

All liquid and sold waste generated during routine use of this equipment must be segregated appropriately. All boron carbide slurry used will be mixed with grit from the sample itself and **MUST NOT BE RINSED DOWN THE LAB DRAIN**. It should all be collected in a clearly labelled waste container for proper disposal. Toxic materials such as arsenic containing solids such as III-V substrates must be collected in separate waste bottles and clearly labeled with their contents.

6.1. IN THE EVENT OF AN EVACUATION ORDER (FIRE ALARM, ETC.)

Leave the laboratory immediately. Turn off the equipment first if it is safe to do so.

7. MATERIALS & SUPPLIES NEEDED

You will likely need some combination of the following items when using this equipment:

- Crystal bond 509 mounting wax
- Glass slides
- Tweezers
- Razor blade

8. STANDARD OPERATING PROCEDURE

Typical operation of this equipment for cutting thin specimens can routinely be divided into the following steps.

8.1. SAMPLE MOUNTING

1. Remove the XY sample table from the black magnetic platform.. Heating it could damage the o-ring, so be careful to remove the slurry retaining ring from the steel puck as well.

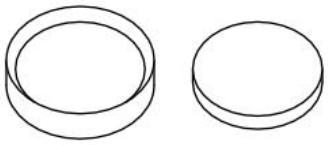


Figure 4: The sample table with (left) and without (right) the slurry retaining ring.

2. Place the XY sample table on a hotplate and let it heat up to 130 degrees C.
3. Cut a small piece of crystalbond with the razor blade and place it on the center of the hot sample table. Let it melt into a small pool.
4. Place a glass slide piece on top of the pool of wax and use metal tweezers to press down and move the slide until the wax is spread uniformly and the slide is sitting flat.
5. Cut another small piece of wax and place on top of the glass slide and let melt.
6. Place sample **face down** in the pool of wax, pressing down gently and moving it around until the max is spread uniformly. Mounting face down will help to protect the surface.

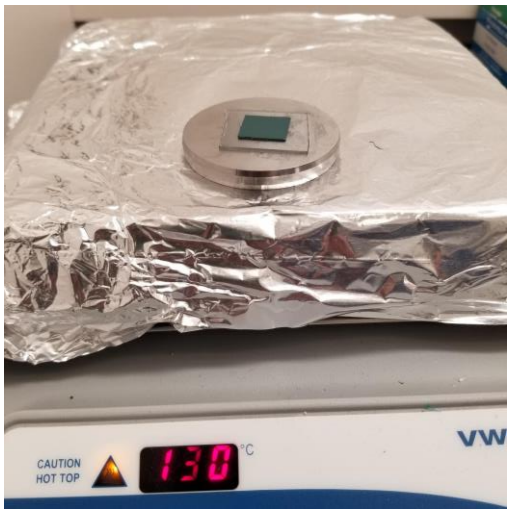


Figure 5: Sample mounted properly using wax on top of glass slide piece on sample table.

7. Put on heat resistant gloves, remove the table from the hotplate and place it on the metal cooling block. Allow it to cool down to room temperature completely.
8. Replace the slurry retaining ring and put the sample table back on the black magnetic base.

8.2. ZERO THE DEPTH-OF-CUT DIAL INDICATOR

1. Place the magnetic base on the hinged tool platform, lining it up with the locating pins.
2. Shift the sample table so that the tool will lower down onto a portion of the glass slide.
3. Using the cutter height control knob, bring the tool down into contact with the glass slide, pressing down slightly until the horizontal indicator is lined up.

Figure 6: The cutting tool in contact with the glass slide with the horizontal indicator aligned.

4. Twist the outer dial on the micrometer to line up the needle with the zero mark.

Figure 7: Rotating the outer dial to zero mark when in contact with glass slide.

8.3. OPTIONAL - LOCATING AREA OF INTEREST

1. Place the magnetic base on the positioning microscope stage, carefully lining it up with the locating pins. The light should turn on when fully in place.

Figure 8: The positioning microscope with the XY sample table in place.

2. Looking through the eyepiece, focus on the sample and lightly shift the XY sample table with your fingers until the area you would like to cut is centered in the microscope crosshairs.
3. Pick up the sample by only touching the magnetic platform, without shifting the steel specimen table. Place it on the cutting tool hinged platform by lining up with the locating pins.

8.4. CUTTING – THIN SPECIMENS (<1 MM)

1. Take a small amount of boron carbide grit and dispense into a small glass vial. Using RO water squeeze bottle add water to form a loose slurry. Put on the cap and shake to mix.

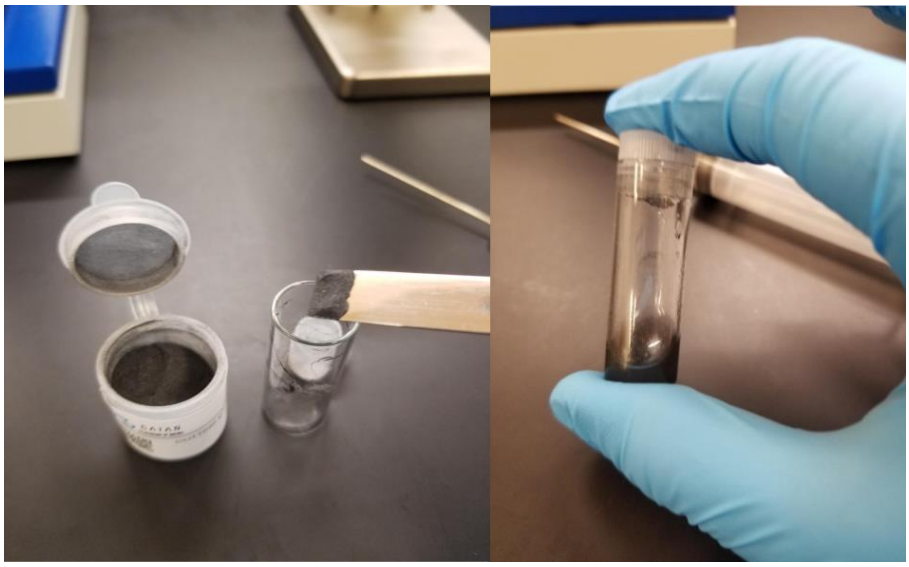


Figure 9: Mixing a small batch of boron carbide slurry in a glass vial.

2. Suck the slurry into the syringe provided with a blunt needle. Add a droplet of slurry to the area of the sample to be cut. Note that this syringe application method differs slightly from Figure 2.

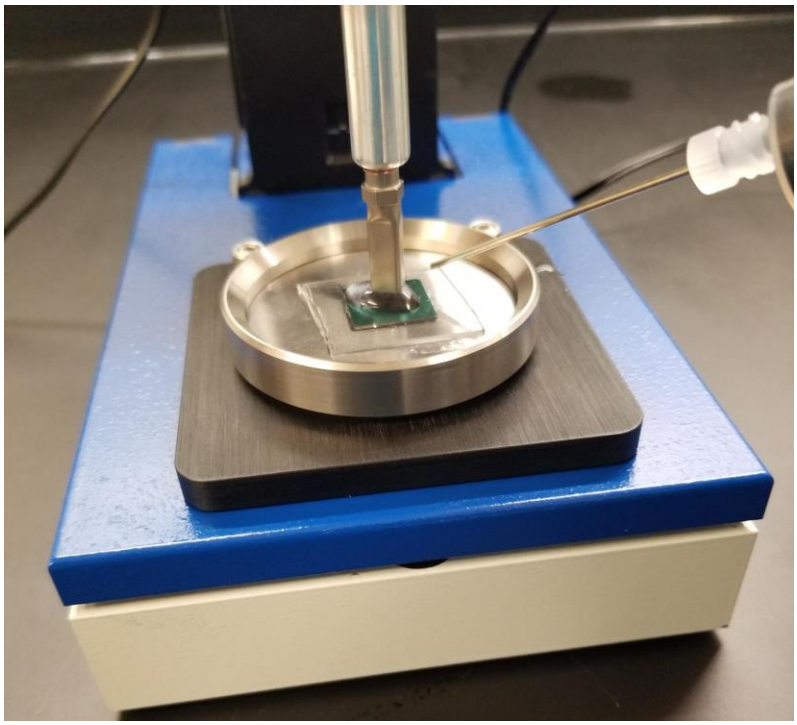


Figure 10: A small puddle of slurry added beneath the cutting tool.

3. Lower the cutting tool down onto the sample until the horizontal indicator is lined up or very slightly depressed. The position of the depth-of-cut indicator dial should show the approximate thickness of the sample at this point.
4. Turn on the cutting tool power. Listening to the sound, adjust the manual tuning knob until the dial starts to move and the sample cutting begins. The actual number value of the tuning knob setting is not important, it is just used to optimize for good cutting.
5. Using the syringe, pump fresh slurry into the cutting area. If needed, add fresh RO water to dilute the slurry and add more fresh slurry to maintain cutting rate.
6. Once the depth-of-cut dial crosses zero, the sample has been cut through. Turn off the tool power and lift the tool away from the surface.

8.5. CUTTING – THICK SPECIMENS (1MM < TO < 5MM)

1. The range of movement of the hinged platform is only ±1 mm. Thus, when cutting thick samples the cutting tool must be lowered periodically to maintain the platform at the appropriate level. Check the horizontal indicator frequently and continue to lower the cutting tool so that the horizontal indicator maintains a consistent position just below the white lines on either side of it.
2. Instead of using the blunt needle tipped syringe to dispense the slurry directly at the cutting tool, fill and connect the tubed syringe kit to the tool through the inlet at the front. This is shown in Figure 2. Pump the slurry back and forth throughout the cutting cycle to gently flush and refresh the slurry through the tool to the cutting interface.
3. Once the depth-of-cut dial crosses zero, the sample has been cut through. Turn off the tool power and lift the tool away from the surface.

8.6. CLEANUP

1. Setup the tubed syringe as shown in Figure 2 attached to the inlet at the front, and use fresh RO water to flush the tool.
2. Flush the tool with fresh water on outside and clean off with a Kim wipe.
3. Remove the magnetic base and pour the waste slurry into an appropriate waste bottle.
4. Flush the grit off with fresh water from a squeeze bottle and wipe with a Kim wipe.
5. Remove the sample table from the magnetic base and detach the slurry retaining ring. Wipe them clean with Kim wipes as well as the hinged base/sample area. If needed they can be cleaned using diluted Liquinox detergent and thoroughly rinsed with water.
6. Place the sample table on a hot plate at 130 degrees C. Once the wax has re-melted, remove the cut sample and place in a beaker with acetone to remove wax. Transfer to a beaker of IPA to rinse and then remove with tweezers and dry off using the nitrogen gun.
7. If the glass slide is relatively undamaged, it and the wax can be re-used several times. Once the glass no longer has fully flat areas it should be removed and a new slide put in its place. Put used glass in the glass waste receptacle, not the regular trash.

9. TYPICAL PROBLEMS & SOLUTIONS

1. If the progress of the cutting stops as you go, try:
   a) Diluting the slurry with water and/or removing excessively dirty slurry
   b) Adding fresh cutting grit to the slurry
   c) Adjusting the ultrasonic frequency

2. If the sample gets stuck in the tool, remove the tool using the steps given in the appendix a flush the sample out using water or compressed air. A toothpick may also be used.

APPENDIX

10. CHANGING THE TOOL

1. Use only the circular tool wrench provided. Thread it up and line it up with the hexagonal end of the tool attached to the ultrasonic head. Turn it GENTLY clockwise to loosen the tool. Do not apply too much torque as this could damage the tool.

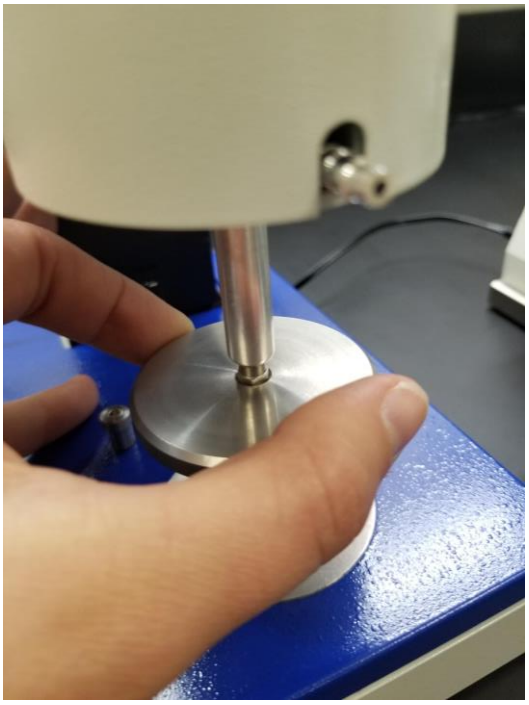


Figure 11: Loosening the tool using the special provided circular wrench.

2. When removing the tool be very careful not to lose the Cu washer.

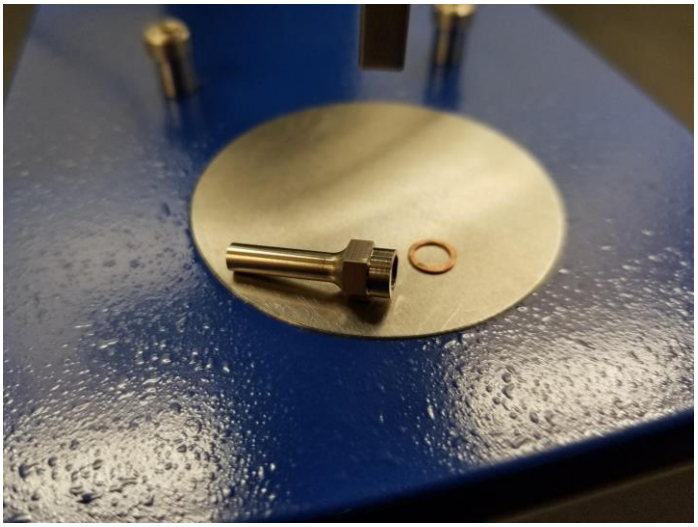


Figure 12: Tool removed and Cu washer.

3. Reposition the Cu washer and finger tighten the new tool in place. Use the circular wrench to tighten the rest of the way counterclockwise.

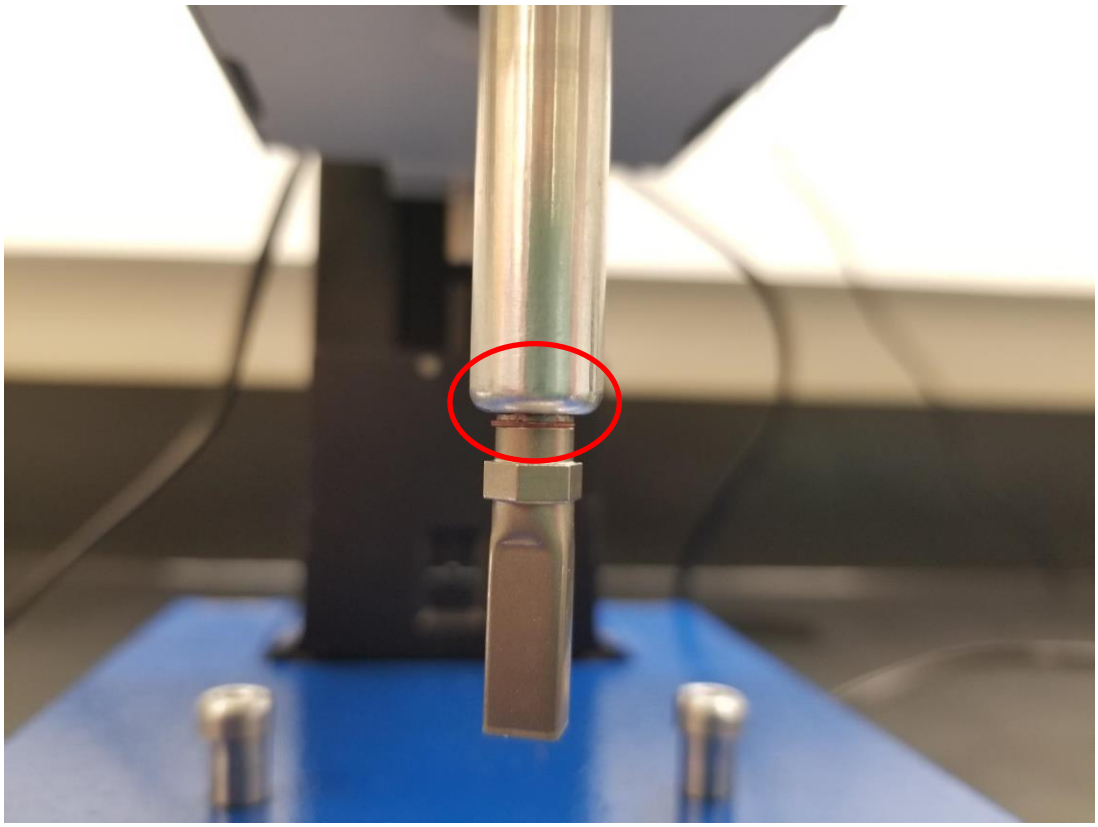


Figure 13: Correct position of tool and Cu washer when installed correctly.