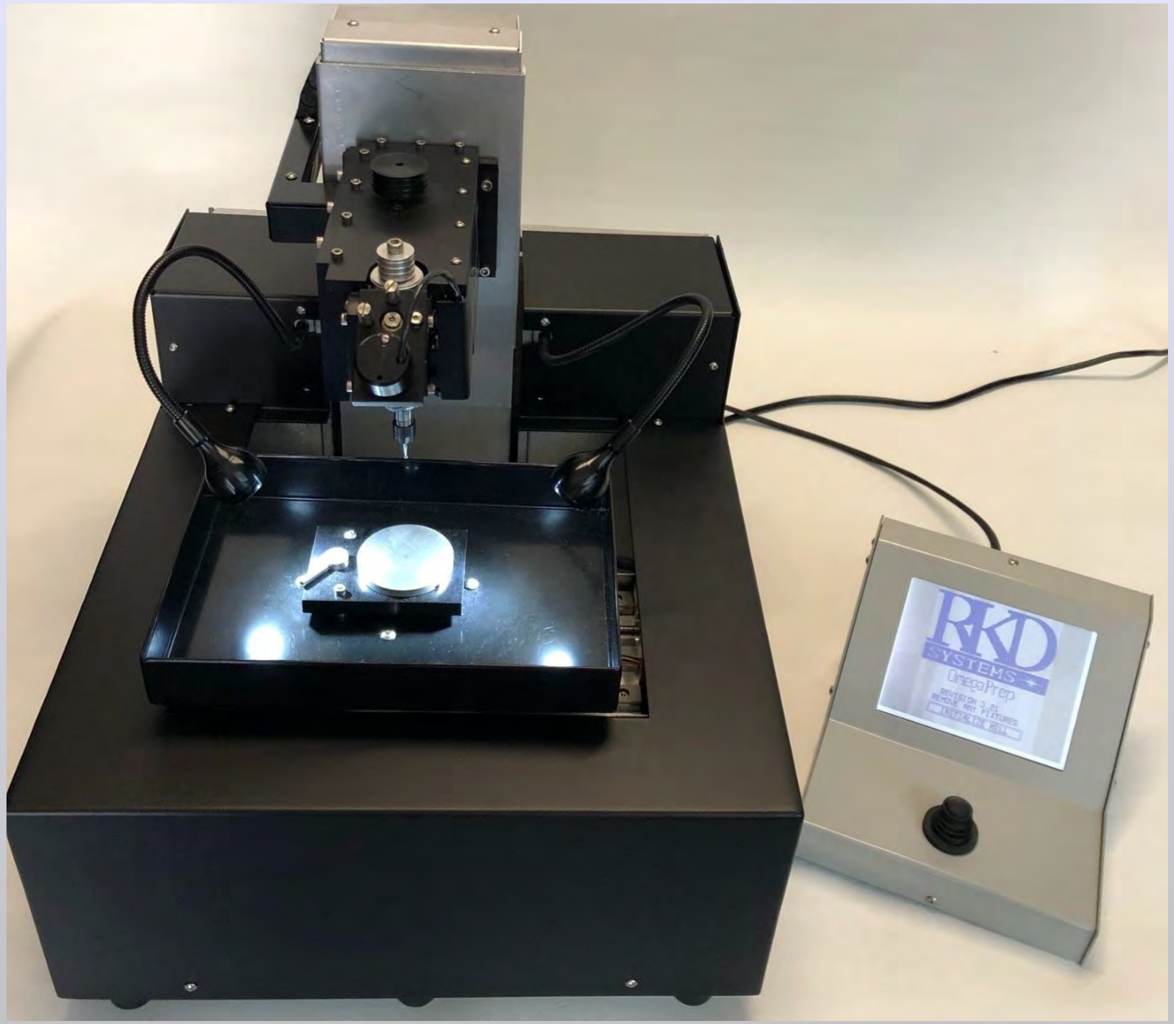
The OmegaPrep

Thinning warped die to a constant remaining thickness



An easy to use, automatic, machining system for all mechanical sample preparation needs.

- Die thinning and polishing
- Encapsulant and die attach removal
- Heat sink removal
- Substrate delayering
- Substrate removal
- Stacked die removal
- C4 ball exposure
- Die delayering
- BGA removal for PCB assembly rework
- Automatic leveling and surface profile measurement
- Simple sample mounting and alignment
- Recipes can be saved for later use
- All process and measurement data is saved and reported

RKD SYSTEMS

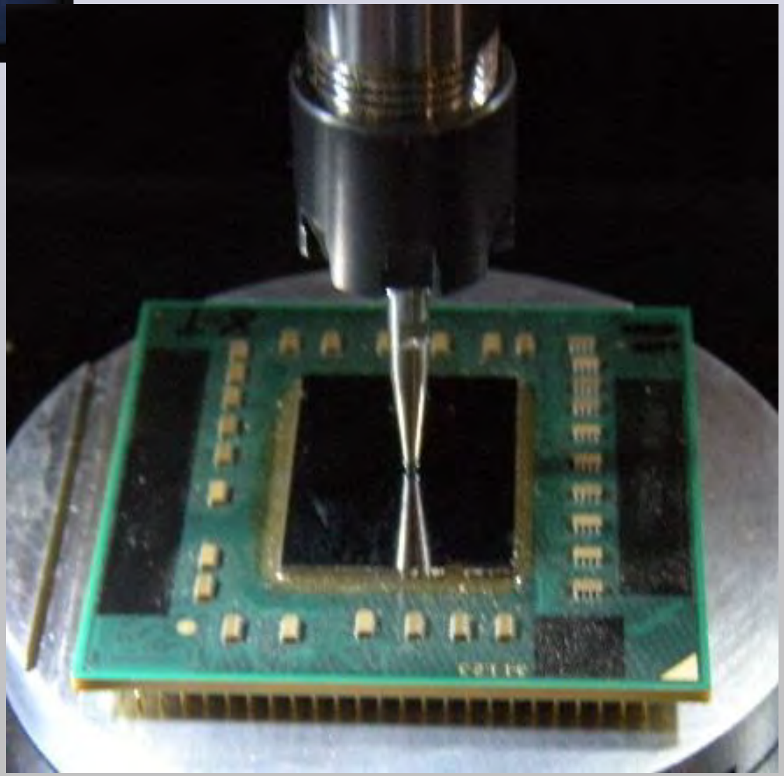
Sample mounting using the MountPlate

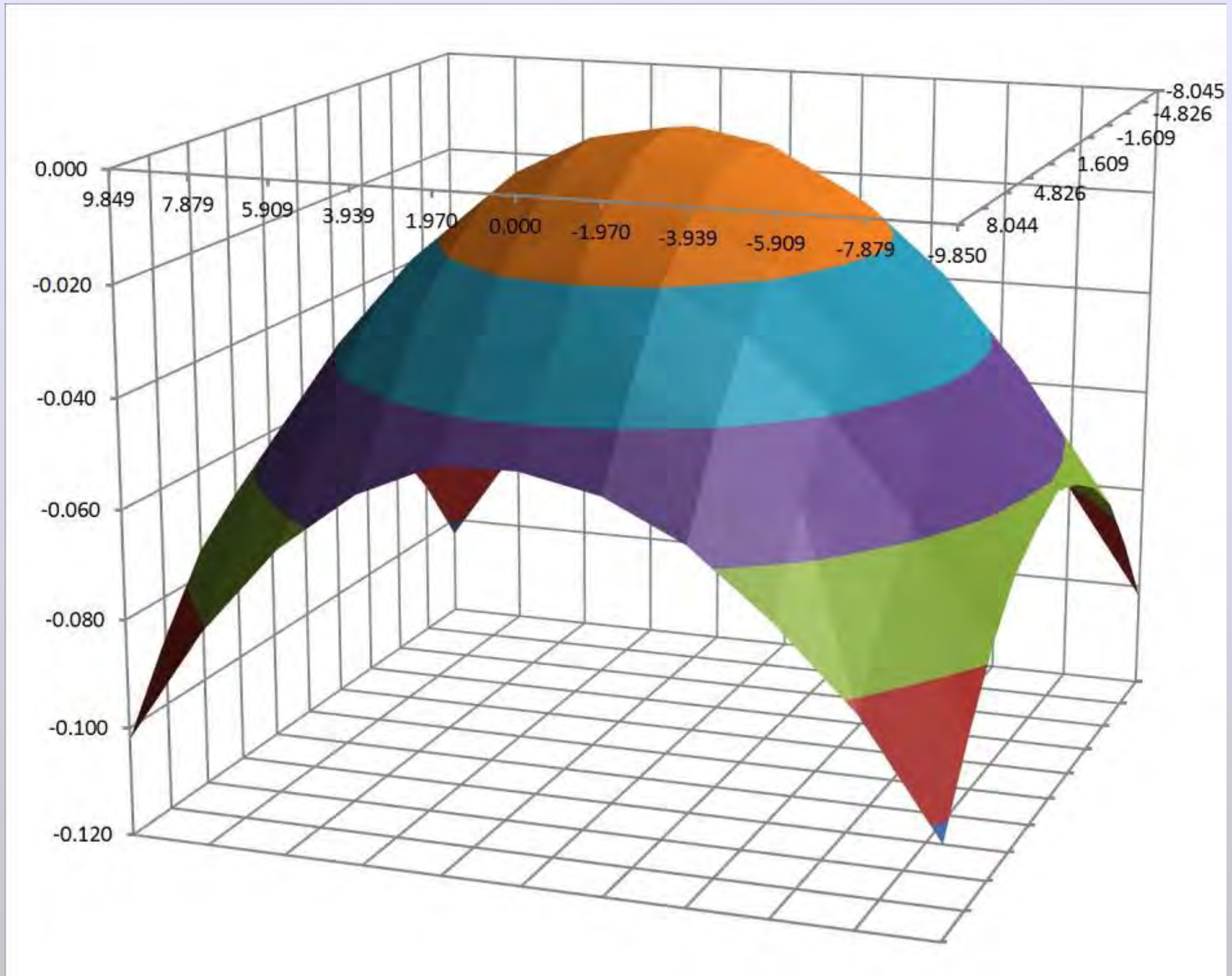
The sample is wax mounted on the sample holder using the MountPlate. It rapidly heats the sample and holder for mounting and rapidly cools the sample. The sample holder is designed for easy removal and replacement without having to remount or re-align the sample.

Once heated, the sample is scrubbed into the mounting wax and moved into the reference corner on the sample holder.

The die is aligned and the surface profile measured

The die corners are aligned to the cross hairs on a video monitor. All four corners may be aligned for rotated die or opposite corners for normal die.

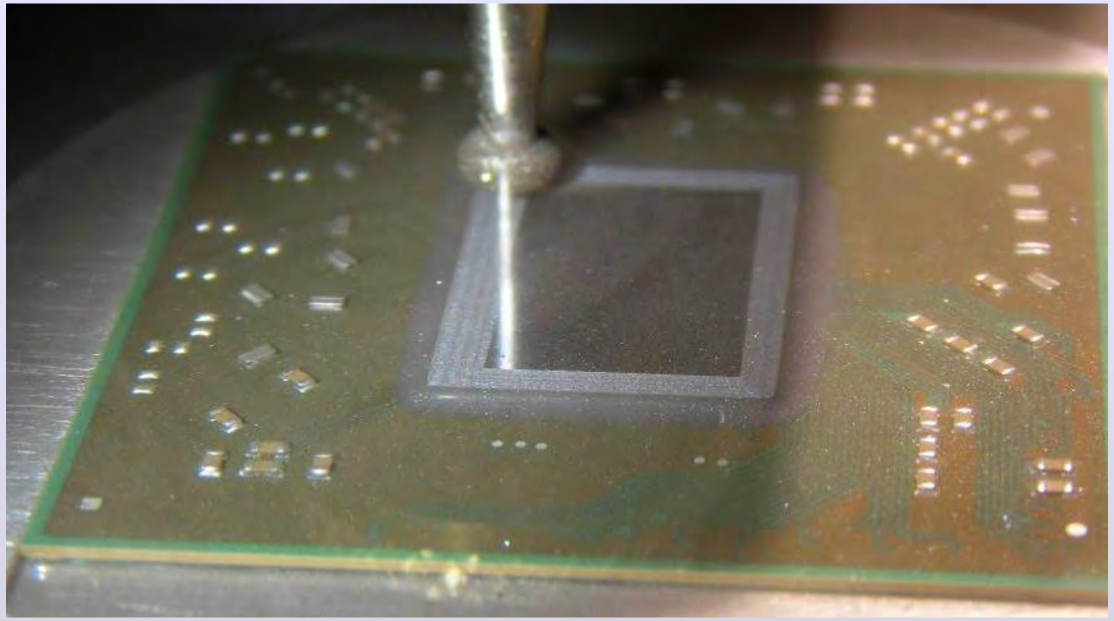


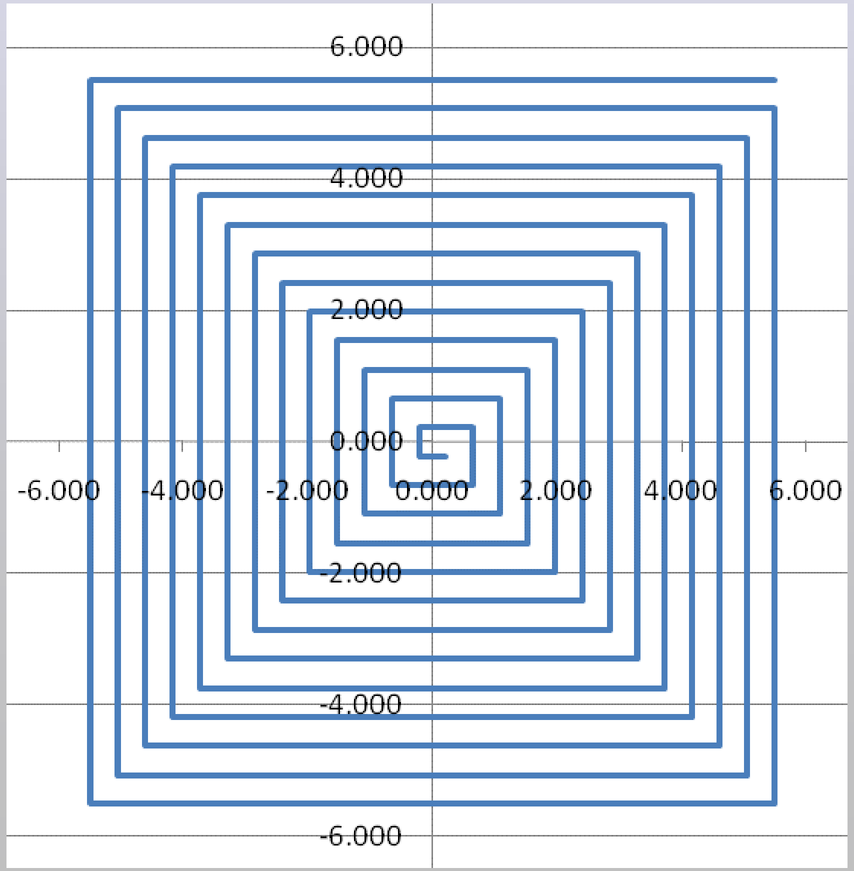


The OmegaPrep measures the surface height at selected surface points creating and saving a wire frame surface representation.

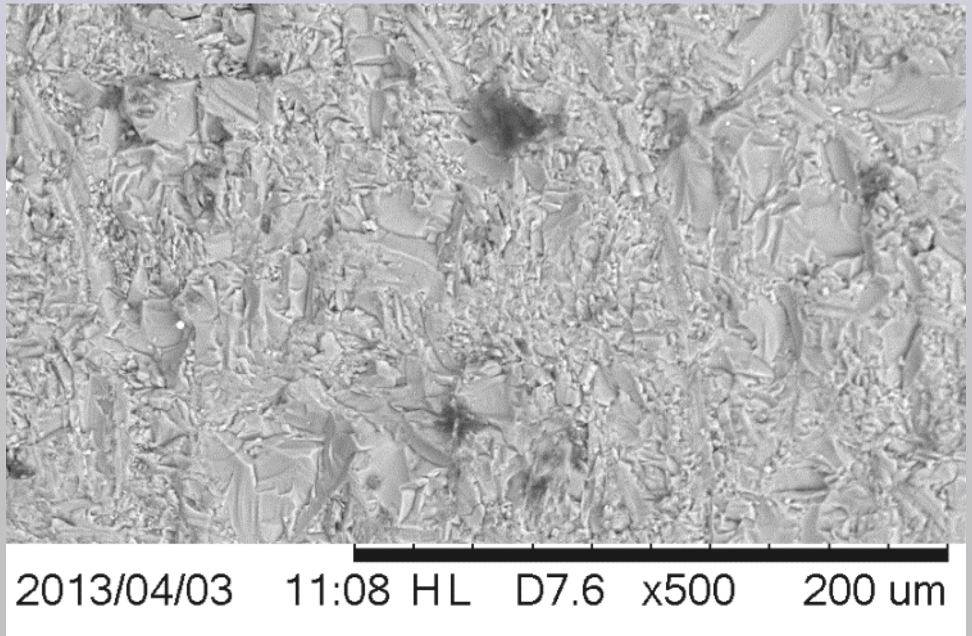
The die is ground to remove the bulk silicon

A ball end diamond grinding tool is used for gross silicon removal. The grinding tool is moved over the die surface in a specific pattern with the tool height following the measured profile.



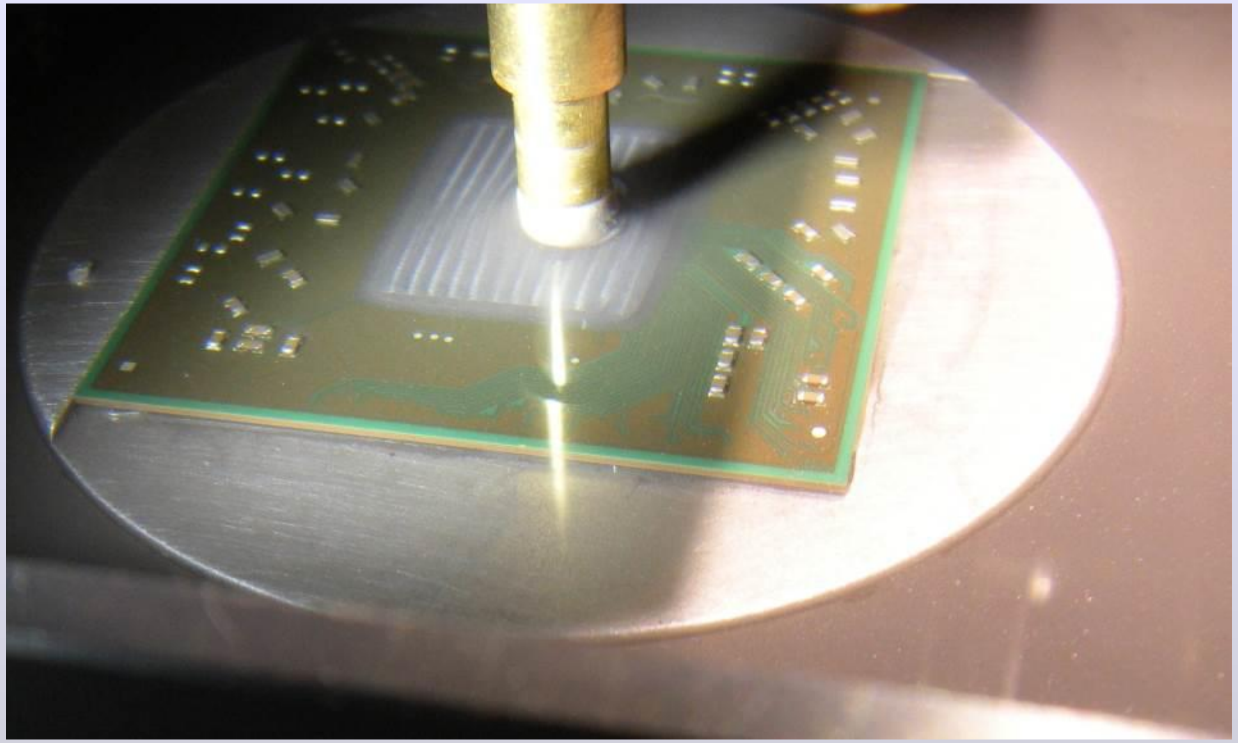


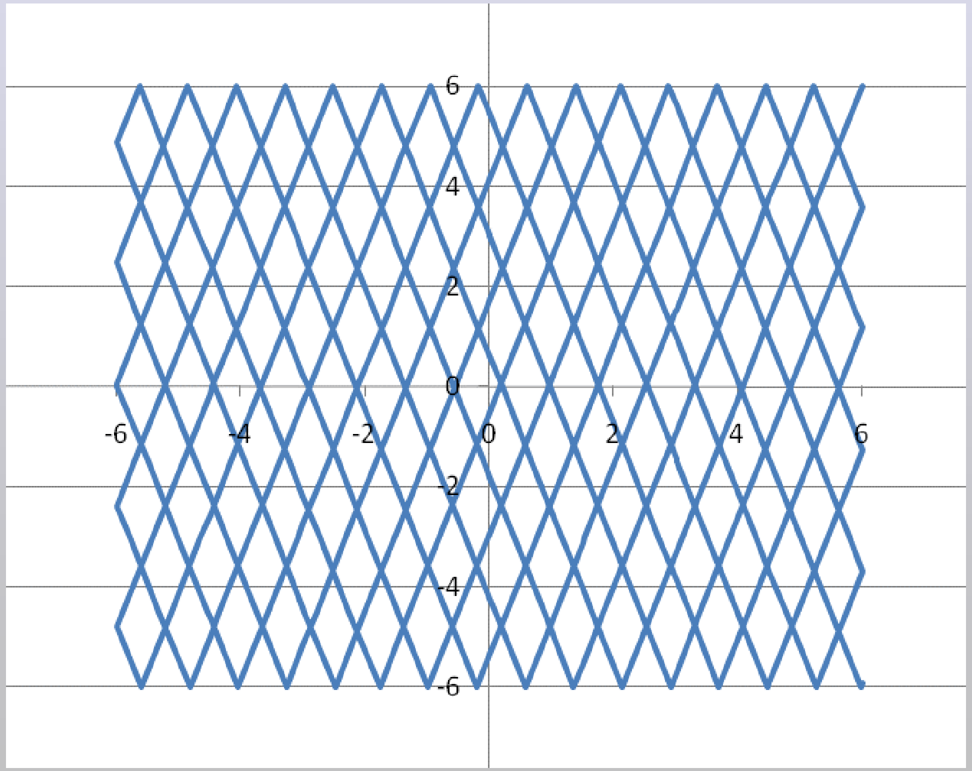
The grinding is done immersed in lubricant preventing surface heating. The forces are kept low by properly controlling tool speed, feed rate, and removal rate. This eliminates all die breakage.



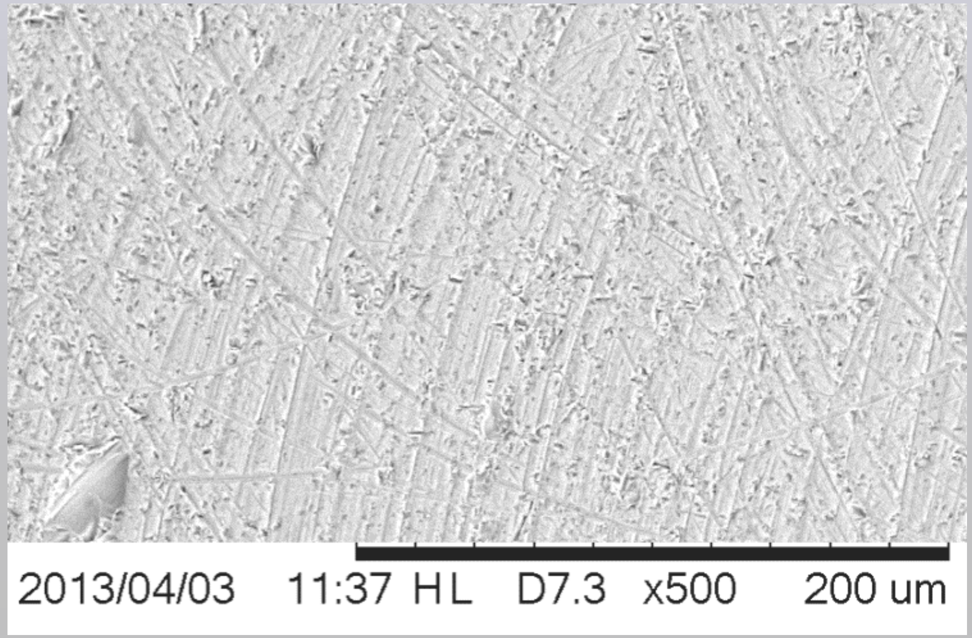
Coarse lapping to remove grinding damage

Coarse lapping is done using a special tool and a disc of lapping film. The lapping tool is moved over the die surface in a specific pattern with the tool height following the measured profile at the calculated contact point between the pad and die surface.



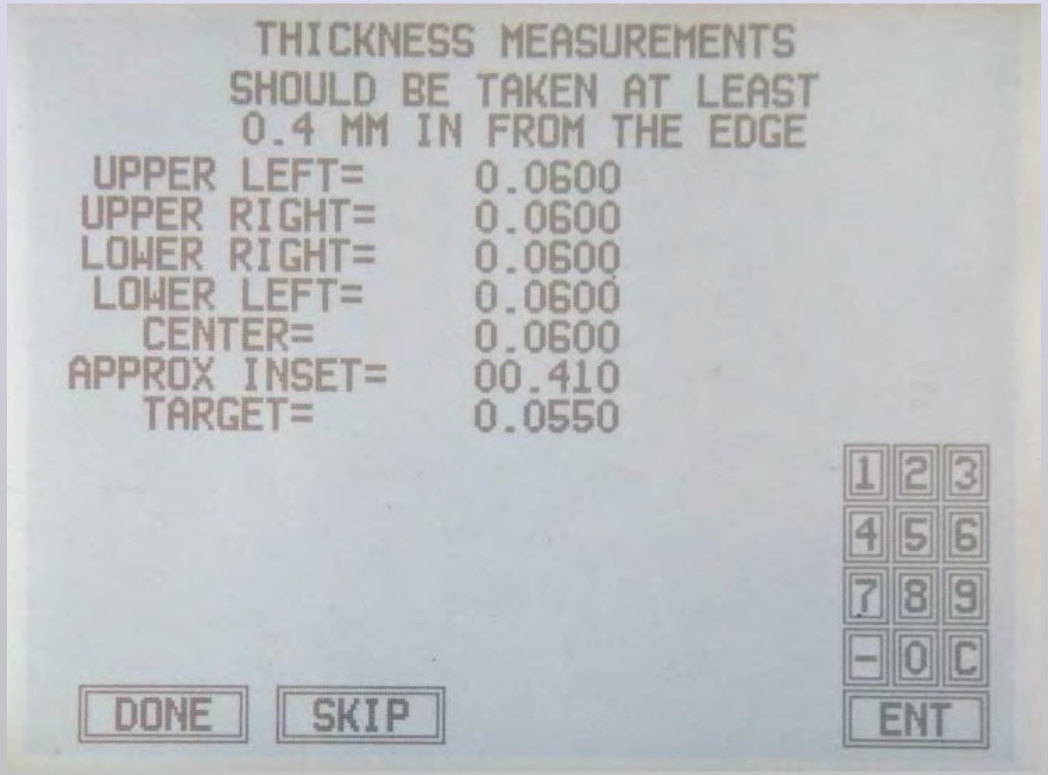


The lapping is done immersed in lubricant preventing surface heating. The forces are kept low by properly controlling tool speed, feed rate, and removal rate and controlling the tool down force.



Thickness measurement and entry to correct for surface profile changes

After coarse lapping, the remaining silicon thickness can be measured. The thickness measurements can be automatically entered if the integrated thickness measurement system is used or manually entered by the operator for profile adjustment.



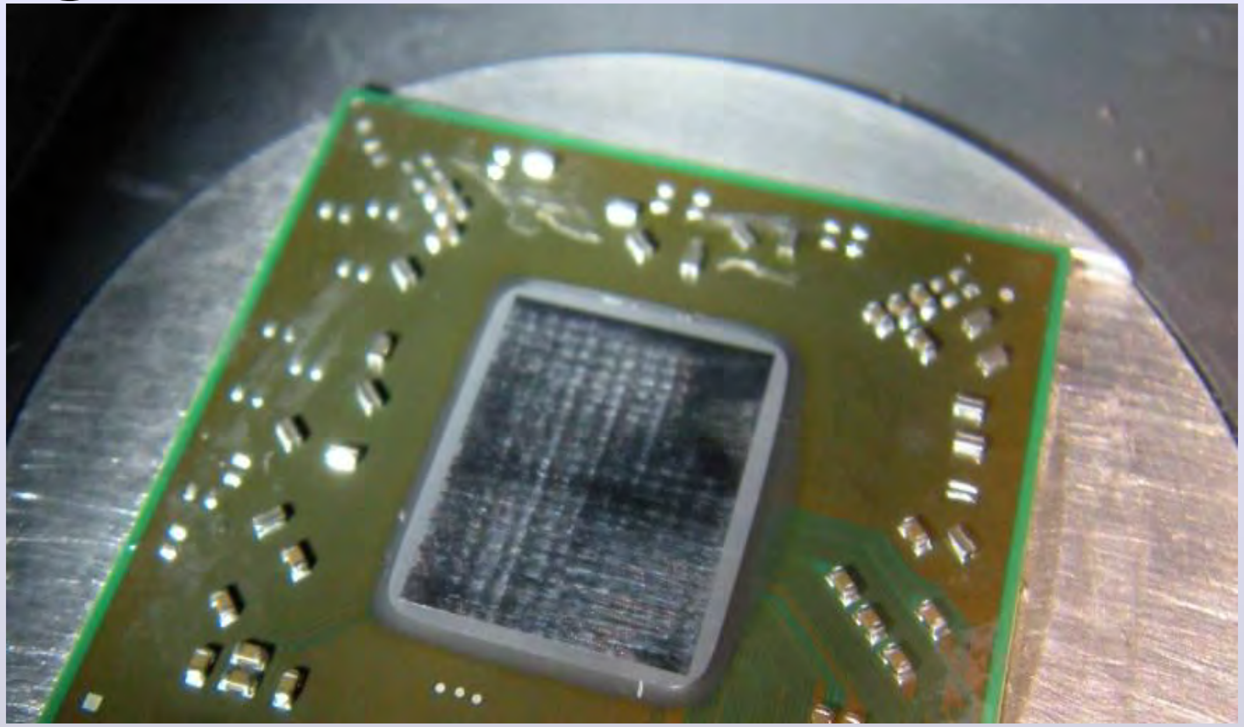
The adjustment of the profile for actual thickness measurements is required because of the re-distribution of the mechanical stresses created during packaging that cause the surface curvature. As silicon is removed, the surface profile increases in curvature due to these stresses. The profile changes during silicon removal cause thickness variation as the original profile is reproduced on the processed surface.

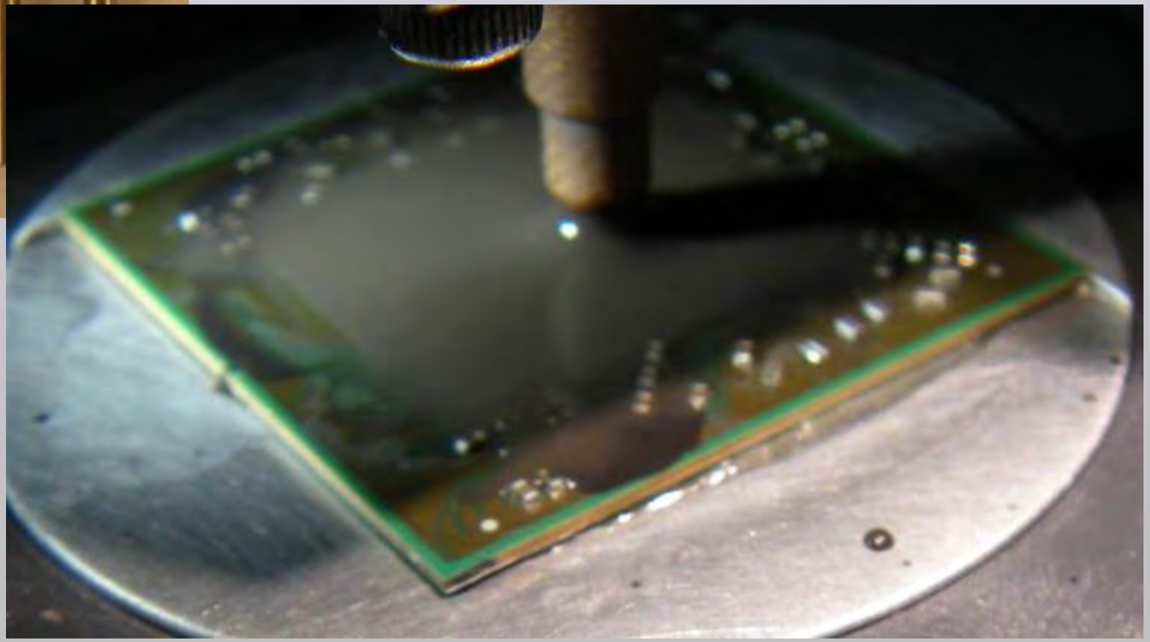
The curvature changes can not be eliminated, only compensated for.

Using the integrated thickness measurement system allows multiple point thickness measurements that can be automatically incorporated into the subsequent process steps.

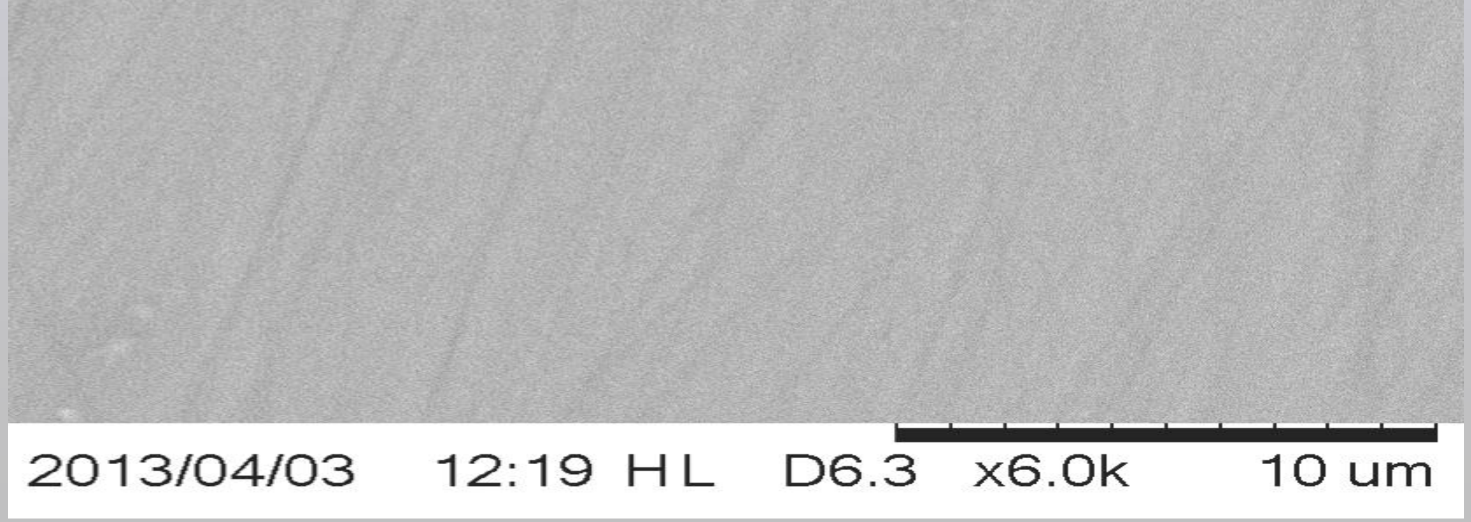
Additional lapping and polishing using diamond suspensions

Fine lapping and coarse polishing is done using diamond suspensions and cotton fiber hollow point tools. Each step follows a tighter tool path pattern and is rotated from the previous step. Silicon thickness should be measured and entered for between each step to adjust the control profile for die profile changes.



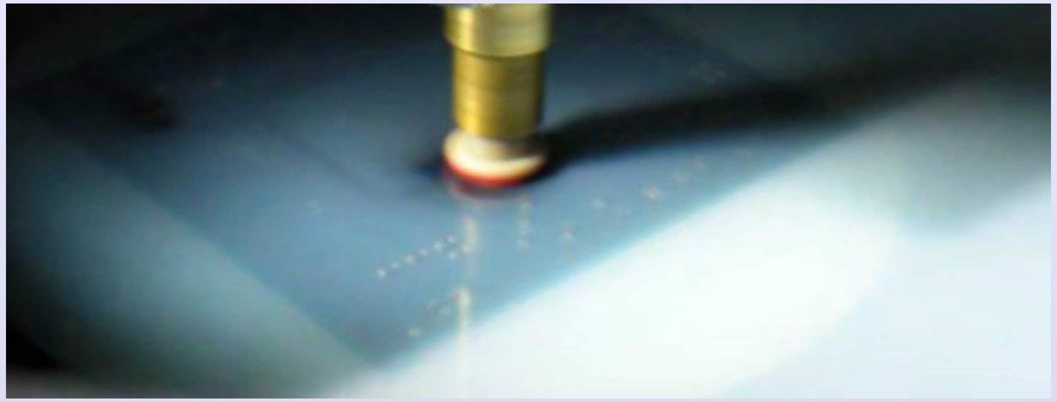


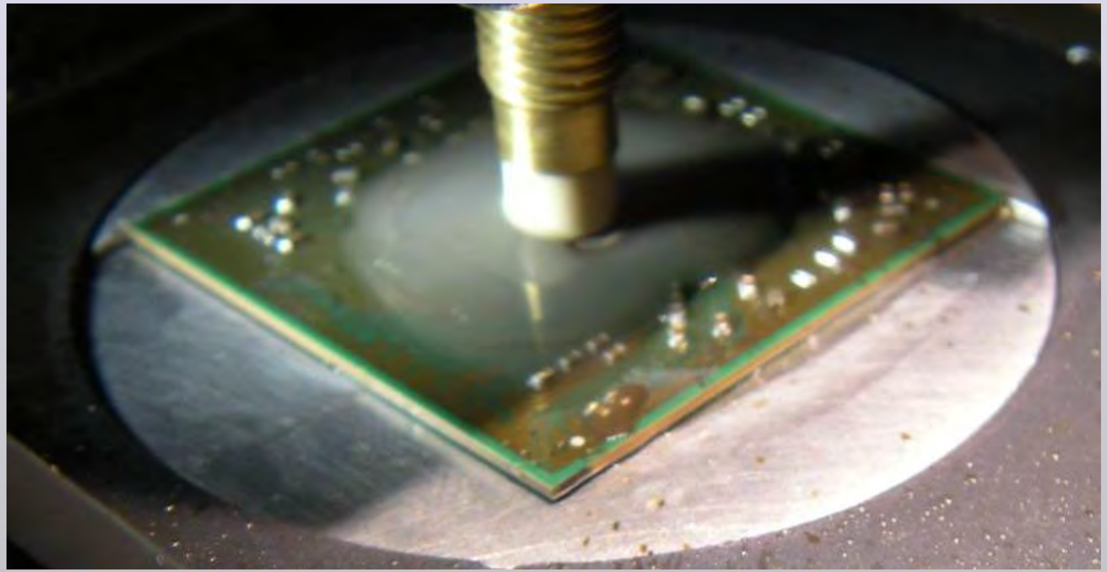
The processes are done with diamond suspension applied to the die surface. The viscosity of the suspension maintains coverage of the die surface.



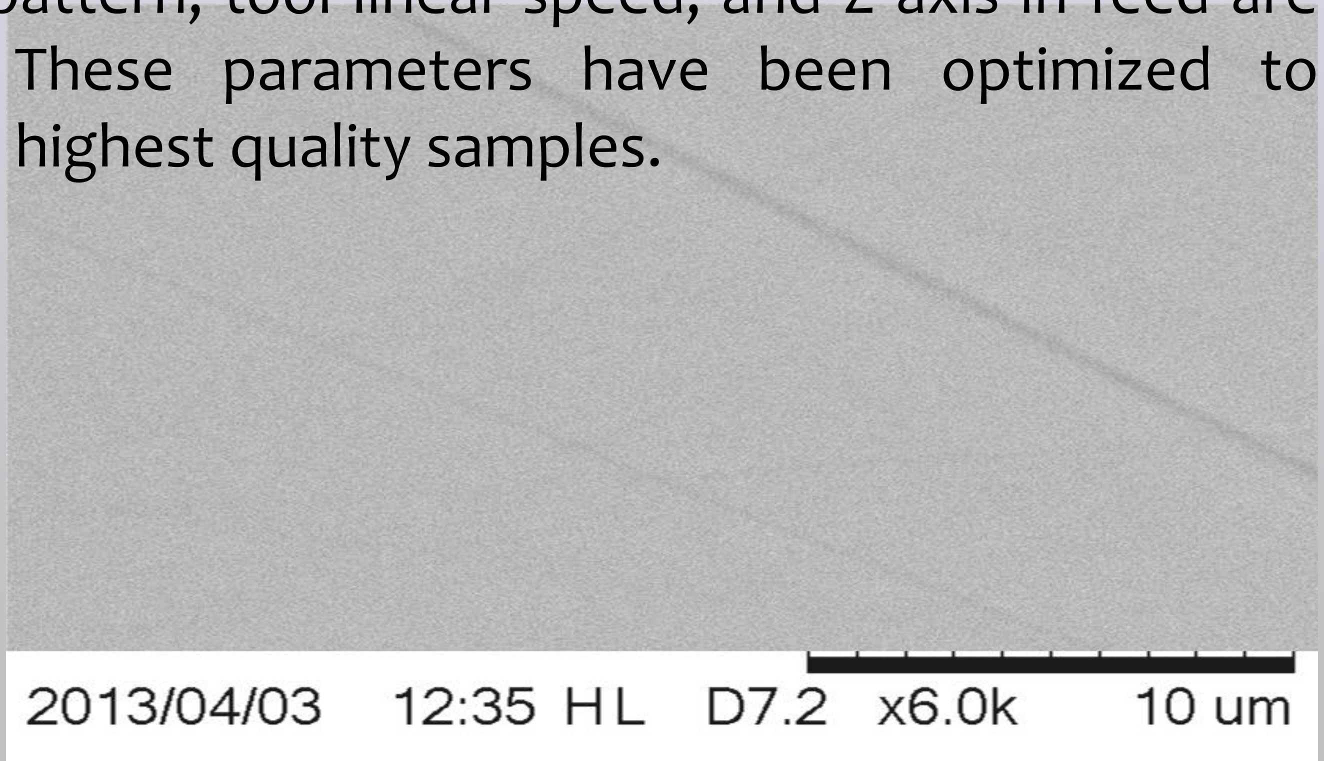
Fine and final polish using a polishing pad and slurry

Fine polish is done with a tool fitted with a polishing pad and diamond slurry. The final polish is done with a polishing pad and colloidal silica. With the UltraPrep moving the tool face according to the measured and thickness corrected profile, the remaining silicon thickness variation will be less than ±5μ. With care, ± 2μ is achievable.



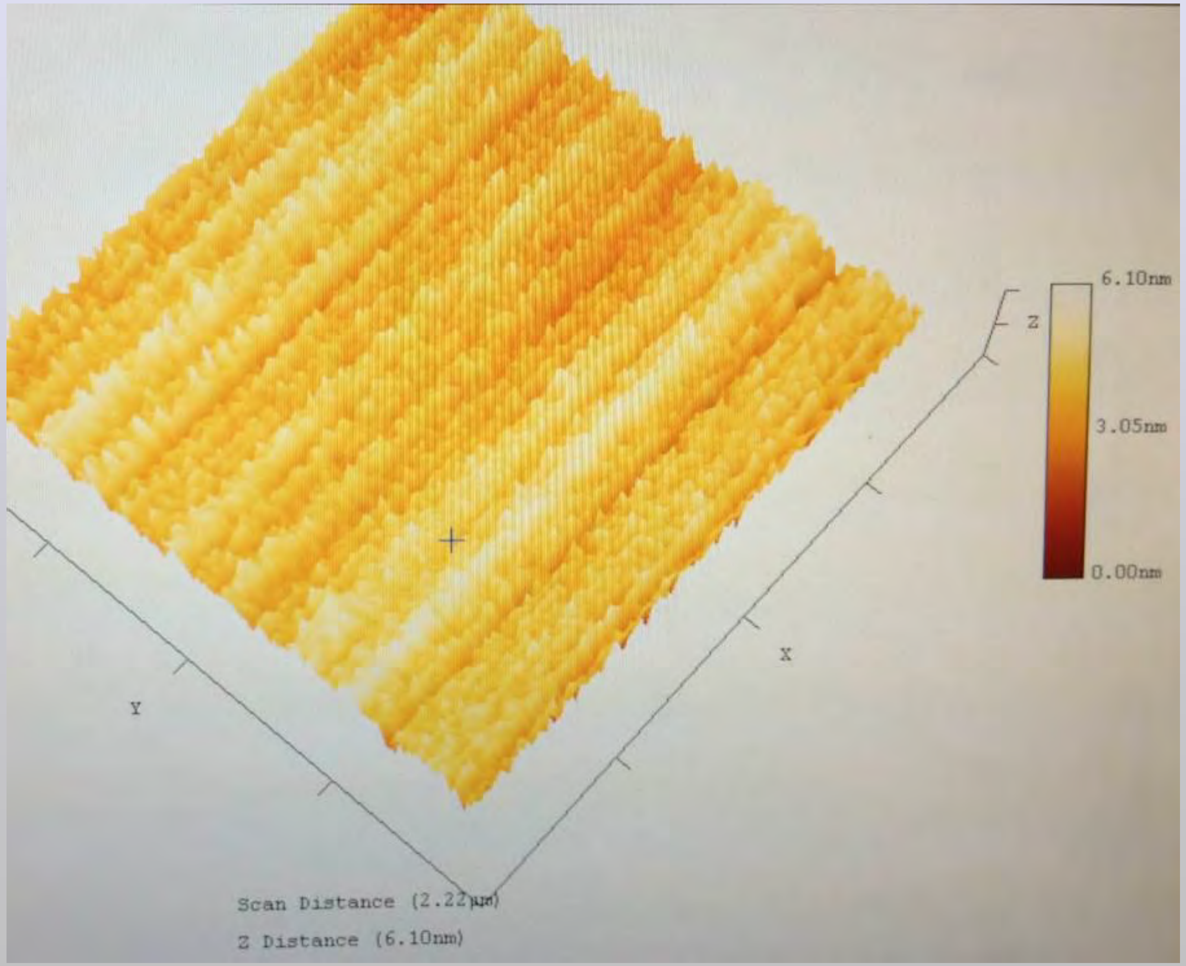


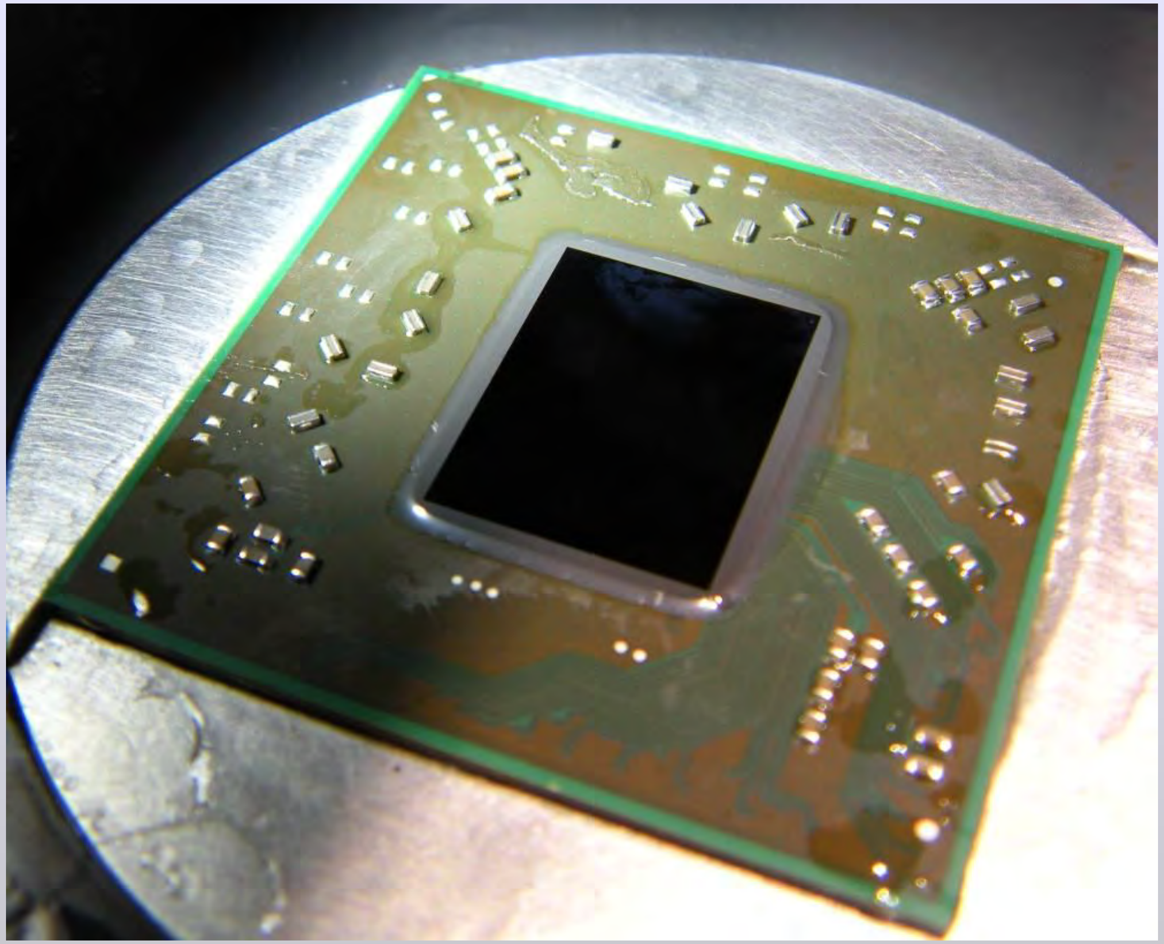
All process parameters including spindle speed, tool movement pattern, tool linear speed, and Z axis in feed are all preset. These parameters have been optimized to produce the highest quality samples.



The best surface quality and lowest thickness variation

The resulting surface has a mirror finish with less than 8nm total surface variation as measured by AFM scans. There is minimal large area surface variation and thickness variation of ± 5µ or less.

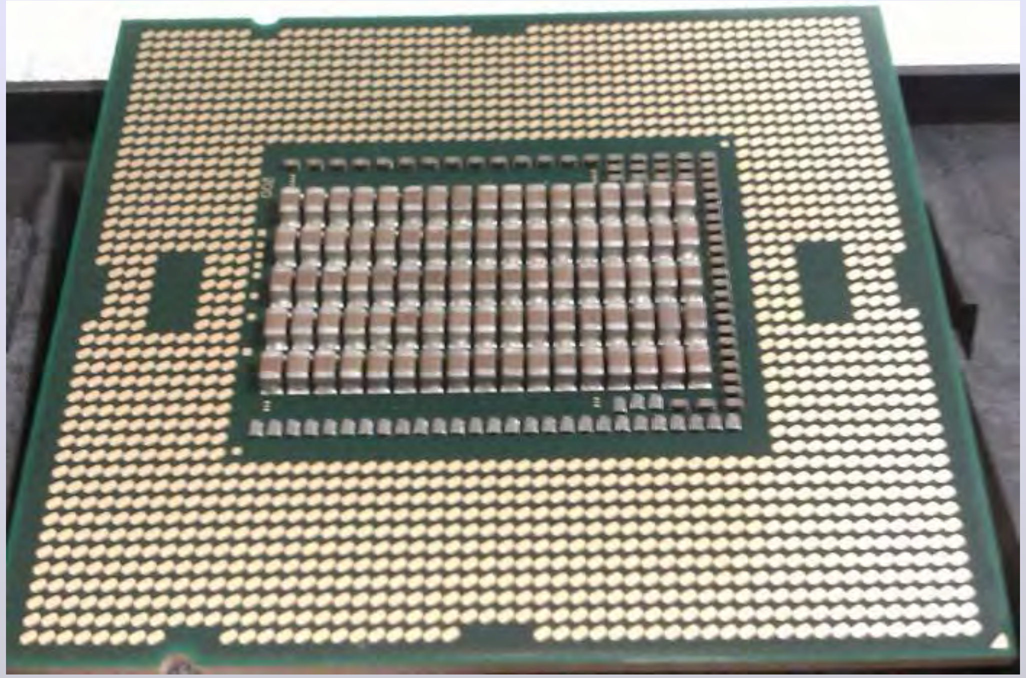




The result is a sample suitable for any additional F/A processing. The high quality surface allows easy SIL imaging and the uniform thickness speeds FIB processing.

Mechanical sample preparation processes

Often, there are mechanical processes needed to prepare a sample.

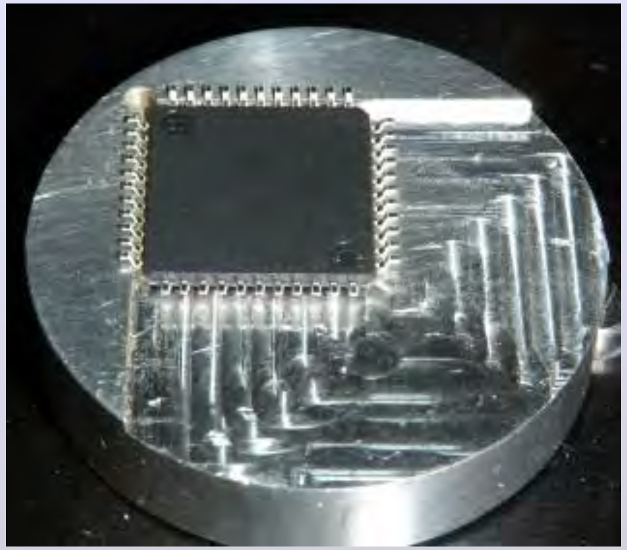


- Encapsulant and die attach removal
- Heat sink removal
- Substrate delayering
- Substrate removal
- Stacked die removal
- C4 ball exposure
- BGA removal from assembled PCBs

All of these processes are easily accomplished using the OmegaPrep. All processes are selectable from the main menu, from exposing a die in a plastic package to creating a custom fixture for a difficult sample.

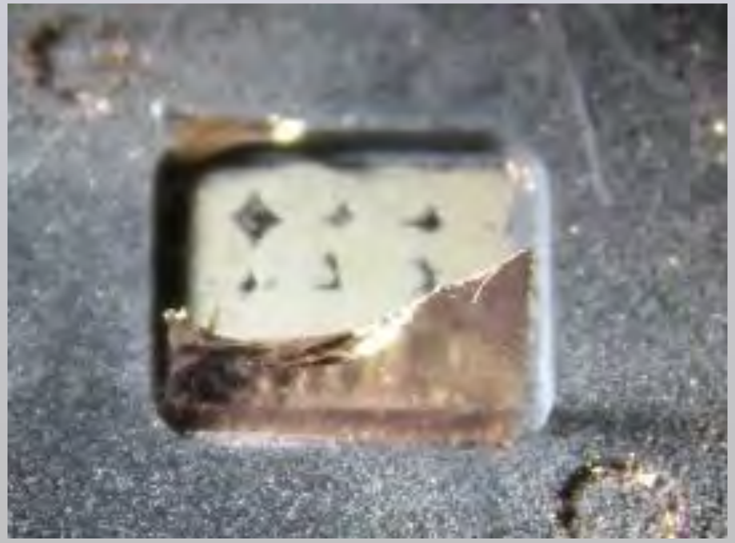
Encapsulant and die attach removal with plastic samples

Removing the encap and die attach metal is routine with plastic encapsulated samples.



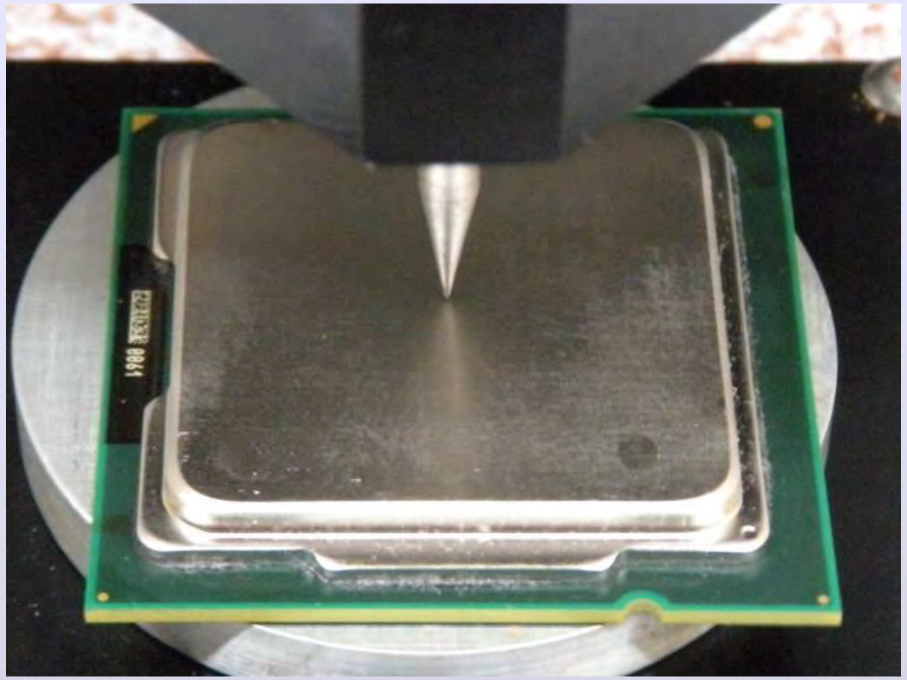
Selecting the EXPOSE DIE process allows the operator to machine through the encap. The OmegaPrep quickly exposes the die flag.

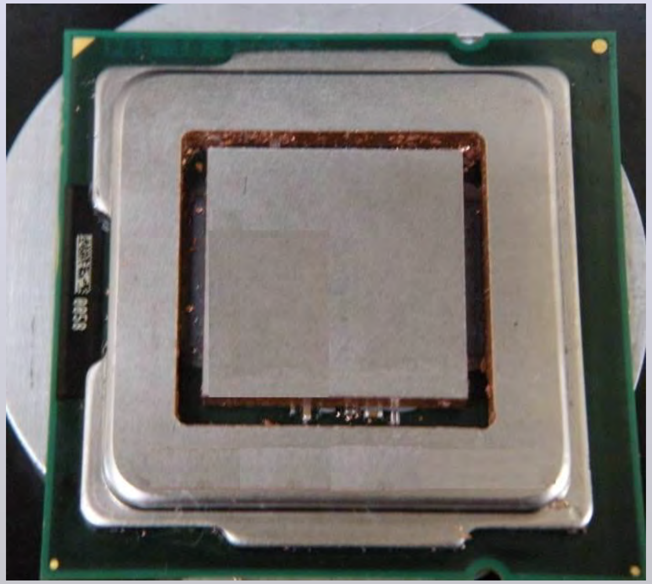
The die flag is partially removed automatically along with the encapsulant. The operator is then asked to control the tool depth so that the process can be terminated when the die attach flag is machined through. The operator then removes the remaining copper and adhesive manually.



Many samples have attached heat sinks.

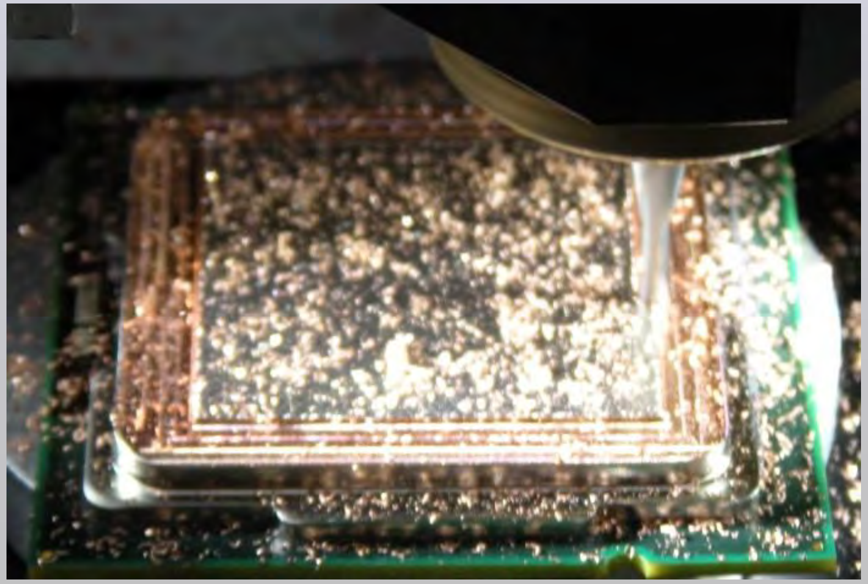
Removing a heat sink is often required to expose the encapsulant or the die itself. This can be done two different ways: machine off the entire heat sink or cut through it near the edges to separate it from the sample package.





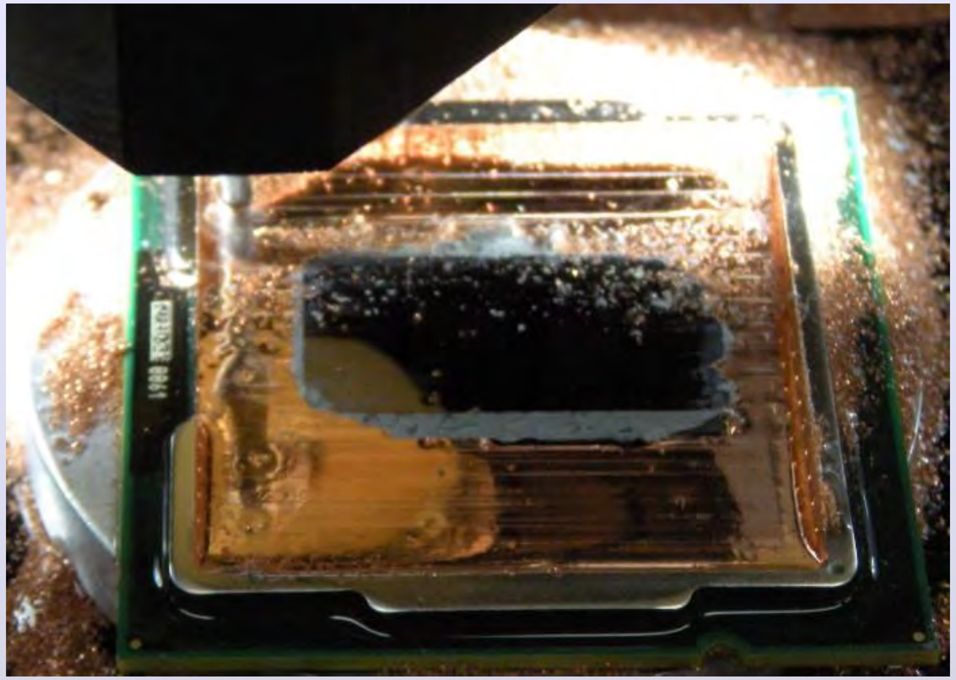
Cutting around the edges is the fastest but will not work if the heat sink is soldered to the die.

Machining through the heat sink takes longer but puts less stresses on the die.

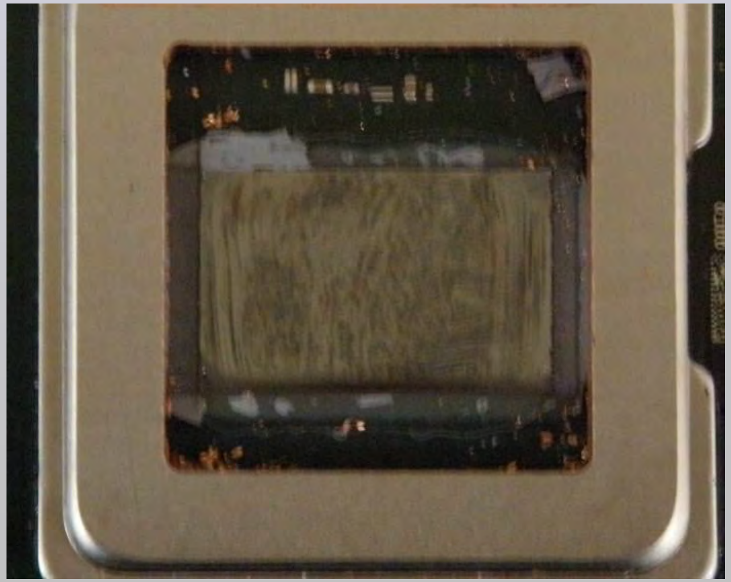


Removing heat sinks - continued

When machining off the heat sink, the process needs to be ended by the operator when the metal is broken through.

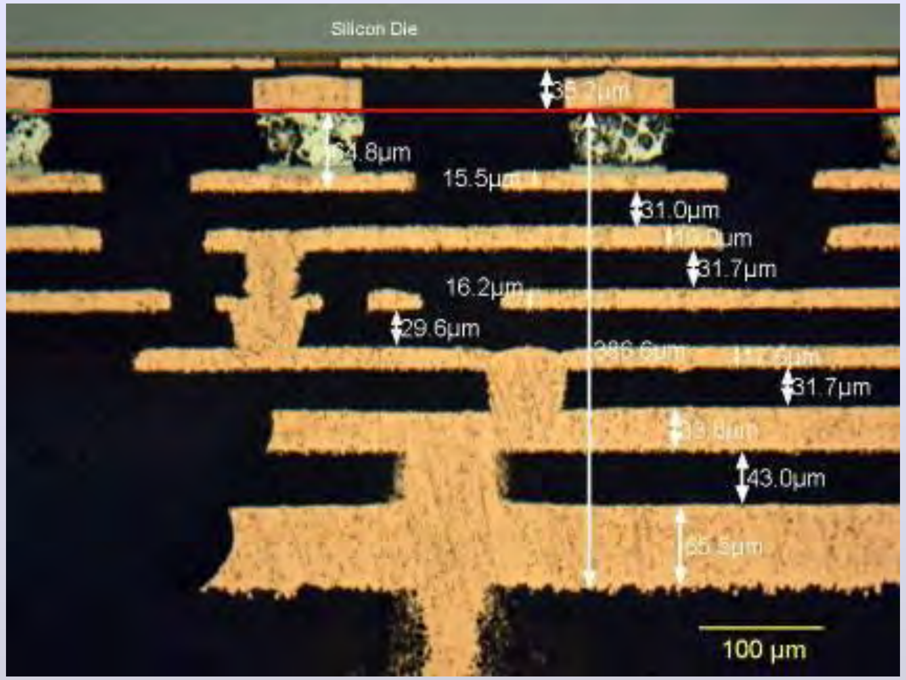


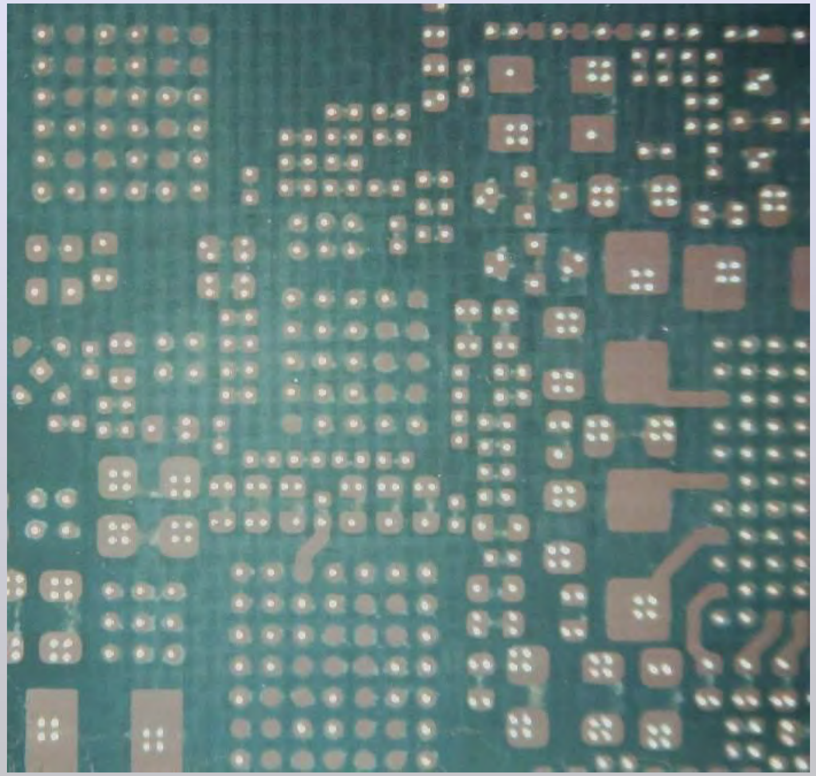
With either process, the end result is the heat sink being removed and the die exposed.



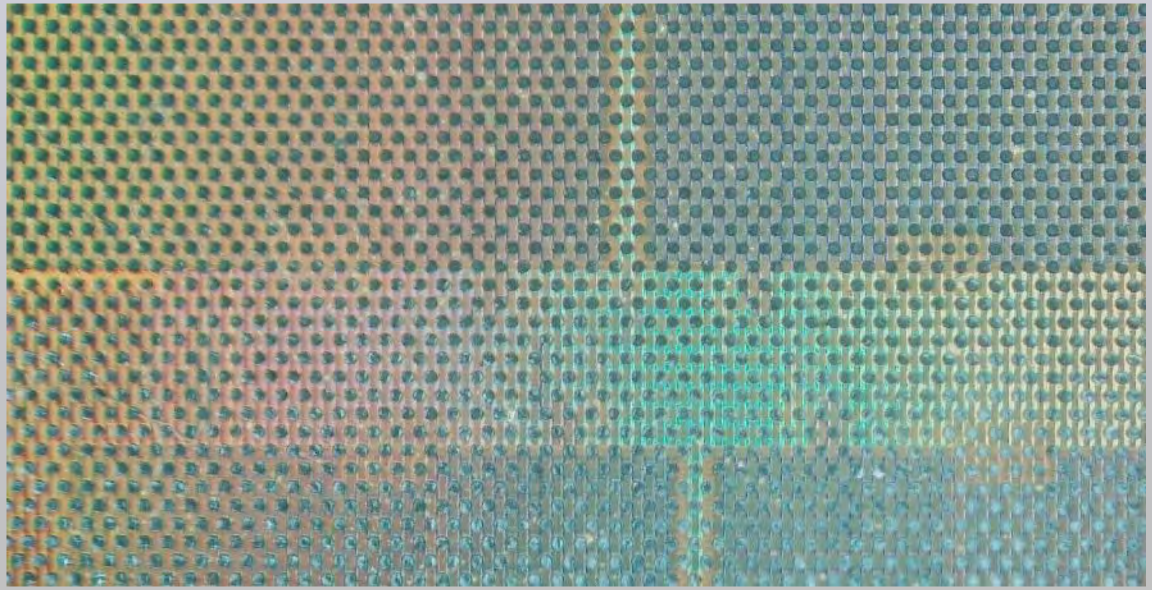
Some samples require the delayering of the PCB substrate

The PCB substrate of a sample can be easily disassembled one layer at a time. The profile machining capability of the OmegaPrep allows for accurate and "planar" layer removal.

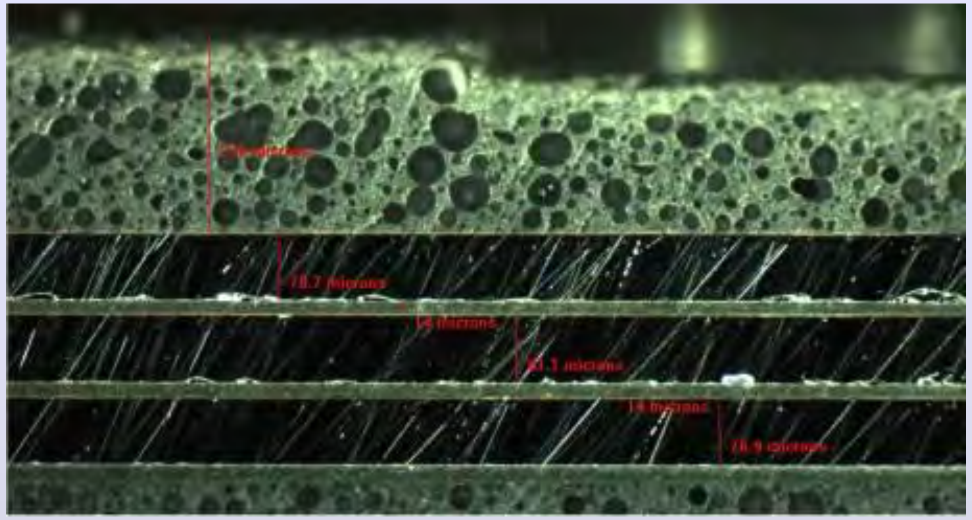




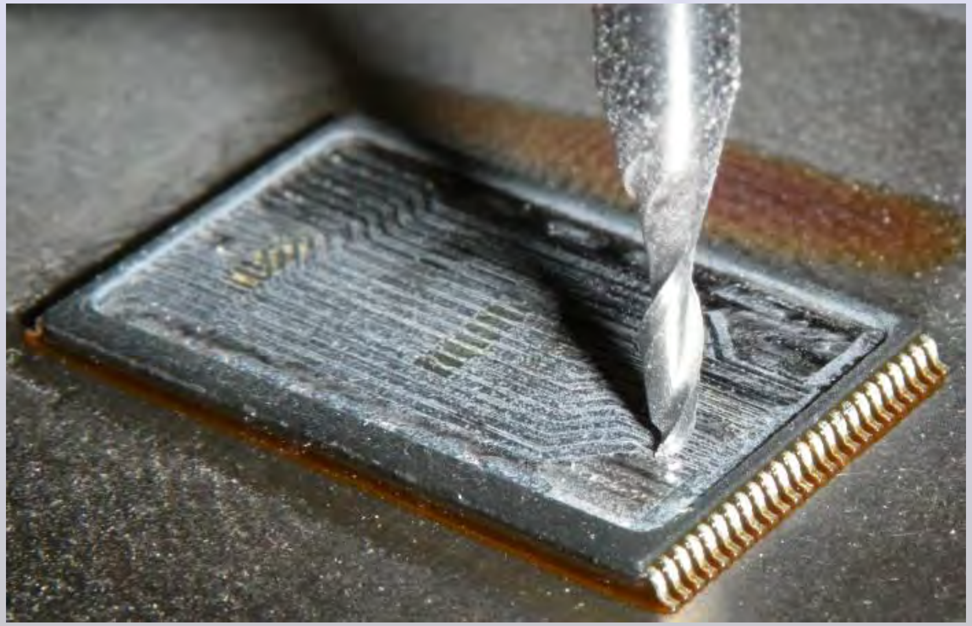
A given layer can be exposed or the entire substrate can be removed to expose components or the C4 balls of a flip chip.



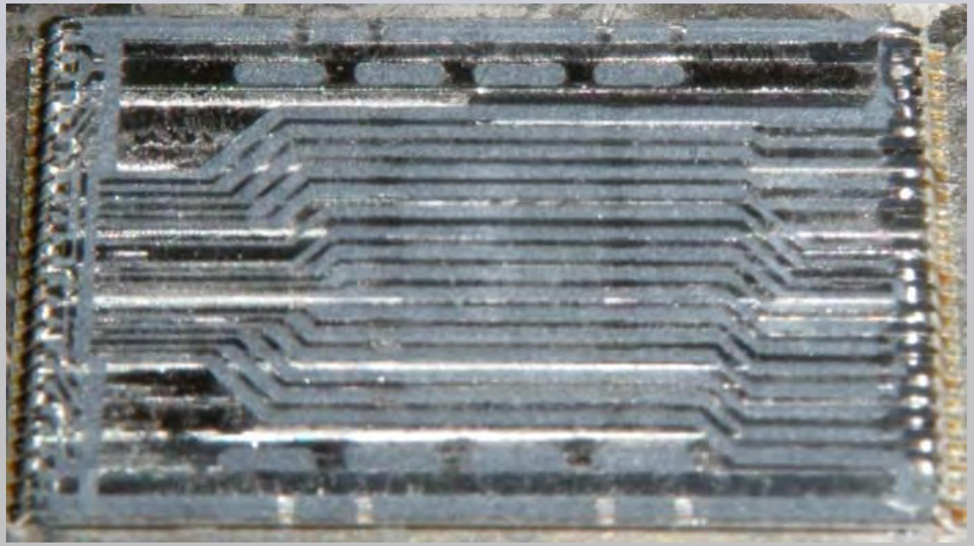
Some samples require the removal of stacked die.



Stacked die removal can be a serious problem. Each die in the stack has a different surface profile, none of which matches the surface of the package or lead frame.

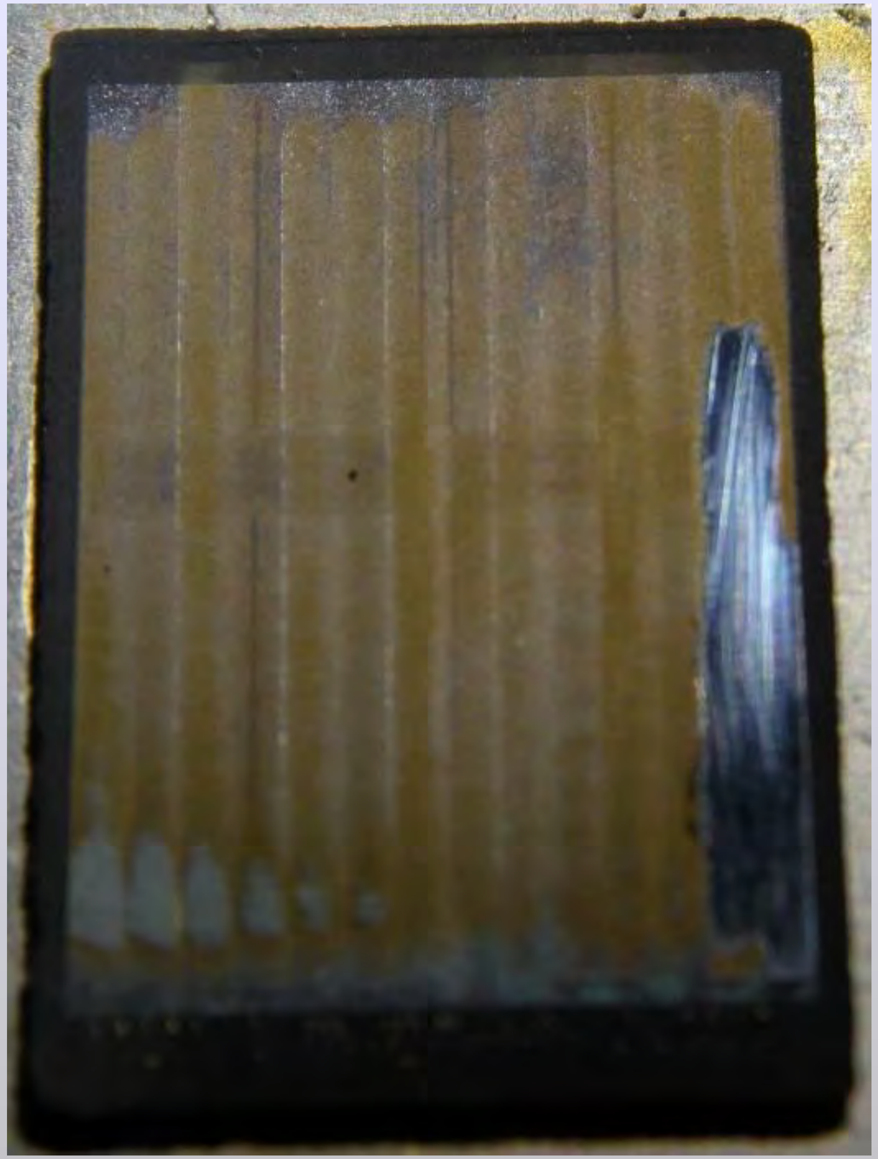


The first step is usually removing the encap and lead frame. Sometimes the lead frame can be complex and awkward to remove.



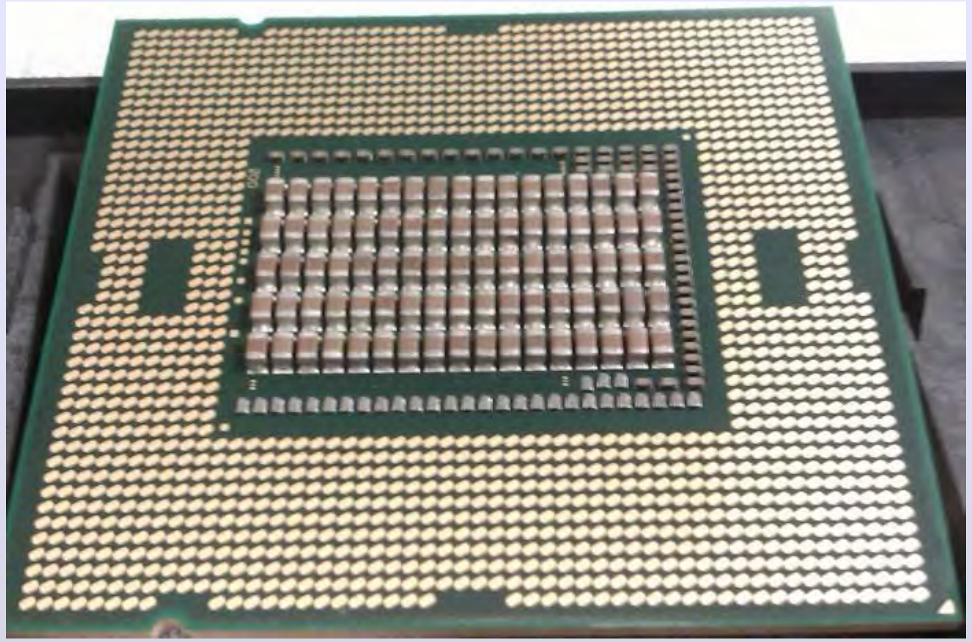
The removal of stacked die - continued

Once the encapsulation and lead frame are removed, the top die can be exposed.



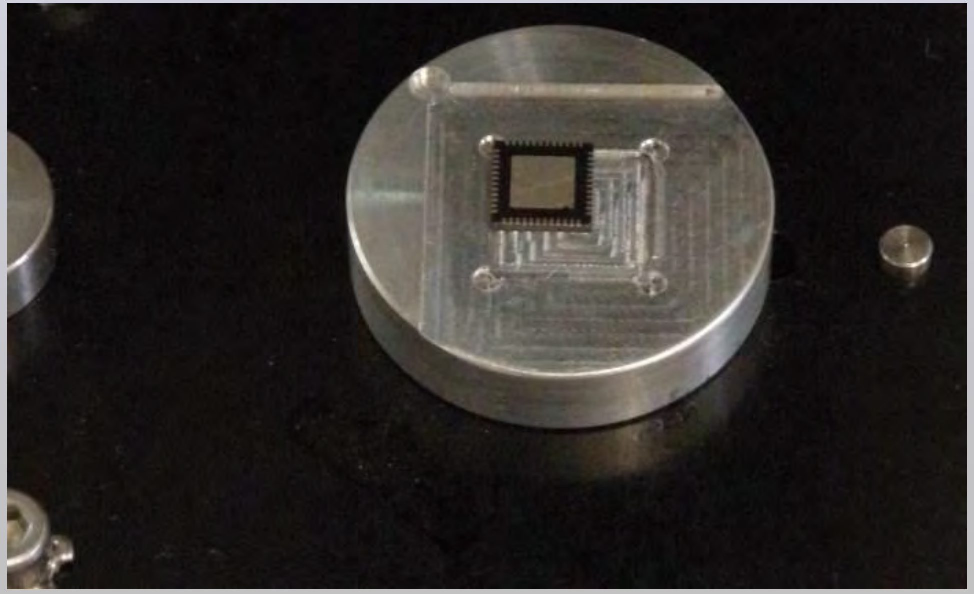
The adhesive is removed manually resulting in a clean die surface. The surface is then profiled and removed by grinding to the measured profile.

Modifying or creating custom fixtures



Some samples are difficult or impossible to mount on the standard fixtures. Some samples have surface mount components on the side mounts on the sample holder.

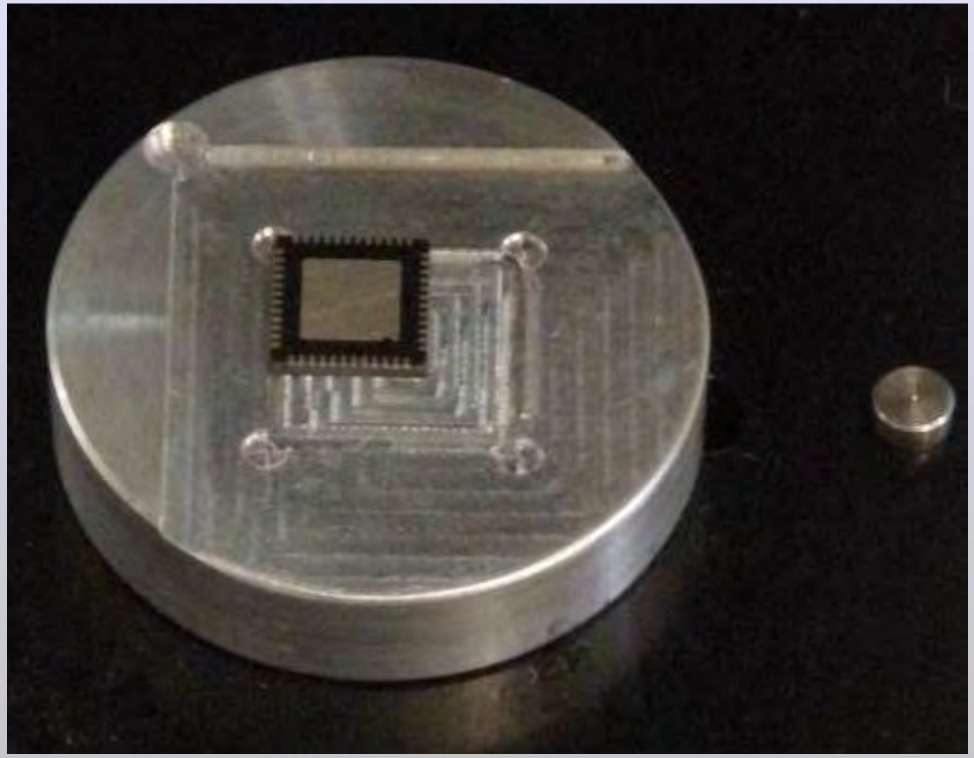
Other samples are very small with the bond wires very close to the die edges. This type of samples can not be mounted normally as the rotational reproducibility of the holding fixture would require re-alignment after each removal from the OmegaPrep.

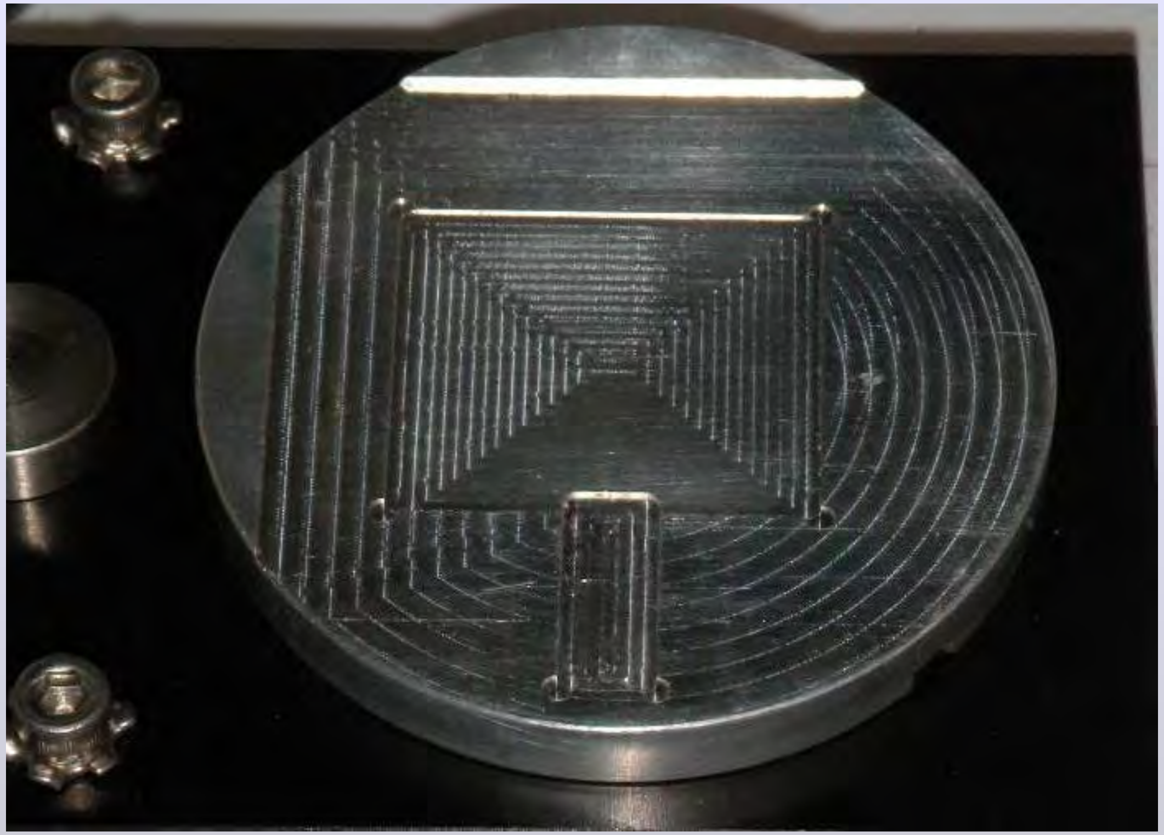


Both of these challenges can be dealt with using the fixture modification capability of the OmegaPrep.

Modifying or creating custom fixtures - continued

Fixtures can be easily modified to accommodate unusual package configurations.

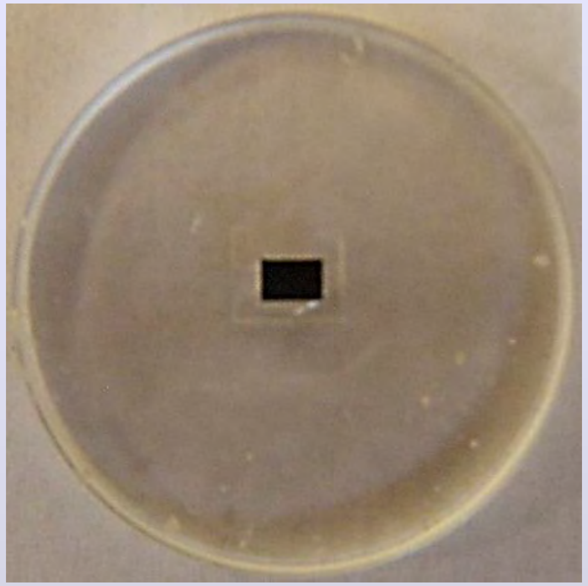


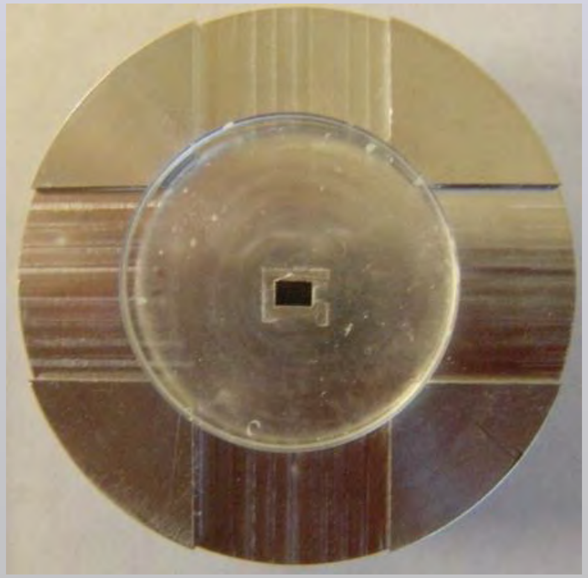


Fixtures can also be modified to align the sample center to the center of the fixture reducing die corner position movement with rotational positioning error and eliminating re-alignment between process steps.

Front side delayering

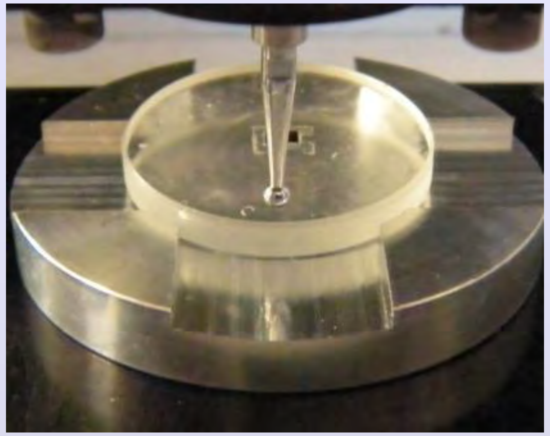
Die delayering requires special sample mounting techniques as well as special processing. After the sample die is completely removed from its packaging, it is mounted on a small diameter optical flat. A special, low viscosity UV curing adhesive is used. The die is placed on a small drop of adhesive in the center of an optical flat. Excess adhesive is extruded from under the sample. When the die is close to, and parallel, with the optical flat, the adhesive is set.



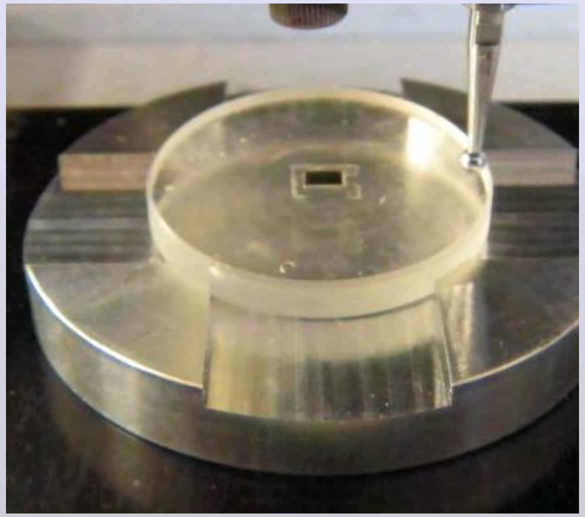


The optical flat is then mounted on a special sample holder using standard mounting wax. The die is now flat and parallel to the X-Y travel of the OmegaPrep.

Front side delayering continued

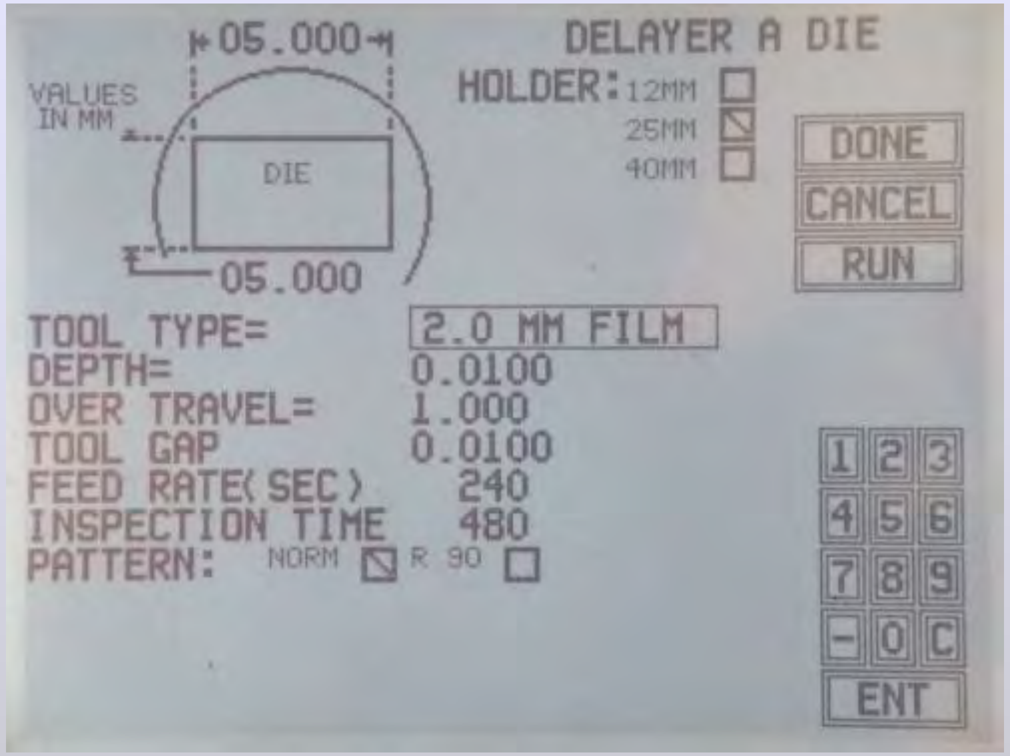


The OmegaPrep will not profile the die. This could produce surface damage that results in processing artifacts. Instead, it measures the plane of the optical flat to determine the operational plane of the tool face.

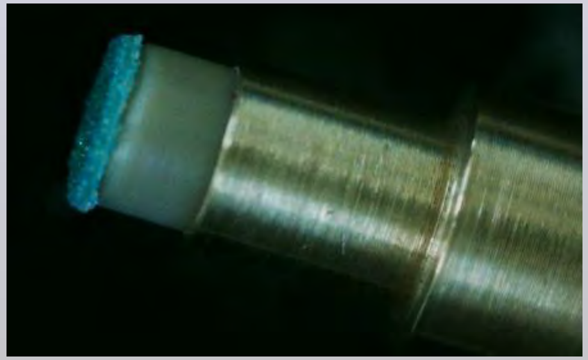


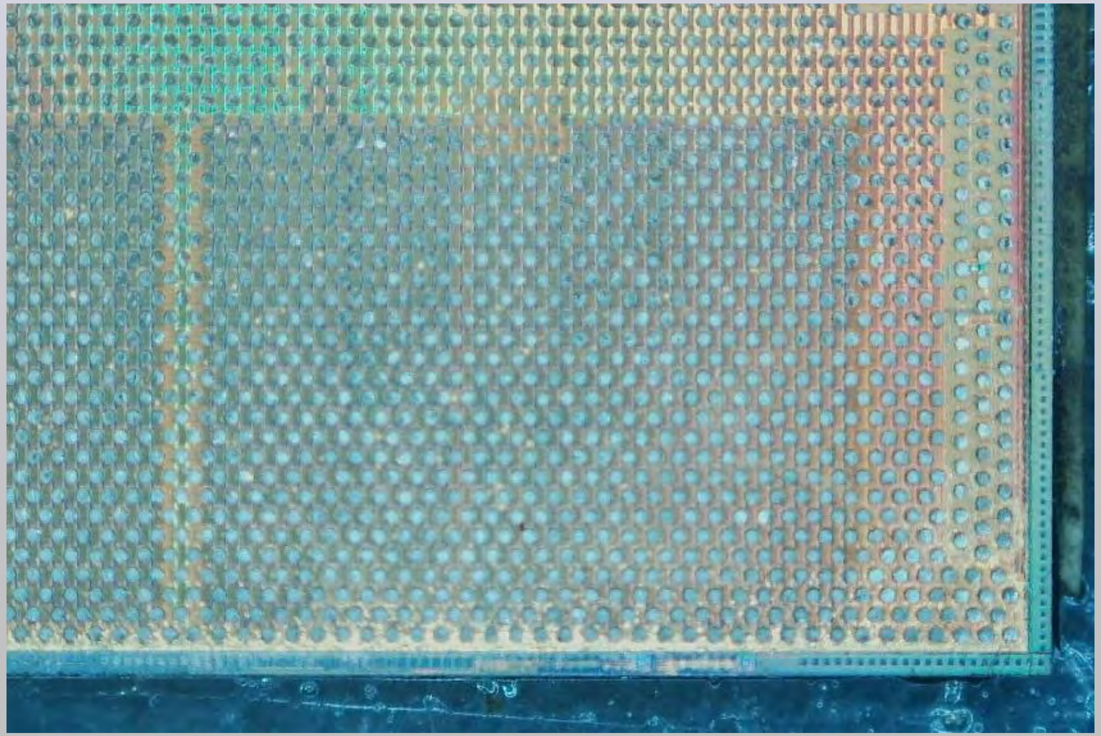
The selected lapping tool is moved in a plane parallel to the measured plane of the optical flat. If the mounting of the die was done correctly, the die surface will be absolutely parallel to the plane of the optical flat. Otherwise, the tool movement plane can be adjusted via the ‘tilt’ function during operation.

Front side delayering continued



Process parameters are entered that determine the type of tool used, the time between inspections of the die surface, tool in feed rate, and total tool downward travel. Additionally, the distance between the tool face and the die surface can be specified maintaining material removal in the hydrodynamic impact mode. This material mode is the most controllable for removing thin layers. For removal of polymer passivation layers may require direct contact between the die surface and an abrasive film disc.

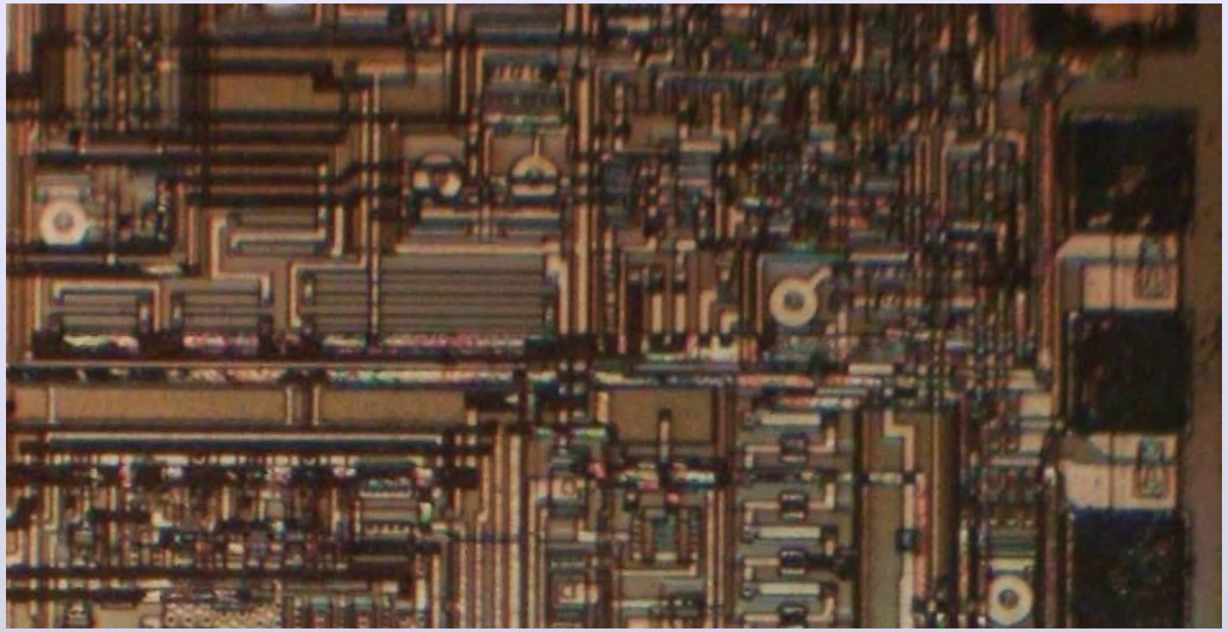


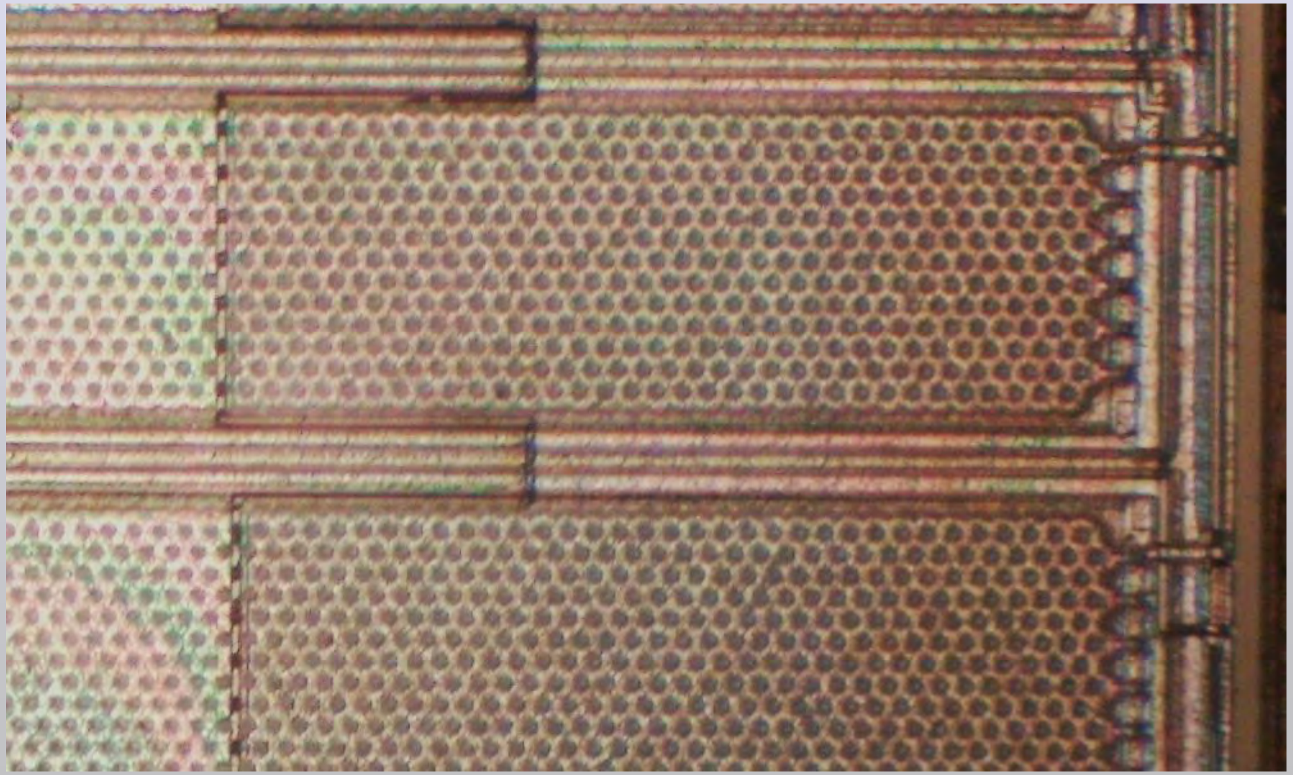


What ever tool is selected, the planarity can be adjusted with the tilt and travel controls and the end point is determined by visual inspection by the operator.

Front side delayering continued

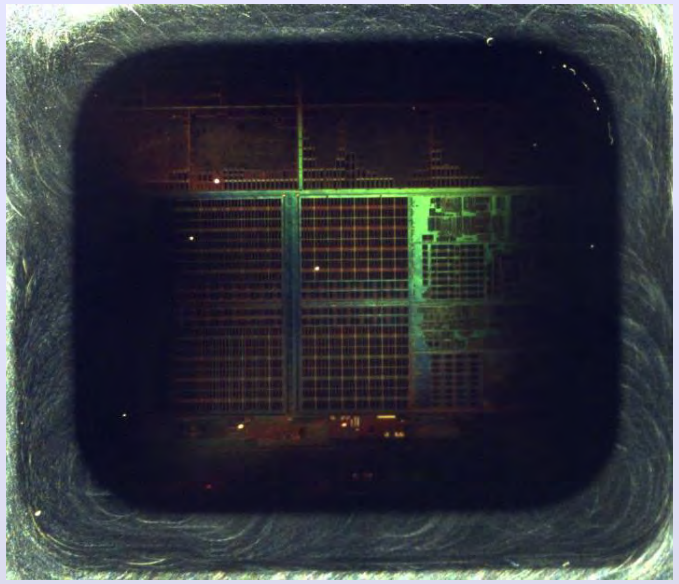
The process is continued, layer by layer with the operator making the end point determinations. It may be required for the operator to adjust the removal plane or tool travel limits to get optimal results.





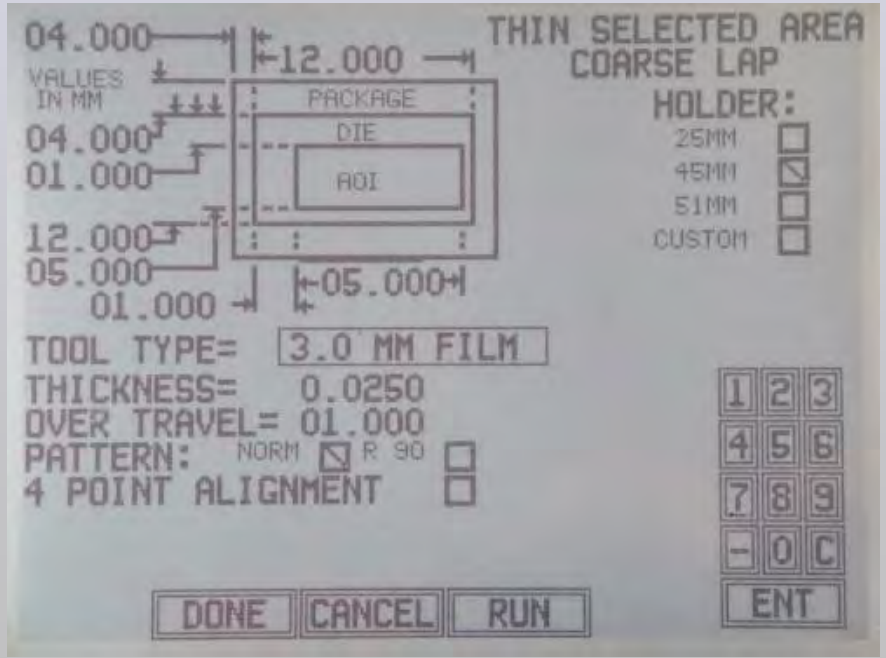
It is also possible to use specifically formulated CMP slurries that have enough chemical selectivity that the process essentially stops removing material at the desired layer. This requires both a lot of chemistry and equipment for dispensing the CMP slurry.

Area of interest die thinning



Thinning a large die to the thickness required for visible light probing is difficult and can make powering the die problematic. The solution is to first thin the die to 50 microns and performing gross fault analysis. When areas of interest are defined, these can be thinned to 1 to 5 microns for detained fault identification.

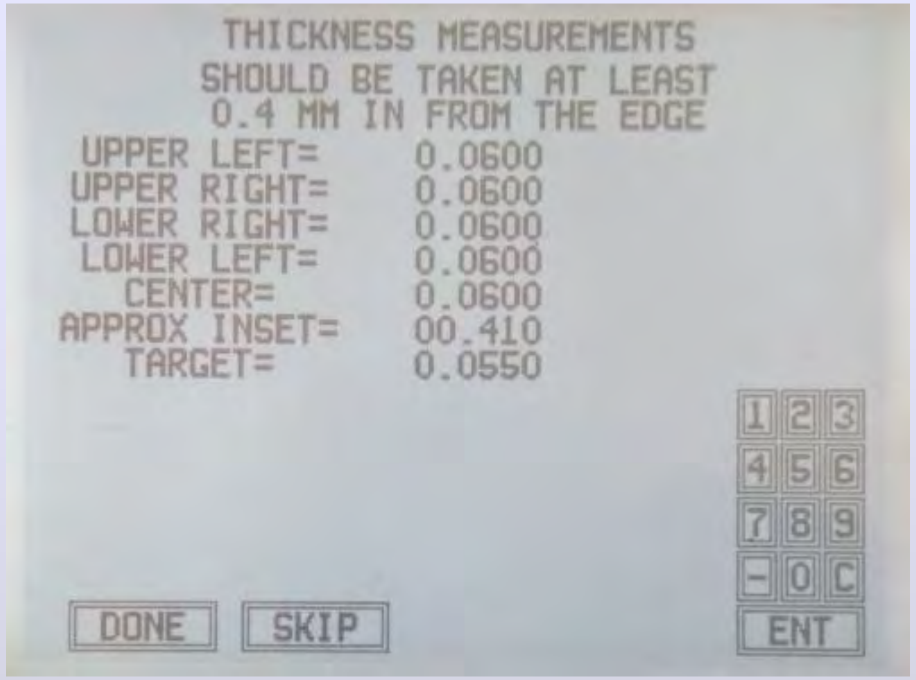
The OmegaPrep has processes available for area of interest thinning. These processes are accessed through a separate menu. The processes available and the programming of process parameters are similar to normal die thinning.

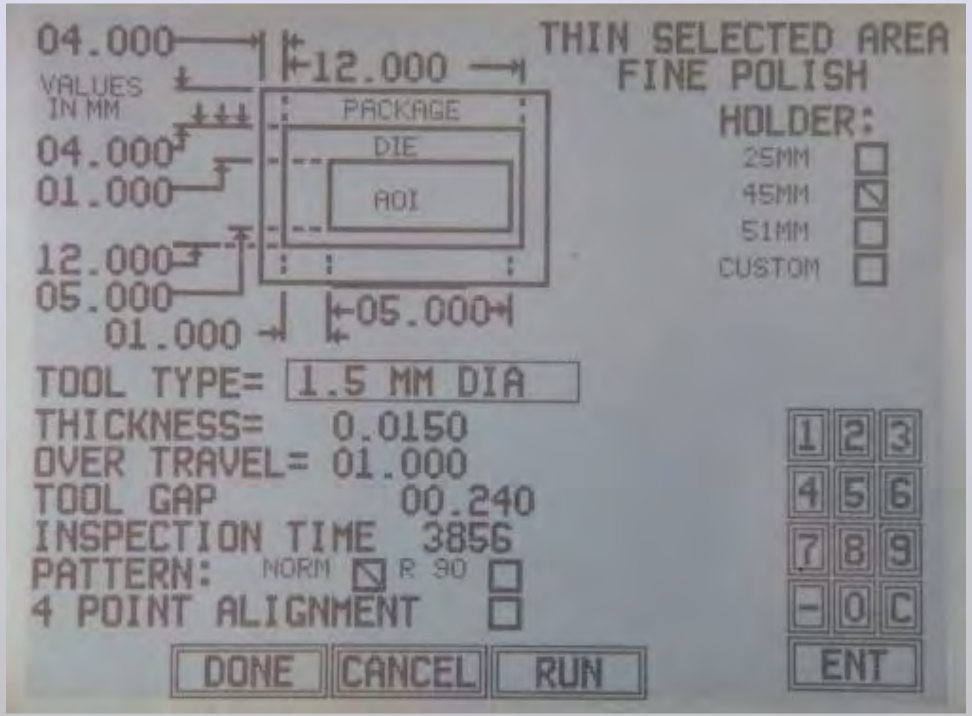


The differences are the addition of the size and location of the area of interest and the change from depth, or amount of material removal, to remaining silicon thickness. Since the removal of silicon is based on remaining thickness, either manual thickness entry or the use of the integrated thickness measurement system is required.

Area of interest die thinning- continued

In the beginning of each process step, the surface will be profiled. If the integrated thickness measurement system is available, it will measure the silicon thickness at each of the points where the mechanical surface profile was measured. If thickness measurements are taken manually, the results will need to be entered by the operator.



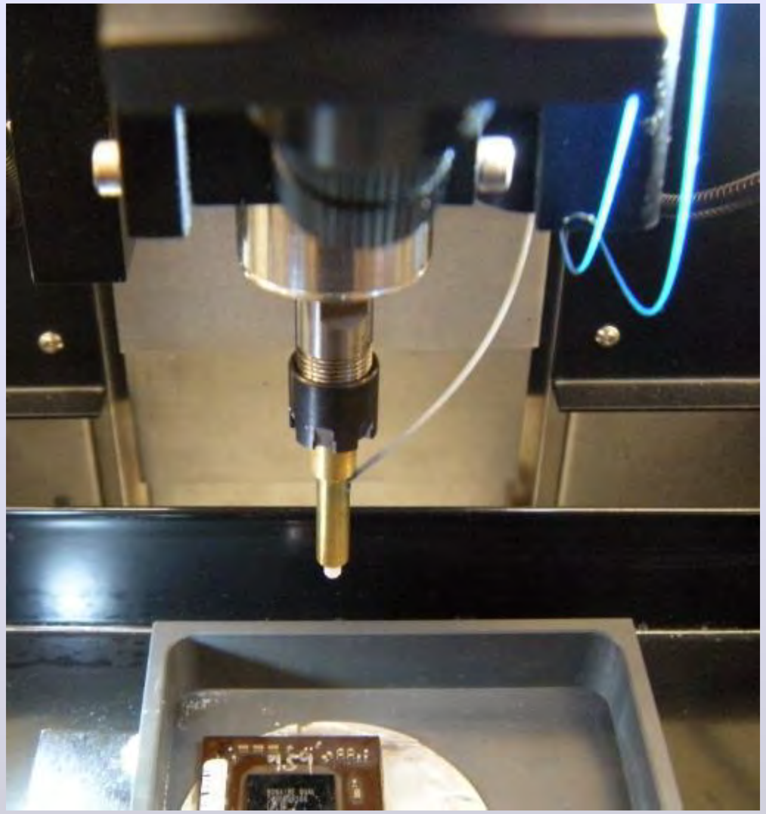


The later process steps can be done with the tool face not contacting the die surface. This is the same process used in the die delayering process to allow absolute control of the amount of material removed.

The distance from the tool face to the die surface is specified as ‘tool gap’ and, as the process may require operator intervention, the process will be interrupted on the basis of ‘inspection time’. The process interruptions for inspection allow the operator to adjust process parameters based on visual ques from the sample.

Integrated thickness measurement

An optional integrated thickness measurement system is available for the OmegaPrep that allows automatic measurement of remaining silicon from 200 to 0.5 microns in thickness. The measured points correspond to the points measured for surface profiles and the measurements are used to adjust the tool path to eliminate thickness variation.



When required, the operator will install the selected thickness probe. This fiber optically coupled, measurement system has two separate components, each with its own probe. One, using a NIR laser, measures silicon thickness from 15 to 200 microns. The other system utilizes a broad band light source and measures thickness from 0.5 to 15 microns.

These systems are not for independent thickness measurement. They are only for providing silicon thickness values for tool path correction. Due to the effects that active area patterns have on optical thickness measurements, special algorithms are used to fill in erroneous measurement values. This eliminates the need for re-focusing and re-positioning as required by separate thickness measurement systems.

The OmegaPrep

We do not break die. Period.

- Some samples are 'one of a kind'. The sample should not be damaged and data lost. We do our utmost to insure the survival of every sample without adding unknown artifacts, damaging the system, or endangering the operator.
- We can process samples to tight thickness tolerances by allowing the correction of the initial, measured surface profile for the actual measured remaining silicon thickness.
- With the optional thickness measurement system, area of interest thinning can be done to less than 4 microns.
- No curvature calculations, force feedback or other gimmicks. Four, five, or six axes are not required; only proper surface profile measurement and processing to the measured profile.
- The samples are processed to the initial measured profile that can be corrected for changes that occur during processing by either entering manual thickness measurements or using the optional thickness measurement system. Correction of the measured profile for stress re-distribution during thinning is mandatory for minimal thickness variation and can only be accomplished by multiple, spatially repeatable, thickness measurements.
- We can perform any mechanical process required to prepare a sample. Creating a holding fixture, heat sink removal, substrate delayering, substrate removal, removal of stacked die, C4 ball exposure, even die delayering. We can even remove devices from PCB assemblies.
- New problems often require new techniques and processes. RKD is the only company that continues to support all of its customers with new software, new techniques, and new processes as they are developed.
- RKD can provide custom fixtures for unusual devices, packages, and problems. We provide all aspects of customer support; custom fixtures, software upgrades, process development, and general problem solving.
- RKD Systems supports semiconductor failure analysis and related fields only. We do not polish gems, polish fiber optics, process metallographic samples, or sell microscopes.