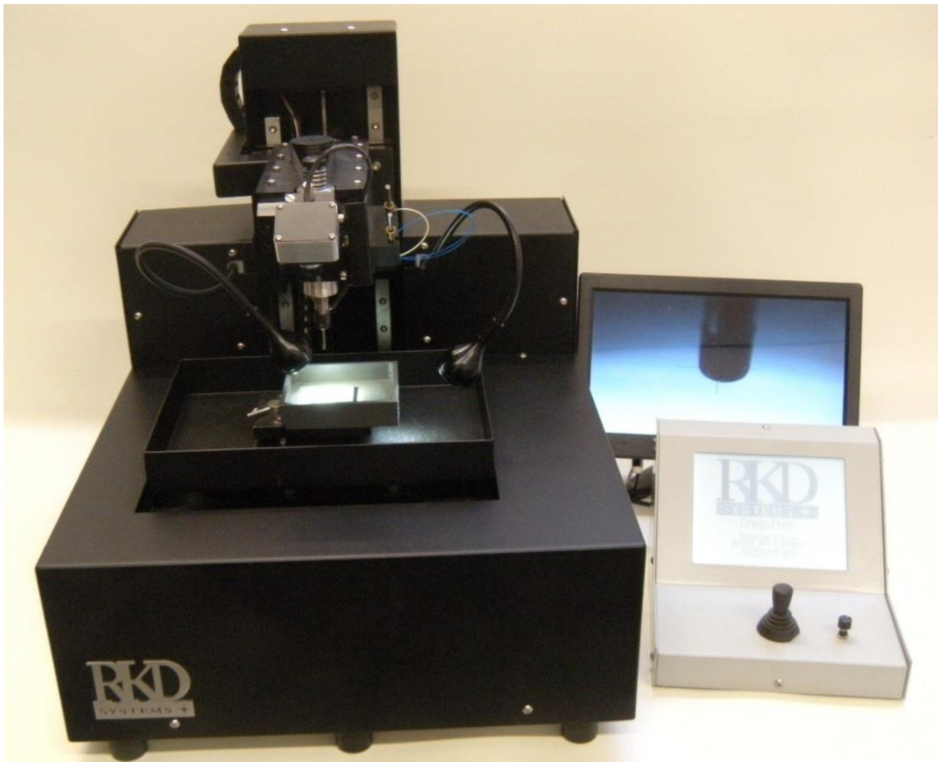
The OmegaPrep II And UltraPrep IV

Easy to use, automatic, machining systems for all mechanical sample preparation needs



A partial list of sample preparation Die thinning and polishing

- Thinning results with tight thickness tolerance
- Thinning corrected for measured remaining silicon
- Encapsulant and die attach removal
- Heat sink removal
- Substrate delayering
- Substrate removal
- Stacked die removal
- C4 ball exposure
- Die front-side delayering
- BGA removal for PCB assembly rework

The OmegaPrep II And UltraPrep IV

System features

- “Push start and go to lunch” operation
- No “baby sitting” required unless operator end point detection is required
- Recipes can be saved for later use
- All process and measurement data is saved and reported
- Simple sample mounting and alignment
- Fast, easy set up - Including video alignment
- Four point die alignment is available to eliminate rotational errors
- Simple operator interface with full process programmability
- System automation of thinning and polishing processes
- Programmable depth accurate to +/- 1 micron
- Removable sample holders – allows removal without re-mounting or aligning
- Contour tool path for grinding, lapping and polishing
- No leveling required during mounting or on the machine
- Little final thickness variation on thinned die < 2.0 microns at 50 micron remaining silicon thickness and <0.5 at 1 micron RST
- Manual input of measured sample thickness for precise thickness control
- Easy removal of heat spreaders, encapsulant, and die attach pads
- Available and inexpensive tooling
- Small footprint – takes little bench space
- Near zero down force during die thinning

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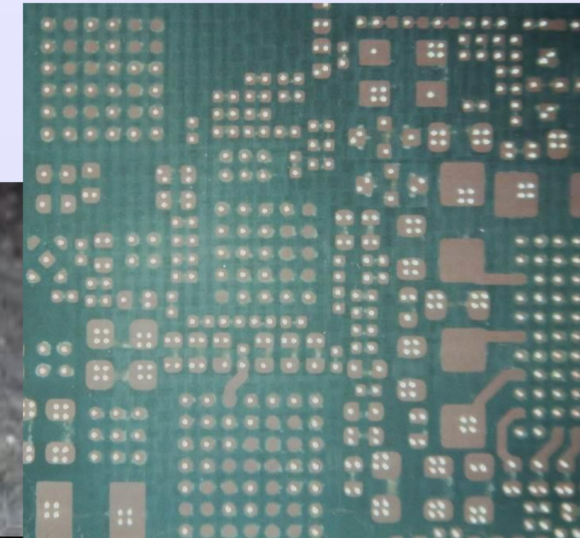
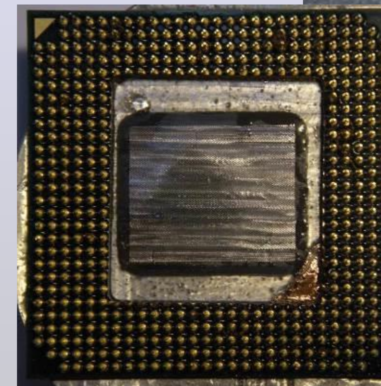
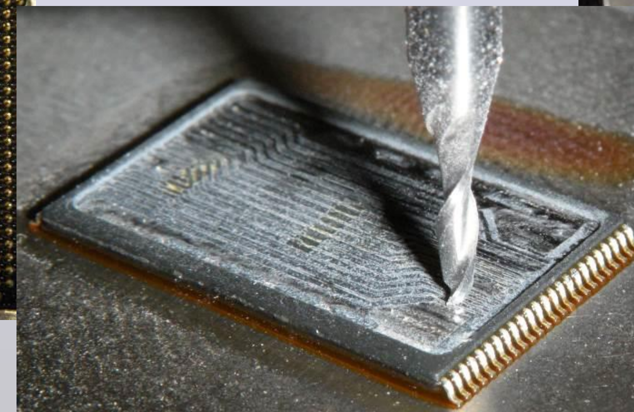
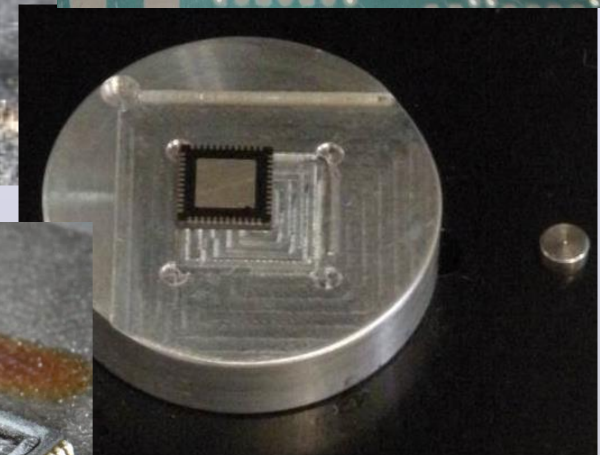
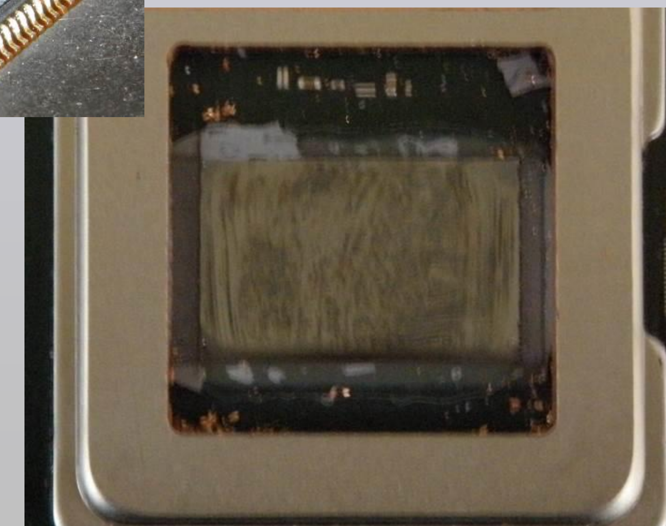
Mechanical sample preparation processes

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
- Make special fixtures
- Machine stiffeners
- Open or remove RFI shields
- PCB and substrate editing

All of these processes are easily accomplished using the OmegaPrep II or UltraPrep IV. 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.

The OmegaPrep II And UltraPrep IV

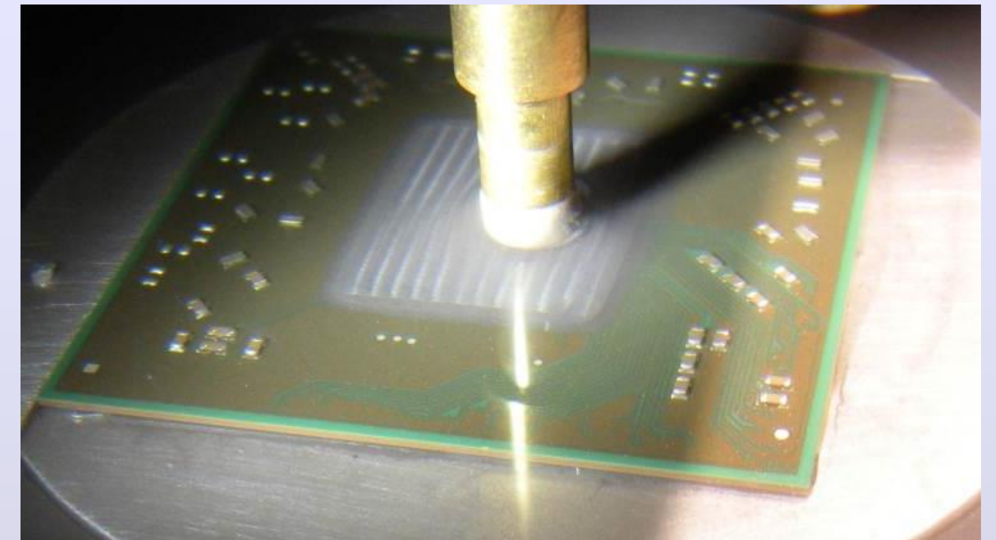
Die thinning processes

After the die is exposed, the die can be thinned.

- Gross thinning with a diamond grinding tool
- Low force gross thinning with coarse diamond lapping film
- Coarse lapping with diamond lapping film
- coarse lapping with small diameter consumable tools
- Lapping with fine diamond lapping film
- Lapping with diamond slurries
- Polishing with fine diamond slurries
- final polishing with colloidal silica

All of these processes are easily accomplished using the OmegaPrep II or UltraPrep IV. All processes are selectable from the main menu, from gross silicon removal using a grinding tool to final polish using a polishing pad and colloidal silica.

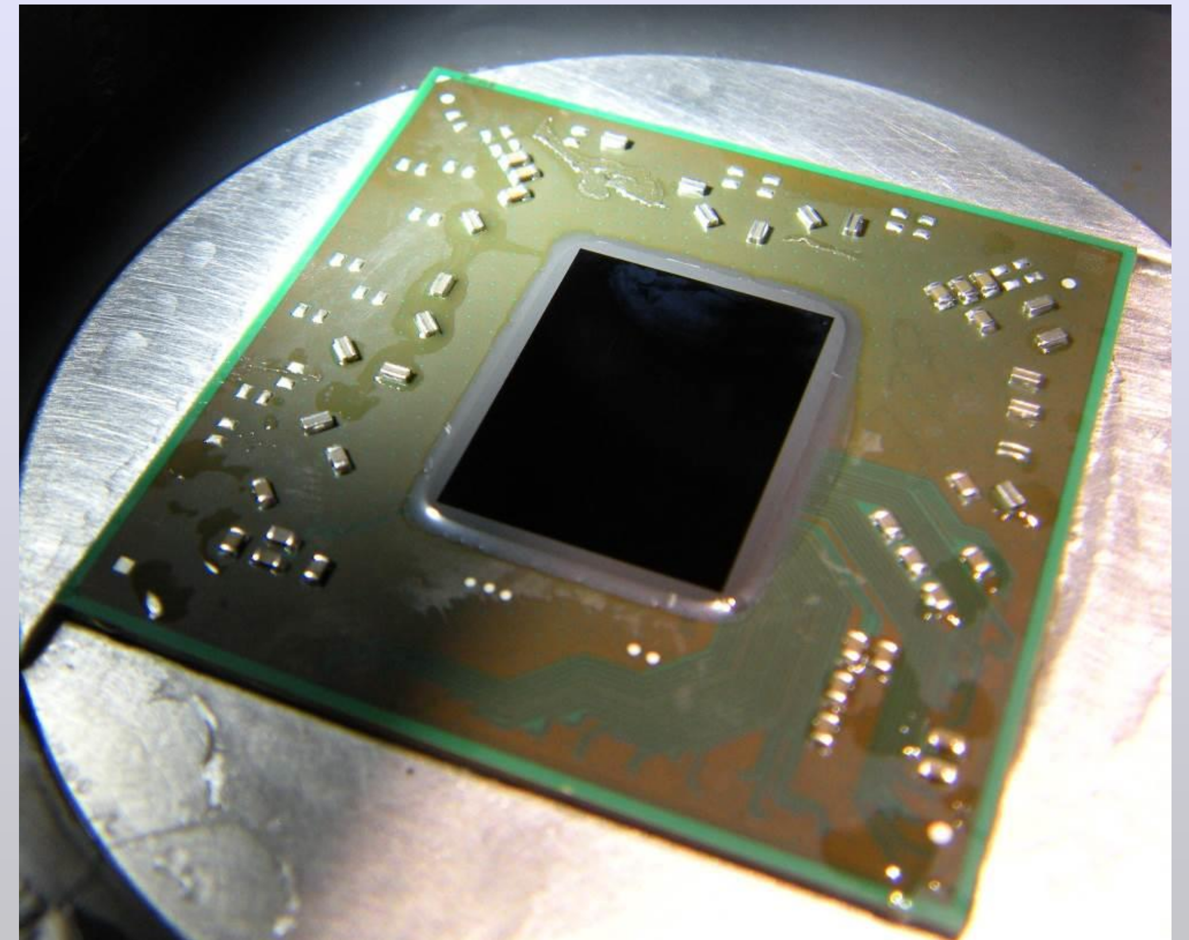
A wide selection of tools and abrasives are available for every process step. Small die are processed using consumable tools and slurries. Larger die are processed with either diamond lapping films, or a cloth pad and slurries.

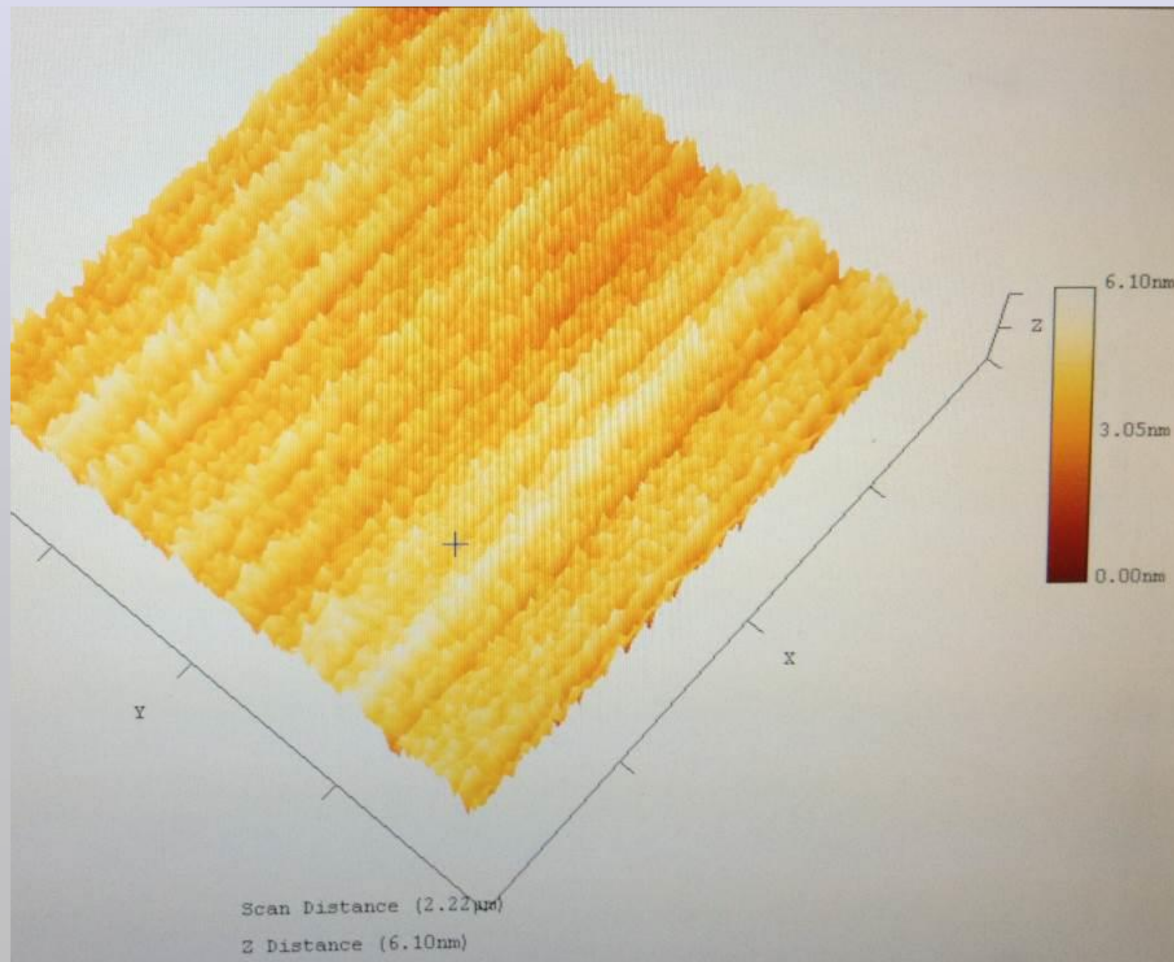


The OmegaPrep II And UltraPrep IV

Die thinning - 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 ± 2 µ 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.

The OmegaPrep II And UltraPrep IV

Remaining silicon thickness control

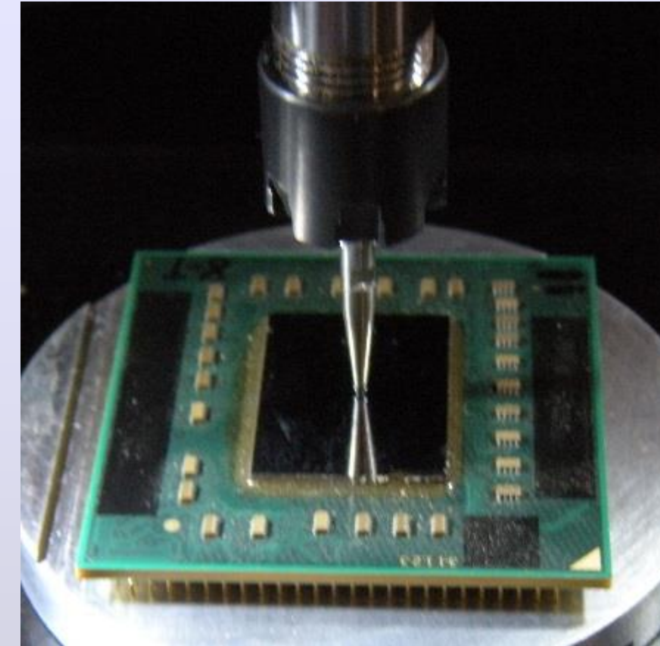
The first step in remaining thickness control is to measure the profile of the die surface. No die is flat after being packaged. Different materials with different thermal expansion characteristics are used in the packaging. The simplest system is a ‘flip chip’ where the IC is soldered directly to the package substrate. Both components are heated to the melting point of the solder balls on the chip. The solder flows, electrically connecting the die to the substrate. As both are cooled, the solder solidifies mechanically joining the die to the substrate. As the thermal expansions of the die and substrate are different, when cooled to room temperature, each component contracts at a different rate. As the two are mechanically joined, the difference in thermal contraction creates stresses that cause both parts to curve. This is just like the bi-metal thermostat that controls heating/cooling system in most houses. Some claim that a die can be flattened by heating the substrate. If the substrate and die are at the same temperature, they will always be curved up to the temperature where the solder melts. If they are not at the same temperature, it may be possible to flatten the die. The temperature gradient required is not well defined and can not easily be controlled. As the die is thinned, the curvature caused by the stresses will change requiring a different thermal gradient to keep the die flat. Using a lubricant or slurry during the process complicates this as the gradient is determined by the heat flow through the substrate and the heat loss from the die’s exposed surface. A slurry or lubricant will change the heat loss from the die surface and the amount of heat that needs to be lost is a function of the thickness of the remaining silicon. It can be done, but there are a lot of variables to control.

The most reliable and reproducible solution is to measure the surface profile and move the tool bit so as to replicate the profile. The die/substrate still change shape during processing, but correcting for the changes is much easier than controlling a very dynamic thermal gradient from a constant heat source through a die that is changing in thickness and a slurry that changes in composition and emissivity. The RKD Systems sample preparation systems are designed to be run by an operator, not an engineer with a PhD.

The first step in the thinning process, after alignment of the die corners, is to measure the die surface profile.

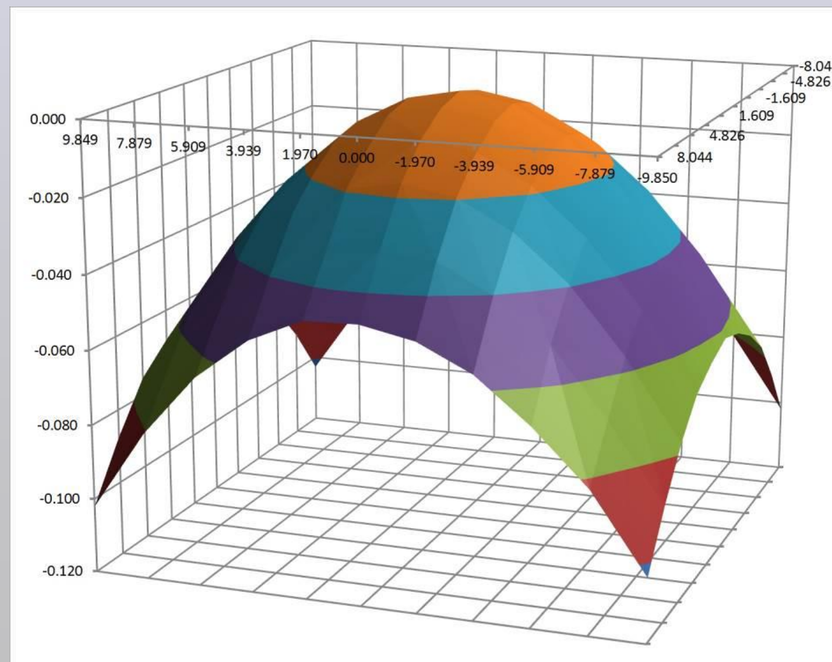
The OmegaPrep II And UltraPrep IV

Remaining silicon thickness control - continued



The first step is to define the position of the die corners. This informs the system of the actual die size, rotation, and relationship to the machine's reference points. For die that are mounted parallel to the package edges, this could only require aligning two opposite corners. For die that are rotated as referenced to the package, a four corner alignment can be selected to provide precise die size, location, and rotation.

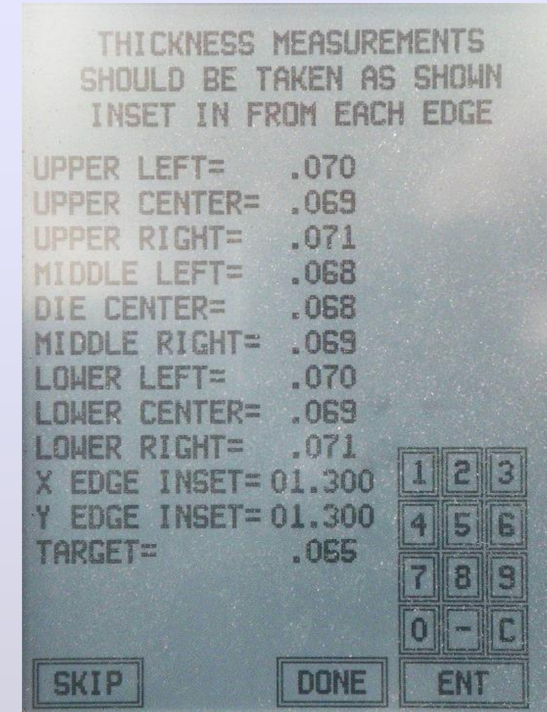
The system will then measure some number of points on the die surface. The number of points and their locations are determined by the system. A 35 mm X 35 mm die will have a lot of measurements, typically 361. A 5 mm X 5 mm die will only require 9 surface measurements and a 2 mm X 2 mm die will only need 4.



The surface height measurements are taken and converted into a wire frame representation of the die surface. The cardinal points of the wire frame are shown to the operator for review. Although there are no mechanical corrections for mounting slope and the systems will compensate for mounting deviations, there are second order effects of the mean slope of the die surface. Proper mounting should produce a mean surface slope of only a few microns per millimeter. A 15 mm X 15 mm die, if mounted carefully, will have less than 15 microns height difference between opposite edges. More than this can make getting a uniform silicon thickness more difficult. A little attention to early details can make later processes much easier.

The OmegaPrep II And UltraPrep IV

Remaining silicon thickness control - continued



After gross removal of silicon with either coarse lapping film or a diamond grinding tool, the die surface is cleaned up with a medium lapping film or slurry. The surface will then allow optical measurements of remaining silicon thickness. The thickness is measured in a 5 or 9 point pattern at a specified distance from the die edges. The measured thickness values are entered and are used to adjust the next process's measured surface profile.

Measurements are taken between each step and used to adjust the next one. This continues through the steps producing a die with very consistent thickness. A typical target thickness of 50 microns can be reached with +/- 2 microns total variation without significant operator intervention. If one step does not remove near the desired amount of silicon, it may have to be repeated. If a step removed more than desired, remaining steps will need their removal targets changed. This is all easy and done between process steps, not on the fly as with other systems.

The process, with little modification, can produce the desired results every time. A novel sample may take some minor process development, but the basic recipe is the same and all of the results will be the same.

Some samples have been encountered where the packaging stresses are very high. Attempting to use a grinding tool for gross thinning can result in fracture of the die. A gross thinning process is available that used a coarse diamond lapping film, eliminating die fracture resulting from high internal stresses and processing forces.

Specifications

	OmegaPrep II	UltraPrep IV
Machine size	425 mm high, 375 mm wide, 450 mm deep	375 mm high, 375 mm wide, 350 mm deep
Weight	30 Kg Shipping weight 35 Kg	25 Kg Shipping weight 30 Kg
Power requirements	90 to 250 VAC 49 to 61 Hertz at 4 amps maximum	
Operating temperature range	16 to 26 degrees C	
Operating RH	10 to 85% non-condensing	
Usable die size	0.5 mm to 48 mm per side	
Usable machining area	0.25 mm to 60 mm per side	
Maximum package size	225 mm X 155 mm with special fixturing	67 mm X 52.5 mm with standard fixtures
User interface		
Screen size	145 mm diagonal	
Input type	stylus touch screen	
input data resolution		
X and Y positional values and dimensions	0.001 mm	
Z axis positional values, dimensions, depths, and thicknesses	0.0001 mm	
Video monitor screen size	10.1 inch diagonal	
Video magnification	X 10 typical for alignment X 20 typical for process observation	
Video resolution	NTSC/PAL standard	
X axis travel	135 mm (110 mm usable)	59 mm
Y axis travel	135 mm (128 mm usable)	62 mm
Z axis travel	80 mm	55 mm
Travel speed	5 to 500 mm/minute	5 to 450 mm/min
Spindle speed	2000 to 10,000 RPM	

Values printed centred across both columns (power requirements, operating temperature range, operating RH, usable die size, usable machining area, user interface values, video values and spindle speed) apply to both machines.

Specifications - continued

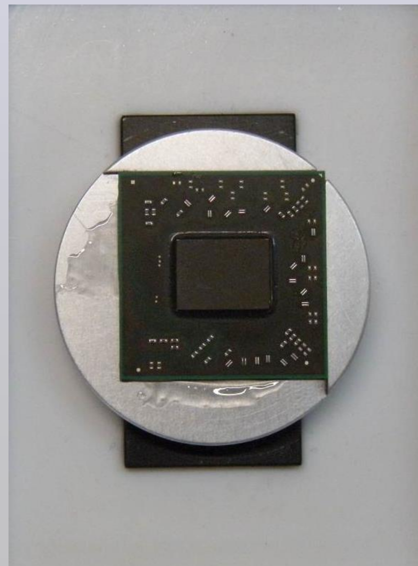
	OmegaPrep II		UltraPrep IV
Axis mechanical resolution and repeatability			
X and Y axis Resolution	0.000496 mm		0.0003125 mm
Z axis resolution	0.000248 mm		0.0003969 mm
X and Y axis repeatability		+/- 0.001 mm in same direction	
X, Y axis overall repeatability		+/- 0.002 mm at constant temperature	
Z axis repeatability	+/- 0.00025 mm in same direction of movement		+/- 0.00035 mm in same direction of movement
Z axis overall repeatability	+/- 0.0005 mm at constant temperature		+/- 0.0007 mm at constant temperature
Scale resolution and accuracy			
Resolution		0.000244 mm	
Scale accuracy		+/- 0.040 mm/meter	
Hysteresis		< 0.002 mm (uncorrected)	
Geometry			
X to Y axis		+/- 0.50 mrad maximum	
Z to X-Y plane		+/- 0.50 mrad maximum	
spindle axis to X-Y plane		+/- 0.25 mrad typical	
Spindle run out		0.003 mm maximum	
Spindle collet type		ER-8 0.125 inch supplied	
Surface measurement repeatability		0.0015 mm maximum 3 sigma over 25 repeated measurements	
Surface measurement contact force		50 grams typical	

The OmegaPrep II And UltraPrep IV

Options, tools, and accessories

The MountPlate II

The RKD Systems Model 2200 MountPlate II is a specially designed hot plate used for wax mounting of integrated circuit packages in preparation for back side thinning and polishing or mechanical decapsulation. The unit heats the sample holding fixture up at a controlled rate to prevent thermal damage or the establishment of thermal induced mechanical stress in the sample being mounted. When the programmed temperature is reached, the operator is prompted to mount and align the sample. When this is done, the MountPlate will cool the sample and holding fixture at a controlled rate setting the mounting wax. When the sample is cooled to the resting temperature, the operator is prompted to remove the mounted device and holder.



Specifications

Temperature program range	60 to 140 degrees C.
Heating ramp rate	Programmable from 0.1 to 1.0 degrees per second
Cooling ramp rate	Programmable from 0.1 to 1.0 degrees per second
Soak time	Programmable from 1 to 60 seconds
Rest temperature	36 degrees C nominal
Temperature accuracy	+/- 1.0 degrees C
Weight	10 pounds (4.6 Kg)
Size	5.5 inches high X 6.5 inches deep X 11 inches wide (140mm X 165 mm X 180 mm)

The OmegaPrep II And UltraPrep IV

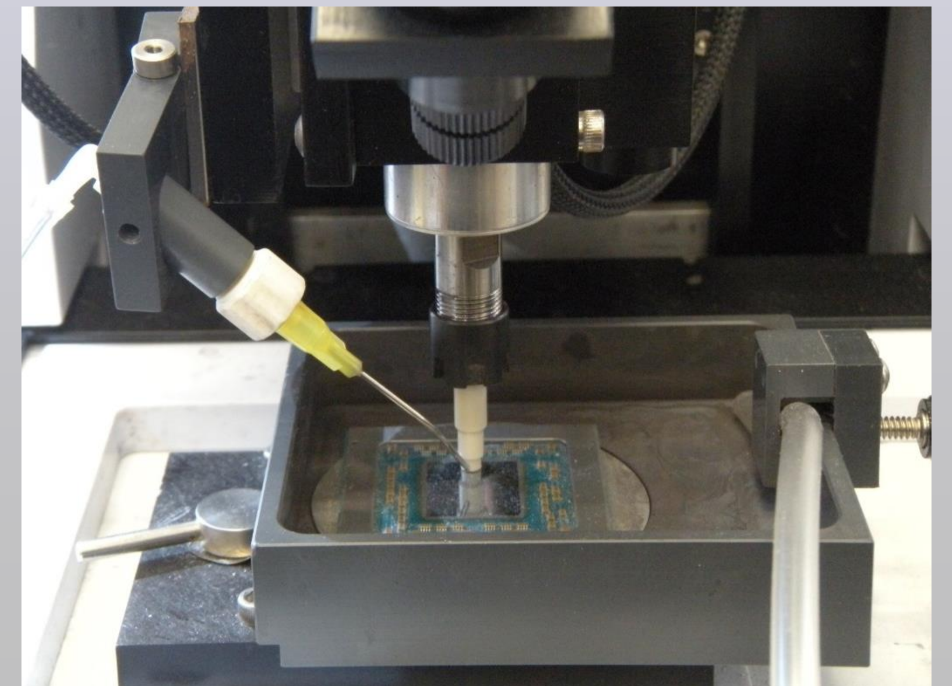
Options, tools, and accessories

The Model 2400 Flow System

The RKD Systems Model 2400 Continuous flow System is a small, compact, machine that provides a continuous flow of water or lubricant over a die surface during die thinning processes that utilize lapping films. Two pumps provide dispensing and scavenging of the lubricant. One pump dispenses clean lubricant from a source bottle while the scavenging pump extracts the liquid from the process cup and moves it to a waste bottle. Both bottles are contained by the system. Level detection is provided to detect a near empty source bottle or a nearly full waste bottle. The bottle housing provides secondary containment and leak detection. Both visual and audible indications are provided for bottle level conditions and leak detection.

The supplied waste extraction assembly clamps onto the process cup providing easy setup without modification of standard tooling. The dispensing assembly clamps onto the spindle carriage assembly of the UltraPrep IV or OmegaPrep, allows dispensing through a standard hypodermic needle, and allows precise adjustment of the point where the liquid is dispensed.

The continuous flow of lubricant over the die surface increases material removal rates, increases film lifetime, and reduces the tool force on the die. This is done by removing the silicon particles generated by the lapping process. Without a continuous flow of lubricant, the particles accumulate on the lapping film preventing full contact of the abrasive with the die surface reducing the removal rate. The controls are simple with a knob that controls dispensing rate and buttons to start or end dispensing, fill the dispense line, or drain the waste line.



Specifications

Machine size	
Width	225 mm (8.75 in.)
Height	155 mm (6 in.) without bottles 280 mm (11 in.) complete
Depth	200 mm (7.90 in.)
Weight	3 Kg (6.6 lb.) Maximum dry
Dispense flow range	0 to 40 ml/minute
Scavenge flow	100 ml/ minute
Bottle volume	1000 ml (32 ounces)

The OmegaPrep II And UltraPrep IV

More options, tools, and accessories

Optional high speed spindle

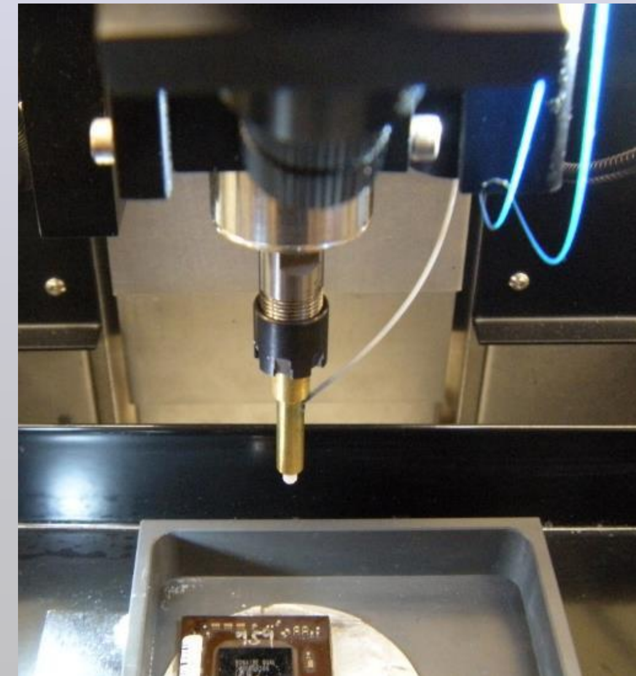
A high speed spindle option increases the maximum spindle speed from 10,000 to 14,000 RPM. This option includes software that adjusts the spindle speed according to the tool diameter being used. This optimizes tool speed and allows much higher material removal rates when using small tool diameters. With this option, a 2.5 mm diameter tool can remove as much material as a 3 mm tool in the same amount of time. This is a valuable option if small die or smaller tool diameters are required.

Optional software for local area thinning

Special processes are available that make local area thinning fast and easy. With this option, there is no need to calculate pattern locations. Direct program entry of area size and displacement from the upper left die corner eliminate the need for alignment of the local area. There are also processes included that allow precise control of removal rates and significant reduction in the effects of tool path positional accuracy. This comes with a significant increase in process speed, but allows a 10 to 1 increase in process control. This can make a 1-micron thick area of interest possible.

Optional thickness measurement

Thickness measurement capability is available in two different ranges. The high range system has a measurement range of 20 to 300 microns and the low range system has a measurement range of 0.5 to 40 microns. Both systems are included in the option, each with its own optical probe.



The included software will measure precisely positioned points on the sample that can be easily correlated to the mechanical profiles. There is a special function in the software that will search for a place that will provide a good reading while still being close to the theoretical measurement point. This function duplicates the searching for a valid thickness reading that a good operator does when measuring sample thickness.

The entire measurement process runs automatically. Depending on the sample, the process can be slow, but it does not require any operator intervention. The operator is allowed to enter estimated values for points that are not measurable.

The OmegaPrep II And UltraPrep IV

Options, tools, and accessories

Optional thickness measurement, continued

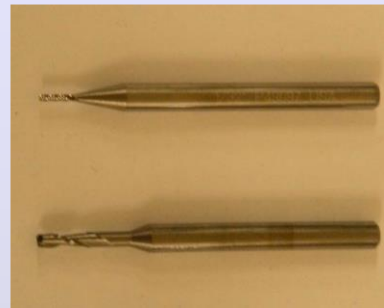
Specifications

	High range	**low range**
Maximum measured thickness	300 microns	40.0 microns
Minimum measured thickness	20 microns	0.5 microns
Measurement accuracy	+/- 1% of reading +/- 1 micron	+/-2.5% of reading +/- 0.1 micron
Effective spot size	< 15 microns	< 220 microns
Wavelength range	1529 nm to 1567 nm	730 nm to 990 nm
Maximum sample surface slope	20 mrad (20 microns/mm)	20 mrad (20 microns/mm)
Maximum thickness variation	25 microns/mm	thickness > 30 microns – 3 microns/mm thickness 20-30 microns - 2 microns/mm thickness 5 to 20 microns – 1 micron/mm thickness < 5 microns – 0.1 microns./mm
Measurement time	5 seconds typical per location	4 seconds typical per location

The OmegaPrep II And UltraPrep IV

More options, tools, and accessories

Consumable tools are used with slurry.



End mills are available in hundreds of sizes but RKD Systems only stock and supply two sizes.

The accessory kits include a wide range of tools and supplies.

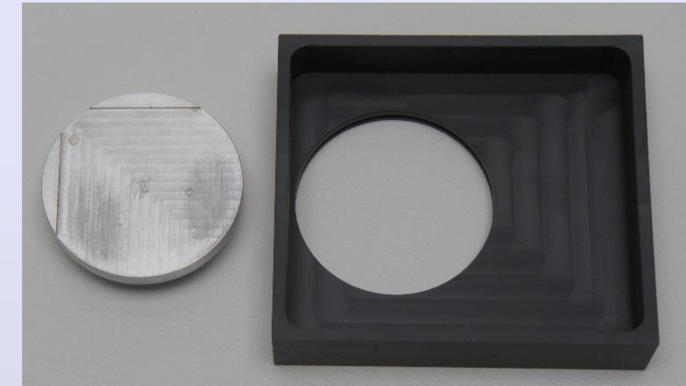
Grinding and lapping tools are available in a wide range of diameters and shapes.

The OmegaPrep II And UltraPrep IV

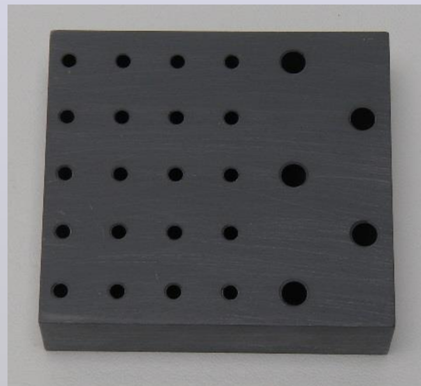
More options, tools, and accessories

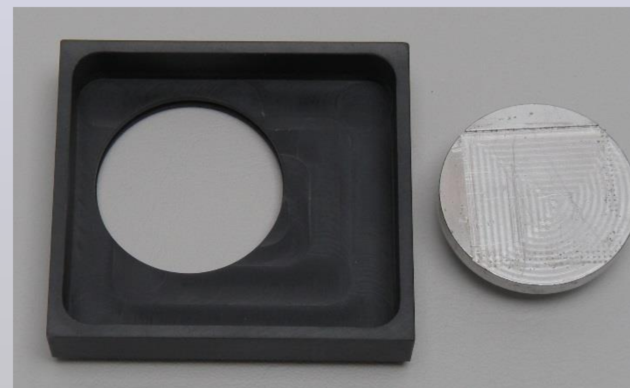
A tool setter is supplied to allow mounting tool bits properly.

The touch tool is supplied with two different tips that screw into the shaft

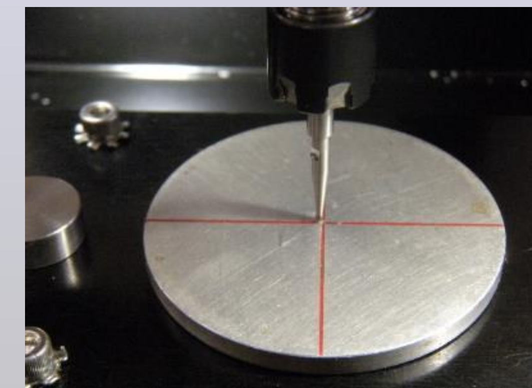


A large part holder and its process cup.





A 45 mm part holder and its process cup.



An alignment fixture is provided for aligning and setting machine and camera zero points.

The OmegaPrep and UltraPrep

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.