

## Handling Summary

Due to the extreme sharpness of a diamond knife edge, it should not be touched or cleaned with any solid object.

Put particular care in trimming the trapezoid base of the specimen block. Cut it with a new razor blade. Before sectioning, clean the block with a spray of distilled water, then blow the water away with clean compressed air.

Clean the diamond knife after sectioning with an air brush spray of distilled water, then blow the water droplets from the diamond with clean compressed air or other gas.

Do not wipe the diamond knife with a wood stick or any other solid object. Doing this repeatedly, will cause edge imperfections and shorten the time before it needs resharpening.

Do not use ultrasonic cleaners; some are very strong and may cause damage.

Do not use acids, ammonia, or strong chemicals; they do not affect the diamond but will damage the metal boat, its finish, or the polymer around the diamond knife.

Chatter problems can be helped by: 1) properly fastening the knife and block, 2) slowing the cutting speed, 3) using a well cured and narrow block, and 4) varying the clearance angle.

## About Diamond Knives

A diamond knife for ultramicrotomy is an extremely sharp and precise diamond blade mounted in a metal holder called a "boat". Diamond knives are used for slicing very thin specimen sections which are magnified with an electron or optical microscope.

A Micro Star edge radius is about 2 nm or 12 carbon atoms. This molecular sharpness is needed to cut sections as thin as 50 nm. The sections are examined in the electron microscope at very high magnifications showing details sometimes less than 10 nm and requiring the diamond knife to be defect free.



Making a Micro Star diamond knife involves an array of precision machines and sophisticated instruments. Each diamond passes a long series of manufacturing processes and more than 100 inspections and tests which, with the skill and expertise of Micro Star technicians, make possible the production of a flawless diamond knife.

Micro Star diamond knives are made from carefully selected, jewel quality diamonds. The crystals are cleaved along their natural lattice and microscopically screened to choose only the flawless ones. Each diamond is welded with a titanium alloy to a steel shank, forming a high strength molecular bond that ensures knife stability during sectioning. A laser instrument is used to align the diamond along the exact crystal orientation that provides maximum edge strength and durability.

Once the diamond is welded in the steel shank, it can be positioned precisely in the various machines and instruments that are required to produce the edge and test its quality. At every step, Micro Star knives are monitored with state-of-the-art equipment to assure process control down to the molecular level. The optical interference contrast and scanning (SEM) electron microscopes allow inspection of diamond surfaces, orientation, and welding quality.

After the polishing process, the diamond knife is tested by cutting gray and purple sections and inspecting every micrometer of the edge. Only if no flaw is detected is the knife allowed to pass to assembly.

The diamond knife is assembled to the metal boat using a laser instrument to ensure accurate alignment. The bonding agent is a very inert and insoluble encapsulating material. This allows the use of solvent solutions for cleaning without any danger of dissolving the encapsulating material.

Micro Star diamond knives undergo a process that makes the diamond hydrophilic. A hydrophilic encapsulating material is also used inside the boat. This attracts the water toward the edge making it easy to maintain the proper level and meniscus for sectioning.



After a knife is assembled in the boat, an exhaustive new sectioning test is performed through the entire length of the edge. Each section is painstakingly examined for evidence of imperfections. Only if this final test also shows the knife to be flawless, it is approved for shipment, packed, and sealed in its wood case.

A certificate of quality is included with every knife indicating the parameters of the final test, speed, section thickness, etc. This is signed and dated by the microtommist performing the test. In the end, the only criterion that defines the quality of a Micro Star diamond knife is its performance in your laboratory. This performance is guaranteed in a very simple way: Micro Star requests that you do not authorize payment until you have received and tested your diamond knife and are totally satisfied with its quality.

## **Diamond Knife Parameters**

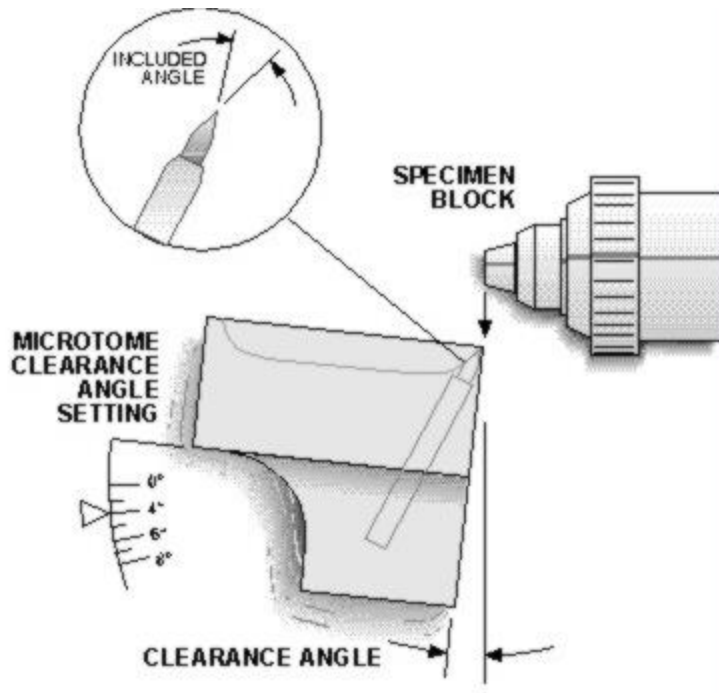
Micro Star makes seven types of diamond knives and six boat styles. For most ultramicrotomy applications the standard diamond knife (type SU) in the standard boat (style S) is totally satisfactory. For some applications, such as cryo or histology sectioning, you may want to choose a diamond knife and boat designed for that application. See our catalog for detailed specifications and dimensions.

There are two angles important in selecting and using diamond knives, the included angle and the clearance angle. The included angle is measured between the two facets that form the knife edge. The standard included angle in Micro Star knives is 45° used for routine sectioning. Optional angles are 35° and 55°.

A 35° included angle is chosen when it is important to keep morphological deformation to a minimum. However, this reduced angle makes the edge more fragile. A 55° included angle is recommended to increase the life of knives used to section hard materials such as bone or non-ferrous metals.

The clearance angle is the angle between the back diamond facet and the block face in the ultramicrotome. Micro Star knives are built perfectly aligned with the back plane of the boat. This means that the actual clearance angle during sectioning is the angle set in the ultramicrotome adjustment. The suggested clearance angle, usually 4° or 6°, is indicated on the name plate and on the quality certificate.

Clearance angles may be set safely between 2° and 10° to adjust for materials or sectioning conditions. Larger than 10° would put too much stress on the edge and decrease its life. Smaller than 2° would make sectioning difficult and cause chatter due to the knife rubbing the block face.



## Diamond Knife Handling

When using a diamond knife, keep in mind the extreme sharpness and perfection of its edge. Although diamond is the hardest material known, a diamond knife can only take advantage of this property when it is used in the microtome. Only in this instrument is the edge subjected to compression forces in the cutting direction alone. Any other time the knife edge is touched by a solid object it will sustain side stresses causing microchips that will show as lines or tears on the micrographs.

When handling a diamond knife, utmost care should be taken to avoid touching the diamond edge with anything, be it a metal object or your finger or even tissue paper. Any accidental contact with the edge may cause damage and edge imperfections.



When you are expecting your diamond knife, instruct the clerks in the receiving department of your institution not to open the box and handle the knife. Experience has shown this to occur occasionally, despite the warning labels on the sealed box. Micro Star diamond knives are supplied in a sturdy wood case that provides excellent protection for shipping or storing.

## **Block Preparation**

Proper techniques for specimen embedding and block preparation are very important to protect the knife from contaminating particles that could damage the edge during sectioning. Examples are, glass particles from pipettes with broken edges, excessive  $\text{OsO}_4$  resulting in discrete crystallization, metal particles from razor blades used for trimming, etc.

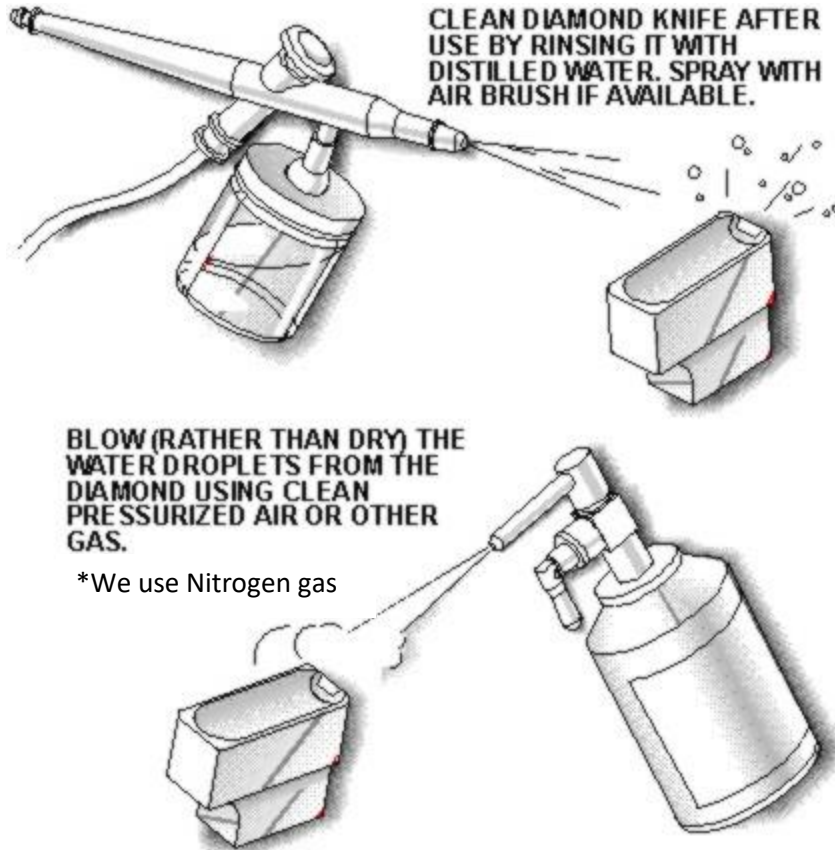
The plastic block containing the specimen to be sectioned is usually trimmed in the shape of a trapezoid. The base of this trapezoid is the first line of contact with the diamond knife edge during sectioning. Special care should be taken when trimming the block, particularly the trapezoid base. It is advisable to do the last two or three slices on this base with a new razor blade. An old blade with nicks and bends would be more likely to leave minute metal particles on the block which, acting as concentrated stress points, could cause chips on the diamond edge.

For the same reason, the block should be thoroughly cleaned before sectioning since dust particles or debris, especially on the trapezoid base, could also damage the knife. Rinse the block with a source of pressurized distilled water spray like an air brush, then blow the water away (rather than dry it) with clean pressurized air or other gas. Water used for cleaning and sectioning should be distilled or deionized. Tap water contains various minerals in solution that are left as crystalline particles after the water evaporates. These particles, particularly on the base of the block, could be a source of edge imperfections.

## **Cleaning Methods**

A clean diamond knife is important because debris on the edge may make sectioning difficult creating stress points and edge imperfections. The ideal cleaning method for diamond knives should not require touching the diamond with a solid object. It should be harmless to the knife, and yet effectively remove

dry sections and debris. We recommend the use of an air brush like the ones sold by hobby shops for spray painting small objects. For cleaning knives, use distilled water and compressed air at relatively high pressure (80 to 150 psi).



As a cleaning solution we suggest a mixture of distilled water (25%), Parsons' Amonia (25%), IPA Alcohol (25%), and Dawn Ultra Blue (25%) The best approach to keep your diamond knife clean is to rinse it after each cutting session before the water in the boat dries and the sections and other debris adhere to the diamond. Spray the diamond with distilled water using the air brush and then blow the water droplets with compressed air or other clean gas. This is the primary cleaning procedure which many times will be sufficient to keep the knife clean.

## Cautions

DO NOT WIPE A DIAMOND KNIFE WITH STICKS OR OTHER SOLID OBJECTS. This is recommended by other manufacturers and will certainly clean the diamond. However, we have found that doing this repeatedly will damage the edge and reduce the time before one must return the knife for sharpening.



**DO NOT WIPE A DIAMOND  
KNIFE WITH A STICK OR ANY  
OTHER SOLID OBJECT.**

DO NOT USE ULTRASONIC CLEANERS. It is not recommended to clean diamond knives ultrasonically. Some ultrasonic cleaners are very strong and could damage the knives. DO NOT USE ACIDS, AMMONIA, OR STRONG CHEMICALS. They will not affect the diamond but could damage the metal boat or its finish.

## Sectioning Problems

LINES AND STRIATIONS. These constitute the most prevalent sectioning problem and often the main reason a diamond knife becomes unusable and in need of sharpening. They are caused by chips and imperfections on the knife edge. Often these imperfections may be the result of poor handling and cleaning techniques. By following the suggestions above, one may prevent edge damage and maintain the top performance of your diamond knife, sometimes for years. Before shipping,



we at Micro Star thoroughly test every knife to verify that it is totally flawless. You can certify this in your acceptance test.

On the other hand, the fact remains that normal use of the diamond knife, sectioning various types of specimens, is going to contribute to imperfections. Certain kinds of materials are more prone to do this specially if they contain discrete particles or areas substantially harder than the rest of the material. A good example is a specimen fixated with excessive  $\text{OsO}_4$  resulting in discrete crystallization through the sample.

Often by the nature of your work it may be unavoidable to section materials which may cause deterioration to the diamond knife. Occasionally, you may want to decide whether to section a material you suspect may be too abrasive. If you have an old diamond knife, you may be able to test the sample observing the effect it has on the old knife before you proceed to cut with a knife in good or new condition.

**CHATTER.** This is basically a mechanical vibration that shows on the sections as marks or wrinkles parallel to the knife edge. It may show only on parts of the section while other areas remain smooth. Sometimes a sound or vibration can be heard when chatter is occurring.

In general, this problem is not originated on the knife itself as evidenced by the smoothly cut areas but is due to some mechanical problem such as the knife, block or microtome stage not being sufficiently secured. A poorly mounted or loose diamond will also cause chatter. Micro Star diamond knives and the knives resharpened by us are metallically welded in their steel shank and are guaranteed for life not to become loose.

Sometimes even if every part is secured, the cutting action produces chatter because the cutting speed is too high or the block is too wide. Other possible causes are external vibration or a block that is too soft because it was not sufficiently cured.





Obviously, the solutions include properly fastening the microtome parts, slowing the cutting speed, trimming the block narrower, and using a well-hardened block. Sometimes changing the clearance angle helps. Clearance angles between 2° and 10° are safe. An angle larger than 10° could put too much strain on the edge of the diamond knife, resulting to damage to the edge

Once chatter has started on a particular section, sometimes it is difficult to eliminate on following sections because it tends to be reinforced as the knife encounters previous chatter marks. To avoid this, turn the stage slightly to make the knife start a new cut toward one side of the block. The narrower new sections are usually chatter free. If the speed has been slowed and the mechanism is clamped better, the knife should continue cutting smooth sections.

COMPRESSION. This is a related problem usually caused by a dull knife. It shows as lines or fine wrinkles parallel to the knife edge covering the whole section and giving it a frosty appearance. It is possible that only part of the knife edge is causing compression while the rest is still sharp; this will permit using the knife on the good area for a while longer. Otherwise, the only solution is having the knife resharpened.

WATER DOES NOT WET THE DIAMOND. Micro Star diamond knives are treated with a special process that makes the front diamond surface hydrophilic, but you may encounter this problem with old knives or knives from other manufacturers.

If you have difficulty in making the water extend to the diamond knife edge as required for proper sectioning, there are some helpful techniques.

One technique is to cut first a dry section, that will bunch on the edge (this will not harm the diamond). Then overfill the boat until the water contacts the section. Finally withdraw enough water to give the meniscus on the edge the proper shape. The following sections are usually cut without difficulty as the water stays at the edge by capillary action. This improves wetting without any danger of dissolving the bonding material of Micro Star knives, or knives resharpened by us.



**WATER JUMPS ON THE BLOCK.** If the water level is too high, forming a convex meniscus, the water may transfer to the block. If the water is already low enough, the reason may be static charge produced during sectioning, especially if the air is very dry. Sometimes the water also wets the back side of the knife requiring that the block and the knife be dried before more sectioning can be done. Do not try to wipe the diamond; this would risk touching and damaging the edge. Dry the knife and block by blowing compressed air or other clean gas.

To prevent this problem, some method to neutralize static electricity must be used. If the room environment is controlled, a relative humidity of 70% or more or an air ionizer will prevent static charging. There are also some handheld ionizers that can be used particularly during the winter when the ambient air is very dry.

## **Shipping**

When shipping diamond knives to us, you may use: UPS, Federal Express, DHL or Parcel Post. If you prefer a different carrier, make sure it delivers to Huntsville, Texas USA. Insure your knives for their trade-in or replacement value. For extra security, **DO NOT USE THE WORD "DIAMOND"** in any label or document attached to the outside of the box.

If this is the first time you will be ordering from outside the United States, please provide detailed information on the documents required by your country and institution to accompany the shipment. You are responsible for paying any fees charged by customs in your country.

When shipping a diamond knife from outside the United States, please describe contents as: "microtome knife property of... (your Institution's name)... to be returned after repair" or words to that effect. For customs declarations, use the trade-in or replacement value.