# The UltraPrep

## Die active surface delayering

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

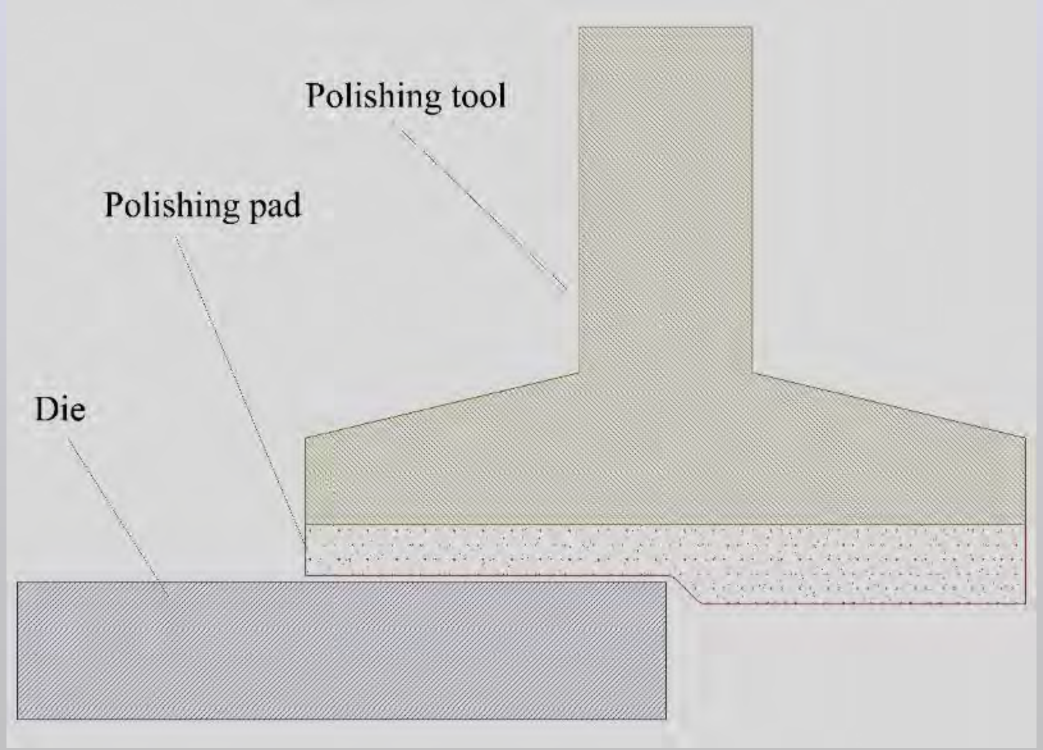
- Die thinning and polishing
- Encapsulant and die attach removal
- Heat sink removal
- Substrate delayering
- Substrate removal
- Stacked die removal
- C4 ball exposure
- Die delayering
- Automatic leveling and surface profile measurement
- Simple sample mounting and alignment
- Recipes can be saved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

RKD SYSTEMS

# Die delayering – the mechanisms of polishing

When using an abrasive slurry to remove material, there are two possible modes of abrasion. The first, and most commonly used, mode is through direct contact of the surface carrying the abrasive particles, the polishing pad, and the surface being abraded. This removes material at a rate dependent on the surface speed of the pad and the pressure forcing the two surfaces together. The removal rate can be high, making depth control difficult as there is compliance in the pad that produces much higher effective pressures as the pad moves beyond the edges of the surface. The distance the pad moves beyond the edges of the die surface determines the uniformity of the process. The pad must move at least half of its diameter beyond the die edges to maintain a uniform time of contact over the entire die surface.

When the pad is half off of the die, the remaining portion that is on contact with the die surface is subject to twice the pressure. Part of the pad is compressed by the increase in contact force while the part not in contact relaxes. The Transition between relaxed and compressed causes rounding of the edges of the die. A hard pad or a pad without nap reduces the effects but does not eliminate them. Even a hardened steel tool without a pad has some compliance. It may be very small, but the layer thicknesses are very small.



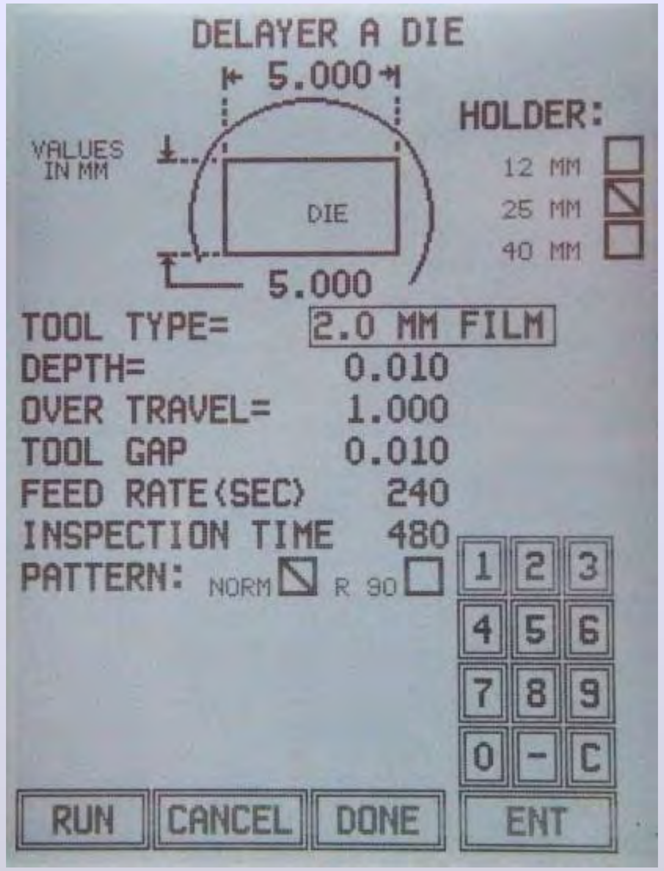
# Die delayering – the mechanisms of polishing continued

The distance from the die surface and the pad must be greater than the maximum diameter of the abrasive particles but not so large that laminar flow is dominant.  As material is removed, the distance between the die surface and the pad needs to remain constant. This requires moving the tool down at the same rate as material removal. It is also required that the pad surface is nearly planar. No strings, lumps, or hanging chads. This may require dressing the pad to make it flat with respect to the tool axis and to remove any surface variations. Pad dressing functions are available in the normal UltraPrep maintenance functions.

This gives the following process parameters that need to be programmed into the process:

- Die size
- Tool travel beyond the edges of the die
- Starting distance from the die surface to the pad
- Down feed of the tool face in seconds per micron
- Time between visual inspections of the die surface
- Total down feed of the process

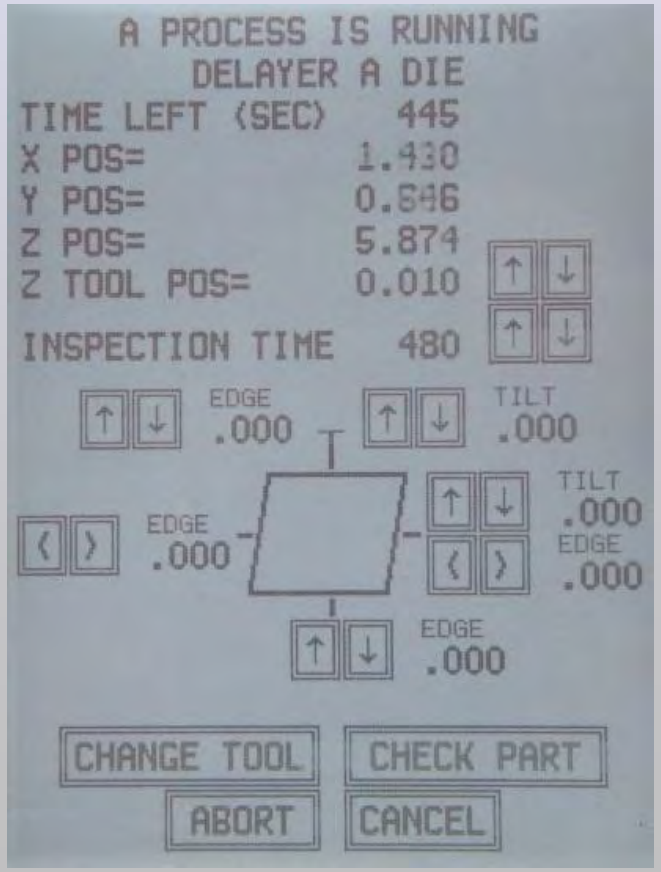
# Front side delayering programming




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 is specified to maintain material removal in the hydrodynamic impact mode.

For removal of polymer or oxy-nitride passivation layers may require direct contact between the die surface and an abrasive film disc.

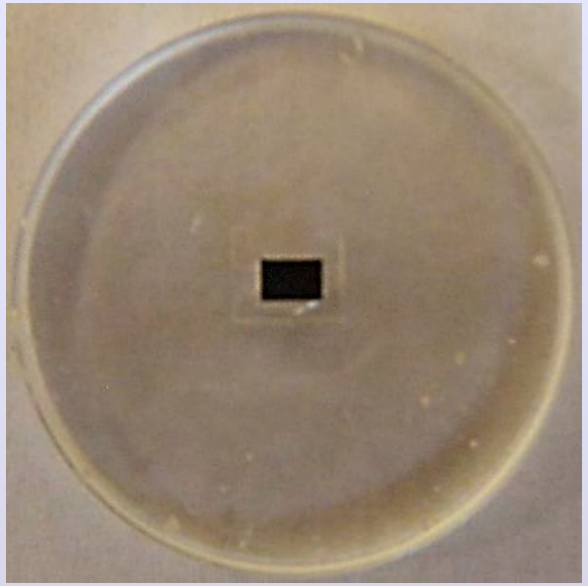
There are faster, chemical processes available for polymer removal. The use of selective chemical processes to remove a layer will significantly reduce the process time.

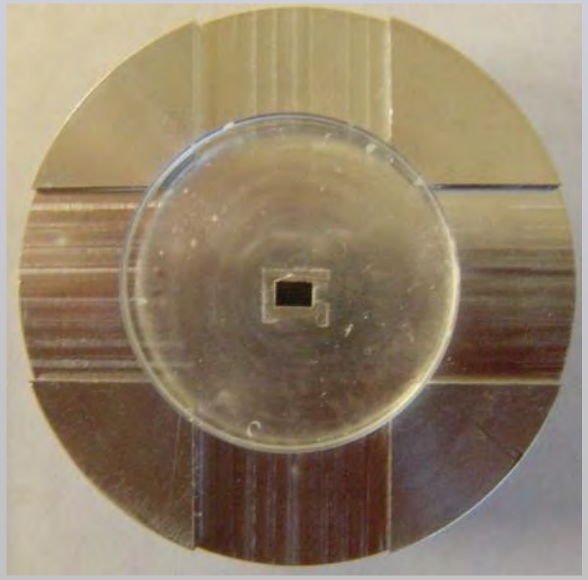



What ever tool and delayering process is selected, the planarity can be adjusted during the process with the tilt and travel controls and the end point is determined by visual inspection by the operator. This requires periodic inspection. The time between inspections is specified on the programming screen although the operator can interrupt the process for a visual inspection at any time.

# The delayering process

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 die must be held as close as possible to flat. Using an optical flat or a high quality gauge block to force the die into the adhesive.

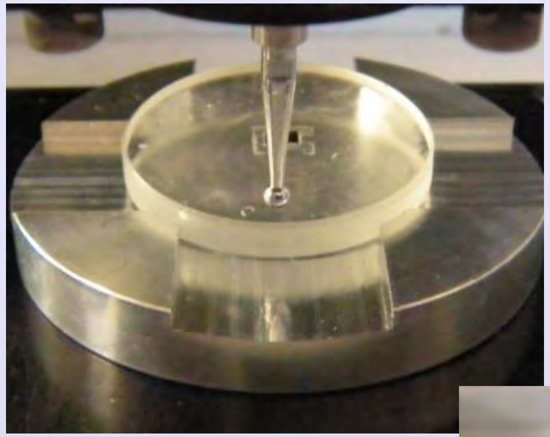


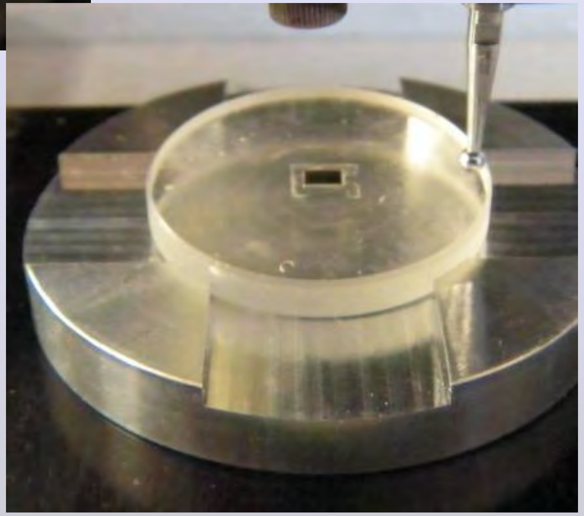


The die should be as flat as possible but there may be local surface variations in the die itself. These variations are a result of variations in metal density over the die surface.

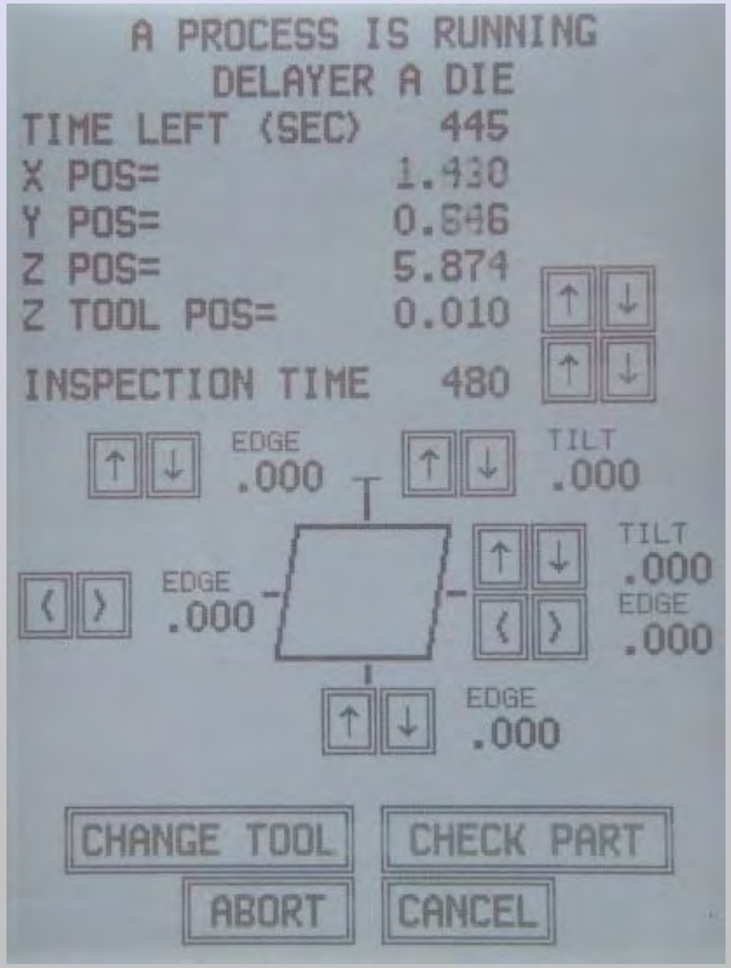
The optical flat is then mounted on a special sample holder using standard mounting wax. The die is now as flat and as parallel to the X-Y travel of the UltraPrep II as possible. That is, ready for delayering.

# The delayering process continued





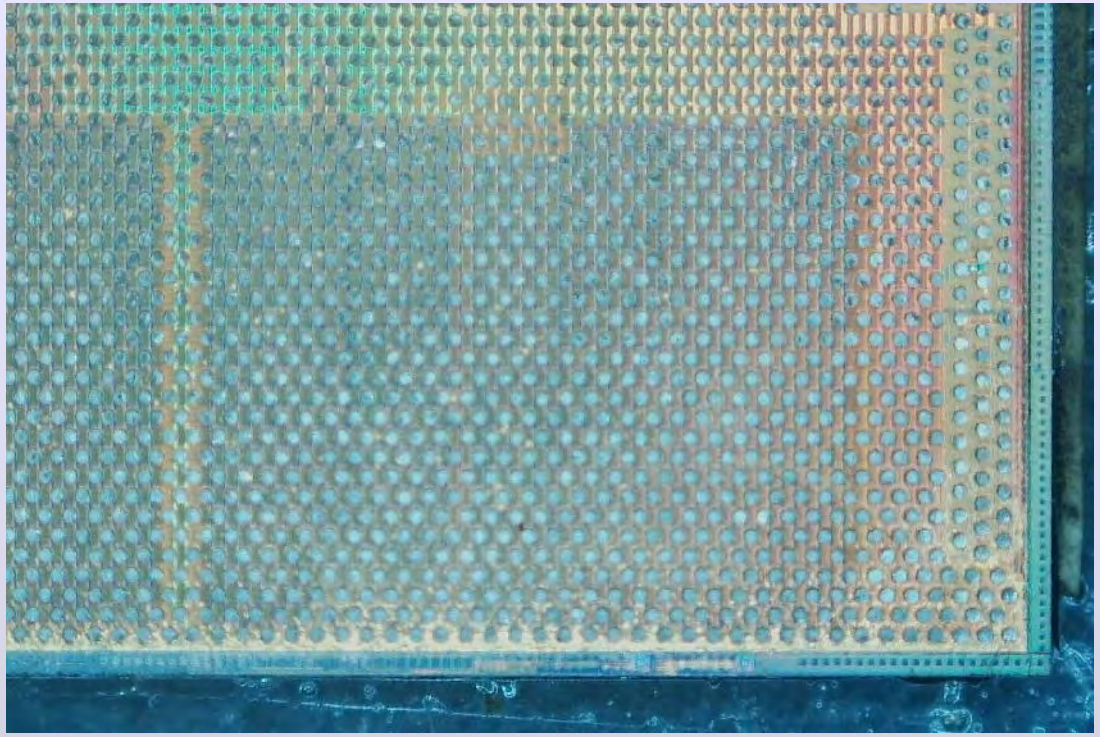
The UltraPrep does not profile the die. This could produce surface damage that results in processing artifacts. Instead, it measures the plane of the optical flat to determine the operational plane of the tool face. This emphasizes the need for a very thin and constant adhesive layer.

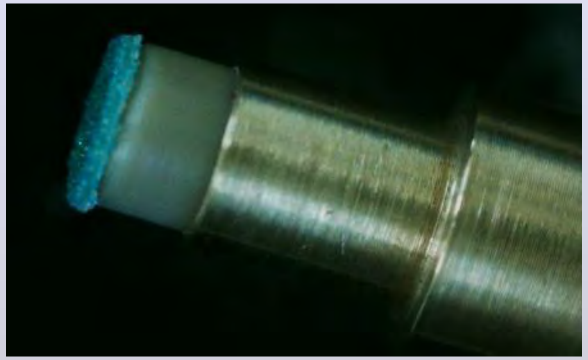



The selected lapping tool is moved in a plane parallel to the measured plane of the optical flat. If the mounting of the die was done correctly, the die surface will be absolutely parallel to the front surface plane of the optical flat. Otherwise, the tool movement plane can be adjusted via the 'tilt'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

# The delayering process continued

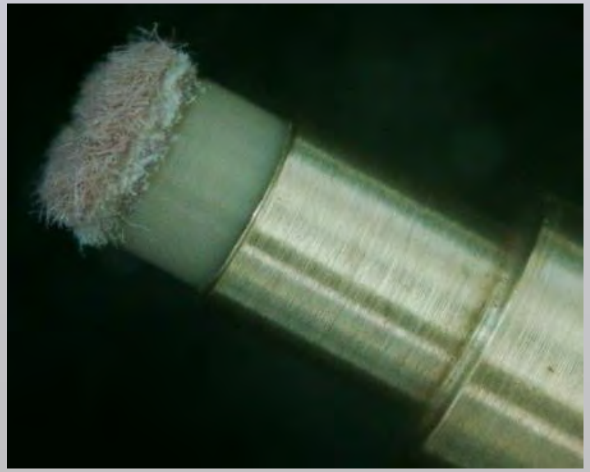
The die surface is rarely clean and free of bond wires or solder balls. This requires an initial process step that removes material down to the surface of the passivation. This is usually done with an abrasive pad.





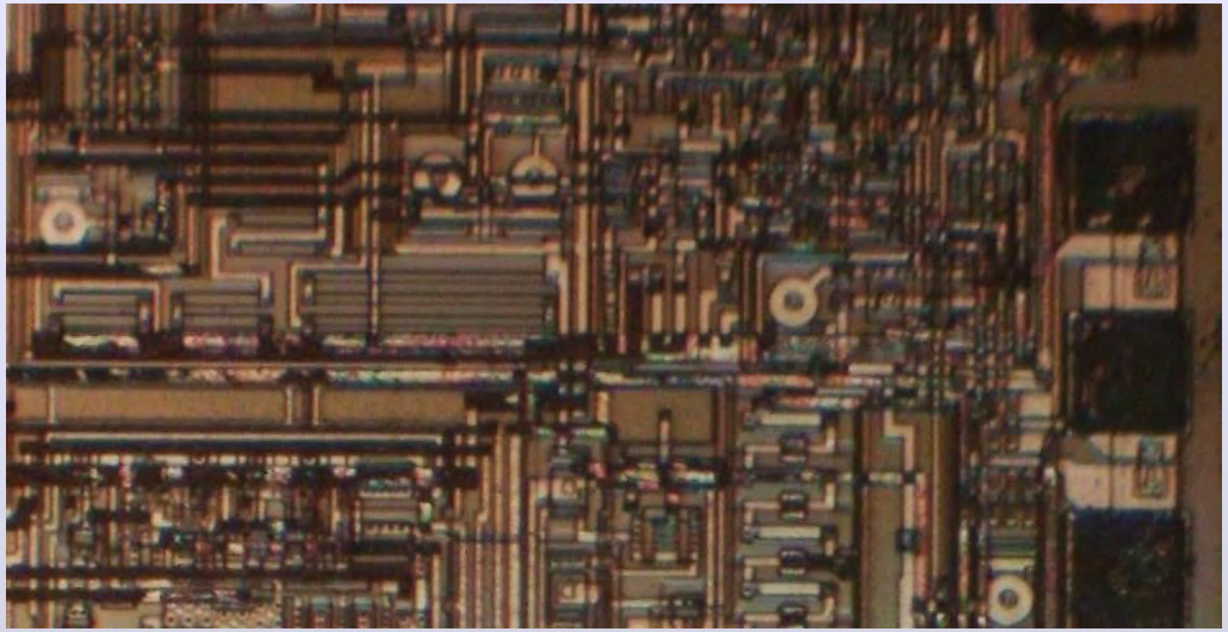
An abrasive pad can also be used to remove the passivation layers. When top metal is reached, the process is continued with a special polishing pad and a slurry. A 0.3 micron alumina works well for removal of thick metal.

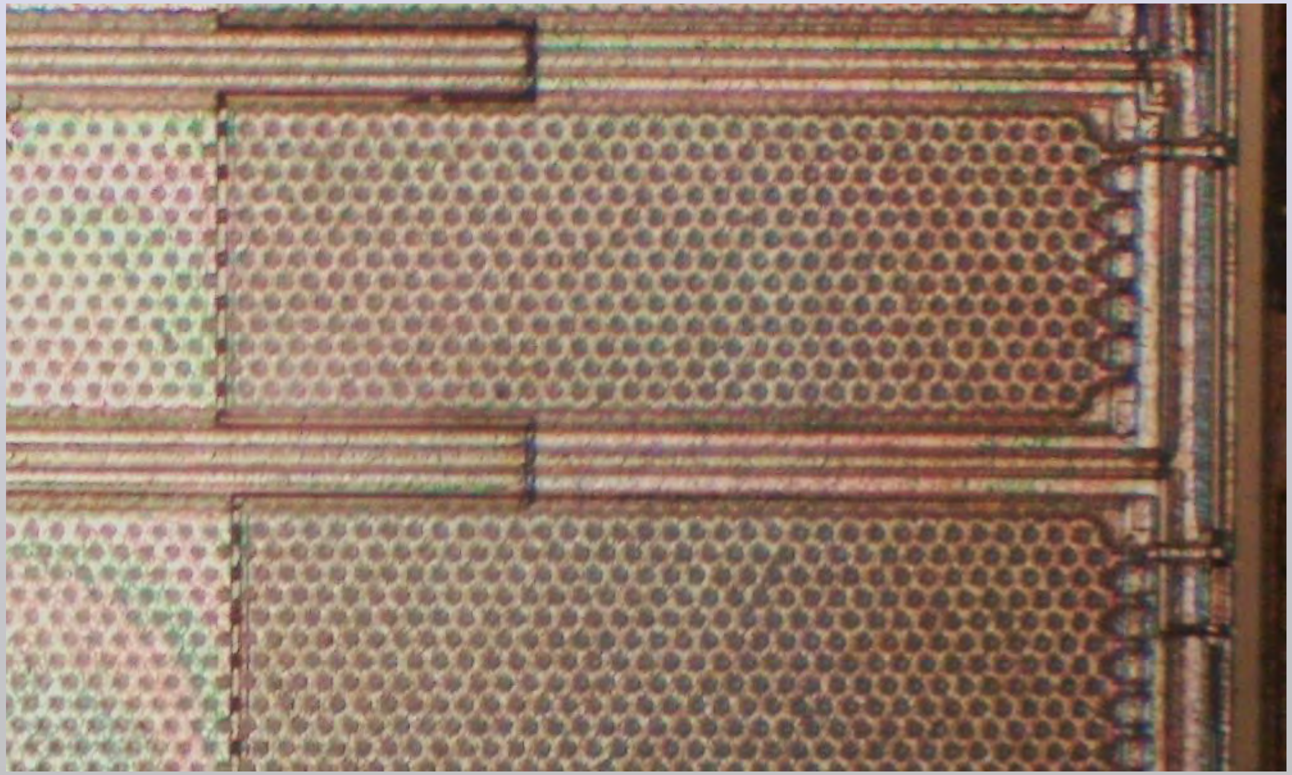
Inter-metal dielectrics and thinner metal layers are best removed with a fine, 0.05 micron, alumina slurry.



# The delayering process 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. An optional accessory for the UltraPrep provides three channels of controlled fluid dispensing for use with CMP materials.

# Conclusions

•The UltraPrep, with the correct accessories, allows effective and planar removal of individual layers from the active surface sf a die. The UltraPrep is particularly effective at planar delayering of smaller die that can not be processed with ‘finger lapping’ processes.

•Larger die can be easily processed although complete die planarity can be problematic due to die surface distortions resulting from variations in metallization density across the die surface. These problems can be minimized by using a selective CMP slurry.

•The accessories available for the UltraPrep allow proper mounting, processing, and even CMP dispensing for delayering semiconductor die. This new capability extends the range of the UltraPrep making it the most versatile and useful sample preparation system available.

•RKD Engineering equipment is made for semiconductor sample preparation, the samples being used for failure analysis and other tasks. The survivability of the sample and the data from it is foremost in all UltraPrep processes. We do not break die. We do not loose or destroy data.

• We do not polish gem stones or fiber optics and we do not process materials science samples or sell microscopes. We are dedicated to semiconductors only and totally support out customers. We provide unlimited applications support including software upgrades for new applications or processes. No one provides better support or more effective and versatile equipment.

# About RKD Engineering

RKD Engineering was formed in 2005 by Richard Cabral, Kirk Martin, and Dan Kaschalk. The original business plan involved the development of fluid handling solutions for the semiconductor industry. All three founders had been heavily involved in the Semiconductor industry and were all instrumental in the development of acid decapsulators. Soon after forming RKD, they were approached by Left Coast instruments to develop a new, state of the art, acid decapsulator. The result was the EliteEtch built by RKD, sold exclusively by LCI and also private labeled as *Sesame* in Europe and Asia.

The product line was expanded with the introduction of the first decapsulators for copper wire samples, the first ESD mitigated decapsulator, and the first large format decapsulator capable of handling samples mounted to a PCB. Recently the I53 was added to the decapsulator line as the first and only effective system for decapsulation of silver wire samples.

Our first mechanical preparation product was the MicroMill that supported the decapsulators by making gaskets and fixtures and also provided machining support for heat sink removal and mechanical decapsulation. This introduced CNC technology to semiconductor sample preparation.

The introduction of the UltraPrep brought contour die thinning to sample preparation, for the first time allowing thinned die with a constant remaining thickness. The capabilities of the UltraPrep have now been extended to simple and effective die delayering.

RKD is responsible for all innovation in chemical decapsulation and mechanical sample preparation. All others have only followed our lead.