MultiPrep™ System Procedure

Precision Cross-Sectioning of an Integrated Circuit (IC)

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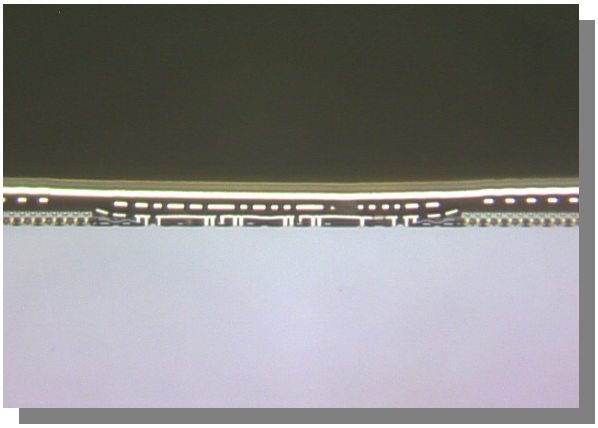
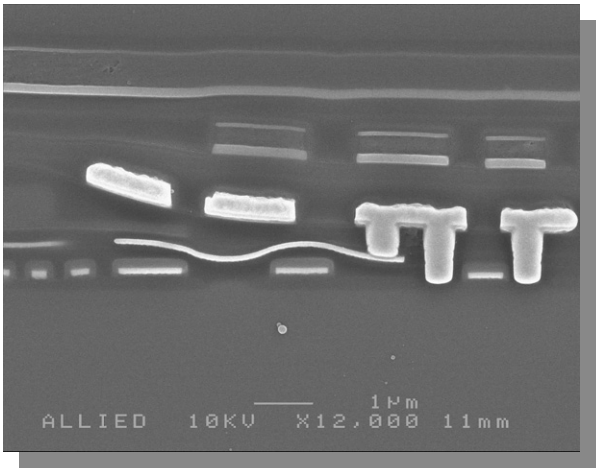
Overview

The MultiPrep™ System is an excellent tool for precision cross-sectioning a wide variety of materials. Industries involved with failure analysis, yield analysis, quality control, and research & development take advantage of its speed, precision, and accuracy.



With feature sizes of certain types of samples becoming smaller, such as in the electronics industry, it is critical to control the material removal rate to avoid polishing through the area of interest. The MultiPrep™ provides consistent sample rotation, oscillation, and load, ensuring uniform material removal. Digital indicators allow the operator to quantify material removal and observe, in real-time, how much material is being removed in one micron increments. A variety of samples and materials can be prepared unencapsulated, including IC die, electronic packages, and printed circuit board (PCB) coupons.

For this procedure, the sample is a silicon-based integrated circuit (IC), approximately 500 microns thick by 4 mm wide. A glass cover slip is secured to the circuit side of the IC to protect it from delamination and rounding. The sample is mounted to a fixture, aligned so the circuit geometry is precisely in line with the abrasive plane, and polished to a predetermined location. It may then be etched/decorated and prepared for SEM observation.



It is strongly recommended that the MultiPrep™ System manual be studied to ensure familiarity with the terms used to describe specific functions and components in this procedure.

Consumable selection, machine settings, and techniques used in this procedure were developed using the MultiPrep™ System in the Allied applications laboratory.

Equipment Used:

- MultiPrep™ System
- Magnetic Platen, 8”
- Cam-Lock Adapter
- Cross-Sectioning Paddle

- Zeiss AxioImager™ Compound Upright Microscope
- Zeiss Stemi DV4™ Stereomicroscope
- Zeiss AxioCam MRc 5™ Digital Camera
- Zeiss AxioVision™ Imaging Software

Consumables Used:

- EpoxyBond 110™
- Glass Cover Slips
- Hot Mounting Wax
- 15 µm Metal Bonded Diamond Disc
- 15 µm Diamond Lapping Film (DLF)
- 6 µm DLF
- 3 µm DLF
- 1 µm DLF
- 0.5 µm DLF
- 0.1 µm DLF
- Rubber Squeegee
- 0.04 µm Non-Stick/Rinsable Colloidal Silica Suspension
- Red Final C Cloth
- Micro Organic Soap
- Cotton-Tipped Applicators/Swabs
- DLF Storage/Blotter Book
- MicroCare Canned Air

Other:

- Hot Plate with Temperature Readout
- Acetone
- Isopropyl Alcohol
- Two (2) Glass Beakers, 100 ml Capacity
- Tweezers, Sharp End

Procedure

1. Align the MultiPrep™ System according to the procedures in the operations manual.
   Note: Set sample load to full.
2. Place the cross-sectioning paddle onto the hot plate and heat it to 175° C.
3. Cut or cleave the sample to be polished from a device or wafer.
4. Using the wood end of a cotton-tipped applicator, mix the EpoxyBond 110™ following the instructions included with the kit.
5. Place a small bead of the mixed epoxy onto a clean cover slip and spread it to match the approximate area of the sample.
6. Place the sample (circuit side, or side of interest) into the epoxy, with the edge to be polished parallel and nearest to the edge of the cover slip.
7. Using an alligator clip, compress the cover slip and sample to remove excess epoxy, creating a very thin glue line (Photo 1).
   Note: A thin glue line enhances clarity when viewing the sample top-down during the procedure.
8. Place the clamped sample onto the heated hot plate. The epoxy will cure in approximately 5 minutes, as indicated when it turns to a deep brown-red color.
9. Once the epoxy is cured, remove the clamped sample from the hot plate and allow it to cool for about 5 minutes.
10. Using a diamond or carbide scribe, remove the excess glass from the sample.

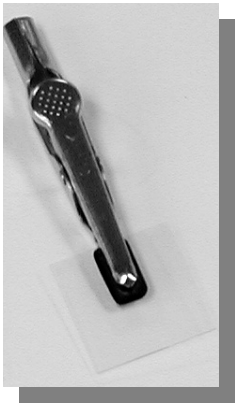


Photo 1

11. Attach the 15 µm Metal Bonded Diamond Disc onto the magnetic platen.
12. Activate platen rotation at 100 RPM counterclockwise.
13. Activate coolant and manually grind the excess glass not removed when scribed. Be sure to grind parallel to the edge of each side of the sample and round the corners of the side to be polished so the diamond film is not damaged or cut upon initial contact with the sample.
    Note: Leave at least 300 microns of material from the edge to the area of interest (AOI) so that chips on the glass and sample edge, as well as subsurface deformation, may be removed.
    TEM Note: If preparing the sample for TEM, grind the sample to a width of approximately 3.5 mm.
14. Melt a small amount of wax onto the heated cross-sectioning paddle near the bottom edge, then remove the paddle from the hot plate.
15. Place the sample onto the paddle with the circuit side up and align the circuit geometry with that of the paddle. Angle adjustments up to 10 degrees can be made using the micrometer heads found on the MultiPrep™, if necessary. However, the sample should still be as closely aligned at this step as possible. Make sure that at least 50% of the sample is on the paddle and that the AOI extends over the edge (Photo 2).
    Note: A stereomicroscope with a cross-hair reticle is very helpful when aligning the sample with the paddle.

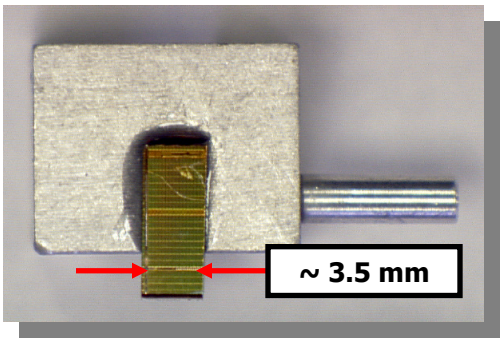


Photo 2

16. Locate the AOI to be cross-sectioned.
17. Use AxioVision 4™ to measure the distance from the edge of the sample to the AOI. It may be necessary to use the lowest magnification to fit both the edge and AOI into the field of view. A stereomicroscope can also be used in the same capacity if the field of view in the compound microscope is too small.
18. Secure a 15 µm DLF to an aluminum platen (with a non-magnetic surface).
19. Attach the cam-lock adapter (15-1005) to the MultiPrep™ and the cross-sectioning paddle (15-1010) to the adapter, as shown in Photo 3.

20. Gently lower the sample with the spindle riser (if raised), then raise the sample using the vertical adjustment knob, if necessary, so it does not touch the DLF.

21. Place a small mirror onto the platen and slide it under the sample. Adjust the sample height, using the vertical adjustment knob, so it is close to, but not touching, the mirror.

22. If the sample appears to be misaligned with its reflection in the mirror, use the right rear micrometer, associated with the "roll" adjustment of the sample, and rotate it to move the sample so the circuit geometry is aligned with its reflection. If the sample needs to be rotated clockwise, rotate the micrometer clockwise. Conversely, rotate the micrometer counterclockwise if the sample needs to be adjusted counterclockwise (each vertical tick mark on the micrometer heads represents 0.02°).
Note: When adjusting the angle, the sample may move close to the mirror and actually touch it. If this happens, raise the sample using the vertical adjustment knob to lift the sample from the mirror. Once the sample is aligned with its reflection, raise the sample with the spindle riser and remove the mirror from the platen.

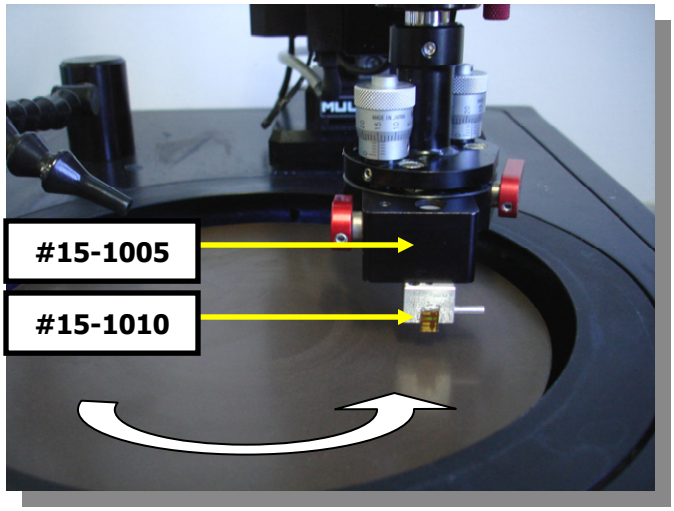


Photo 3

23. Lower the spindle riser and zero the front digital indicator by pressing the yellow button labeled "zero".

24. Using the vertical adjustment knob, lower the sample into the abrasive until the front digital indicator displays 100 microns more than what needs to be removed.
Note: The objective is to stop approximately 200 microns from the AOI after using 15 µm DLF. For example, if the distance between the edge of the sample and the AOI is 400 microns, then 200 microns needs to be removed (Photo 4) and the display should be set to read 300 microns. Use AxioVision™ to measure and monitor the material removed and the distance to the AOI.

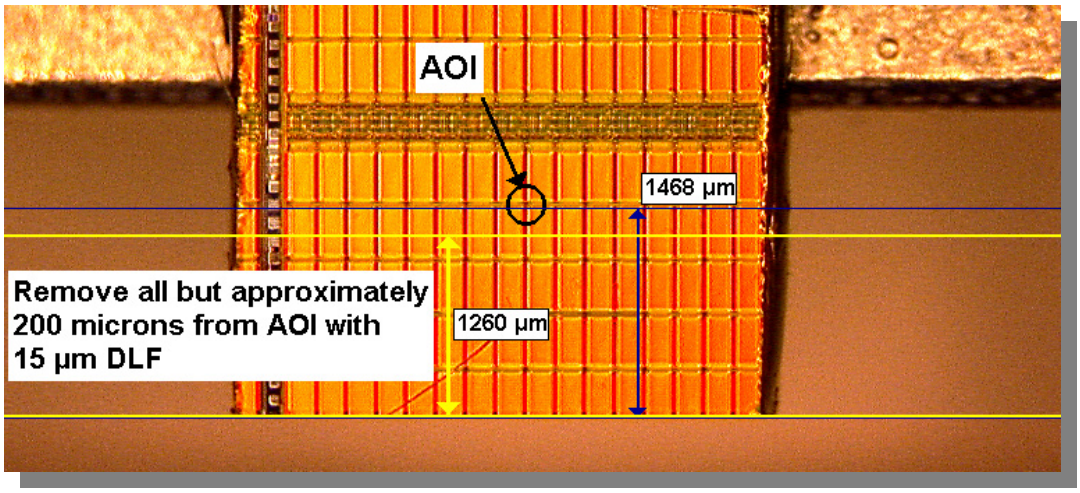


Photo 4

Note: The polishing rate using 15 µm DLF may be too quick. It may be necessary to start with 6 µm, or even 3 µm, DLF if less than 200 microns exist between the edge and AOI. Due to compression in the DLF, the sample will make contact and compress into the film almost 20 microns before the display will change from zero. This is the reason for lowering the sample into the film 100 microns more than what is to be removed.

Note: The rear digital indicator may also be used to remove specific amounts of material, and is recommended for abrasive sizes larger than 3 micron. For a description of the procedures used for material removal using either the front or the rear digital indicators, and the differences between them, see pages 27-28 of the MultiPrep™ System operation manual.

25. Raise the sample using the spindle riser.

26. Activate platen rotation counterclockwise at 10 RPM.

27. Activate coolant, gently lower the sample onto the DLF with the spindle riser, and zero the front digital indicator. At 10 RPM, there will be enough time to zero the digital indicator before any significant amount of material is removed.

28. Increase the platen speed to 150 RPM. When the display indicates that all but approximately 200 microns has been polished from the AOI, lift the sample from the abrasive with the spindle riser and stop the platen.

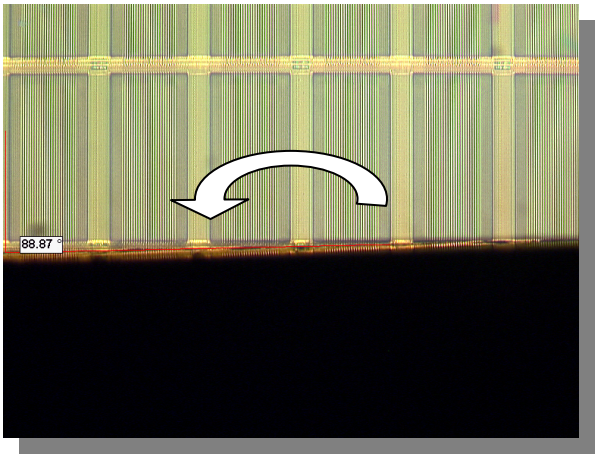


Photo 5

29. Remove the cross-sectioning paddle from the cam-lock adapter.

Note: The sample holder and sample should be cleaned between polishing steps using water and a cotton-tipped applicator.

30. Swing the MultiPrep™ arm away from the platen.

31. Clean the DLF with a lint-free wipe and place it into the DLF Storage/Blotter Book. This storage method is ideal for each DLF, since it reduces the possibility of contamination.

32. Secure a 6 µm DLF to the platen and reposition the arm and sample.

33. Polish the sample until approximately 100 microns are left to the AOI. Repeat steps 23-31 except use 100 RPM.

34. Inspect the angle of polish to determine if alignment using the micrometer head is necessary.

Note: The sample shown in Photo 5 requires a counterclockwise rotation adjustment. Using AxioVision™, the angle is measured so that an exact adjustment can be made. By subtracting the angle (88.87) from 90, the difference is 1.13°. Divide the result by 0.02 (the increment of the micrometer head, in degrees); in this case, it equals 56.5. This represents the number of vertical lines (Photo 6) the micrometer needs to be adjusted. Fifty vertical lines equal one full revolution, and 1° total. For more information on performing angular adjustments, see page 24 of the MultiPrep™ System operation manual.

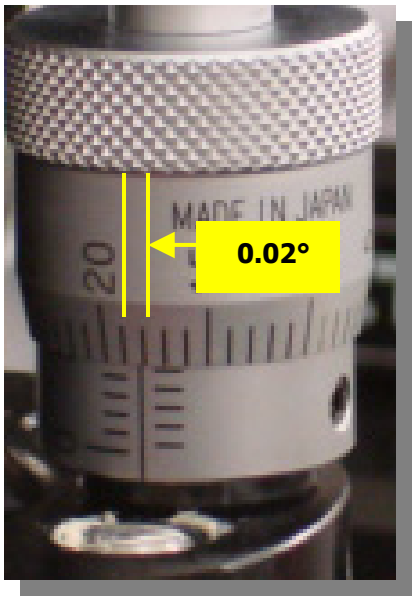


Photo 6

35. Adjust the right rear micrometer head to properly align the sample, using the value obtained in the previous step.

36. Continue polishing until the sample is polished edge to edge.

Note: Observation of the platen and the debris trail width will indicate when this happens. When one edge of the sample is lower, the debris trail will be narrow at first and widen as the sample advances into the abrasive. A certain amount of material

will be removed, determined by the degree of misalignment. If the sample is grossly misaligned, it may require more material removal that may run past the AOI. Therefore, it is important that enough material remains on the sample prior to this adjustment so the AOI is left untouched/intact.

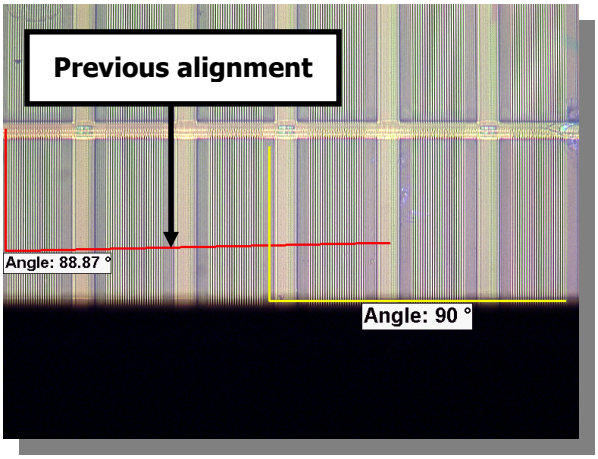


Photo 7

37. Continue to polish and inspect the sample until it is aligned (Photo 7). If a measurement system, such as AxioVision™, is not available, adjust the micrometer a few divisions at a time and inspect the sample frequently. Additional angle adjustments may also be made using finer micron size diamond films as the AOI is approached.

38. Set the sample load to 300 grams (because sample sizes vary, the selected load should be changed accordingly).

Note: Sample load affects two things when polishing IC's: 1) smearing of the circuitry, and 2) cracking and chipping of the device substructure (very important for TEM samples).

39. Secure a 3 µm DLF to the platen and polish the sample until approximately 25 microns of material are left to the AOI. Repeat steps 23-31 except use a platen speed of 75 RPM.

40. Secure a 1 µm DLF to the platen and polish the sample until approximately 10 microns of material are left to the AOI. Repeat steps 23-31 except use a platen speed of 50 RPM.

41. Secure a 0.5 µm DLF to the platen and polish the sample until approximately 1-2 microns of material are left to the AOI. Repeat steps 23-31 except use a platen speed of 25 RPM.

42. If the AOI is 1 µm or less from the polished edge of the sample, proceed to the final polish (step 44). If more than 1 µm remains, continue to step 43.

43. Using 0.1 µm or 0.5 µm DLF, set the RPM to 10 and lower the sample onto the film. After a half-revolution of the platen, remove the sample and inspect it. Repeat this step until the AOI is identified through microscopic observation to be 1 µm or less from the polished edge of the sample.

44. Attach a Red Final C polishing cloth to a spare platen.

45. Once finished, swing the MultiPrep™ arm away from the platen and exchange the platen used with the DLF with the Red Final C platen.

46. Saturate the cloth with water, and then turn the water off.

47. Swing the MultiPrep™ arm back to its original position and reattach the oscillator linkage.

48. Remove the cam-lock adapter, attach the cross-sectioning paddle (with sample still attached) directly to the underside of the micro-hub assembly, and then lower the spindle riser. This will allow for the use of rotation during the final polishing step.

49. Reduce the sample load to 100 grams, and then zero the front digital indicator.

50. Activate clockwise platen rotation at 200 RPM.

51. Activate sample rotation at speed 3 and oscillation at speed 1 (adjusted to approximately a 1 inch range of motion).

Note: Rotating (full or limit) the sample during

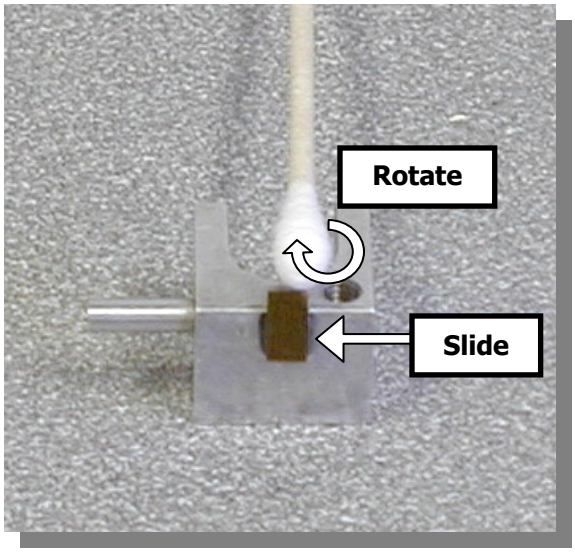


Photo 8

the polishing step eliminates polishing artifacts and smearing, and it improves flatness.

52. Activate the water and position the flow at the edge of the platen to wash the colloidal silica from the sides of the bowl.

53. Apply 0.04 µm colloidal silica suspension to the cloth.

54. With the vertical adjustment knob, lower the sample into the cloth until a trail is observed and the front digital indicator displays between 20 and 30 microns, ensuring sufficient sample contact with the cloth. It may be necessary to add more colloidal silica to the cloth while lowering the sample, so the trail can be more easily observed.

55. Polish for between 20 and 40 seconds, and rinse the cloth and sample of colloidal silica for an additional 10 seconds.

56. Stop rotation so the cam lever is to the right, raise the sample using the spindle riser, and stop the machine.

57. Loosen the cam lever, remove the paddle, and immediately rinse the sample with water for at least 5 seconds.

58. Saturate a cotton-tipped swab with a diluted solution of micro organic soap and water (1:10) and wipe the sample, as shown in Photo 8. Rotate and slide the swab across the sample at least twice using a different location on the swab for each swipe.

59. Rinse the sample with water.

60. Using clean air (i.e. Aero-Duster compressed air), dry the sample <u>in one direction **ONLY**</u>. Failure to direct the airflow in one direction will produce water spots on the polished section, contaminating the polished surface as a result.

61. If after inspection the sample requires further polishing, repeat steps 50-60.

62. Rinse the Red Final C cloth with water, remove the platen, and dry the underside of the platen.

63. Dry the platen base when finished with the machine to remove any standing water, moisture, or debris.

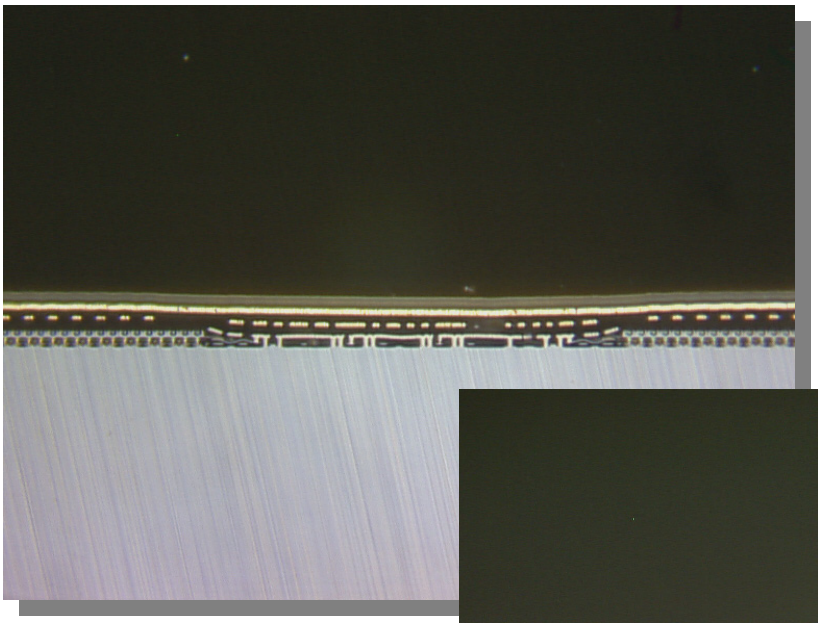


Photo 9, Left: As-polished sample, after 0.5 µm DLF (1500x magnification, Brightfield, Water Immersion Objective)

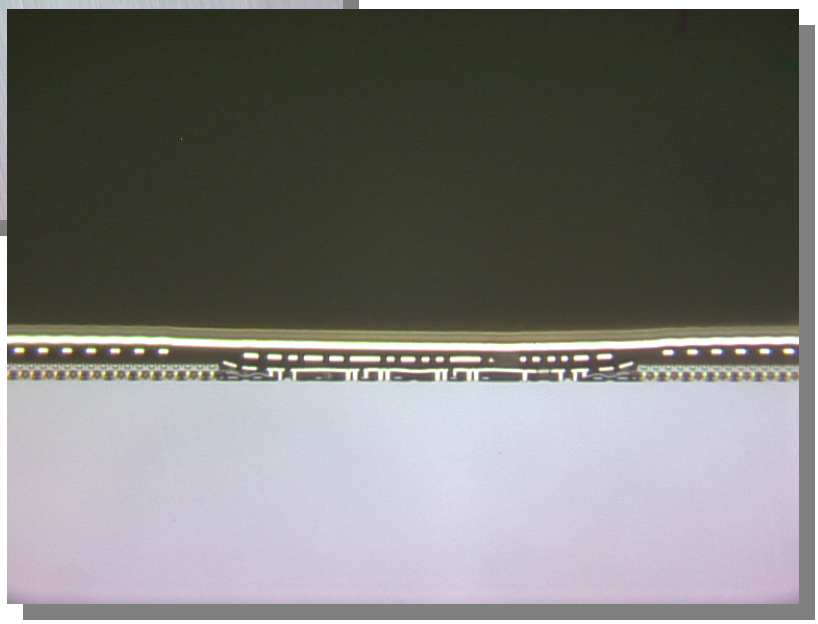


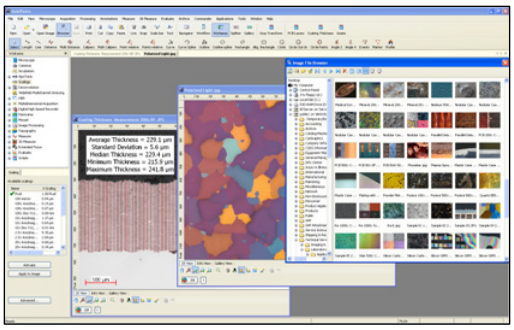
Photo 10, Right: As-polished sample, after colloidal silica on Red Final C, 20 seconds (1500x magnification, Brightfield, Water Immersion Objective)

Cross-Sectioning Quick Reference Chart

DLF	Load Reduction	RPM	Lubricant	Indicator
30 µm	No	175	Water	Rear
15 µm	No	150	Water	Rear
9 µm	No	125	Water	Rear
6 µm	No	100	Water	Front
3 µm	Yes - 200	75	GreenLube	Front
1 µm	Yes - 300	50	GreenLube	Front
0.5 µm	Yes - 400	25	GreenLube	Front

MultiPrep™ System with AD-5™ Fluid Dispenser

TechCut 4™ Low Speed Saw



Zeiss AxioVision™ Imaging Software

Zeiss AxioImager™ Upright Microscope

Zeiss Stemi DV4™ Stereomicroscope