

Mechanical Preparation of Materials

Deakin School of Engineering

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What is Mechanical Preparation

The basic process of mechanical specimen preparation is material removal using abrasive particles in successively finer steps, to remove material from the surface until the required result is reached. There are three mechanisms of removing material: *grinding, polishing and lapping*. They differ in the tendency to introduce deformation in the specimen surface. In general, the sequence of steps involves; a single plane grinding step, 1 – 2 fine grinding steps, 1 – 2 polishing steps and an optional oxide polishing step.

Selecting the correct method

In order to select the appropriate method for preparation of your material, you need to have an understanding of these parameters:

- The hardness/ductility of the specimen
- Characteristics of the different abrasives
- Abrasive techniques
- Parameters that influence material removal (time, force, speed etc.)

The latter three are discussed in further topics.

There are three different ways to select the appropriate procedure for plane grinding, fine grinding, diamond polishing and oxide polishing:

1. According to the material name using [e-Metalog](#) (in the e-shop).
Login with email: eng-mat@deakin.edu.au and password:
2. According to a specific application using [Struers Application notes](#).
3. According to a materials physical properties using the [Metalogram](#).

Some materials such as composites, coatings or other materials consisting of various phases or components cannot be easily placed in the Metalogram. In these cases, the following rules can be applied when deciding on the preparation method:

- *Predominant component* - Select a method which is suited for the material's predominant component.
- *Artifacts* - Check the samples after each step and, if preparation artifacts do occur, consult troubleshooting for advice. The most common artifacts are edge rounding, relief, pull-outs and porosity.

For composites containing less than 10-20% of hard phases/components (800HV+) in a soft matrix/softer components

- Select method appropriate for the softer phases/components

For composites containing more than 10-20% of hard phases/components (800HV+) in a soft matrix/softer components

- Select the PG step according to the hard phases/components
- Select the FG, DP, OP steps according to the softer phases/components

Lapping

- The abrasive is applied in a suspension on to a hard surface.
- The abrasive rolls and moves freely in all directions, hammering small particles out of the specimen surface and introducing deep deformations.
- Used for very hard, brittle materials eg: ceramics and minerals.

There are three positions of an abrasive grain passing the specimen surface in a rolling fashion (figure 1):

1. The grain enters the specimen surface.
2. The grain rolls over and hammers a piece of the specimen material out, causing severe deformation in the specimen material.
3. The grain rolls on without touching the specimen surface. When it passes the specimen again a smaller or bigger piece is hammered out, depending on the shape of the grain.

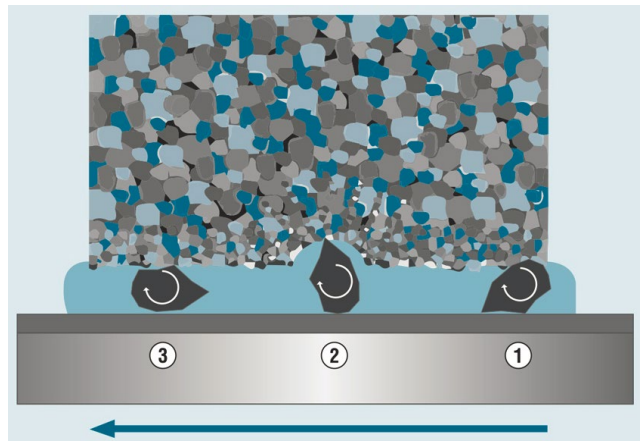


FIGURE 1: THREE POSITIONS OF AN ABRASIVE GRAIN PASSING THE SPECIMEN SURFACE DURING LAPPING.

Grinding

- The abrasive is fixed.
- Fixed abrasive particles produce chips of the specimen material. Sharp abrasive grains produce the lowest amount of deformation in the specimen while giving the highest removal rate.
- Dull abrasives cause ploughing instead of cutting, which produces greater deformation and heat.

The three positions of an abrasive grain passing the specimen surface in a fixed state are (figure 2):

1. The grain is entering the specimen surface. The grain is totally fixed in the X-direction; movement (resilience) in the Y-direction can take place. The chip is started when the grain enters into the specimen material.
2. The grain is halfway through and the chip is growing.
3. The grain passes out of specimen surface, leaving a scratch in the surface with relatively little deformation in the specimen material.

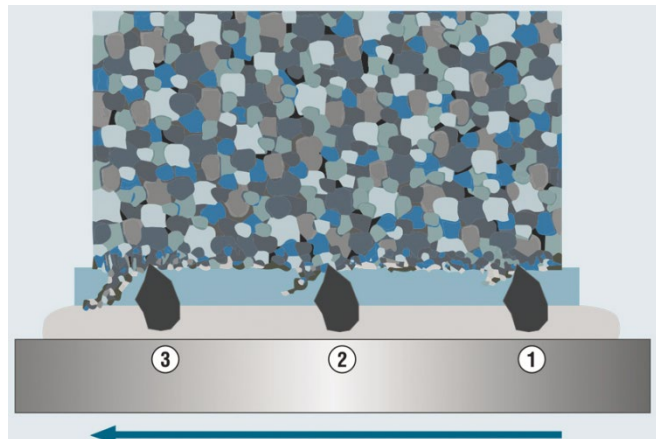


FIGURE 2: THREE POSITIONS OF AN ABRASIVE GRAIN PASSING THE SPECIMEN SURFACE DURING GRINDING.

There are two types of grinding processes in mechanical preparation:

1. Plane Grinding

- Normally the first step in the grinding process.
- Totally fixed grains with a relatively large grain size are preferably used.
- During wear, new abrasive grains are revealed thus ensuring a consistent material removal.
- Removes damage introduced by cutting.
- Ensures that the surfaces of all specimens are similar.
- Keeps multiple specimens in same plane.
- Short grinding times.
- Maximum flatness.

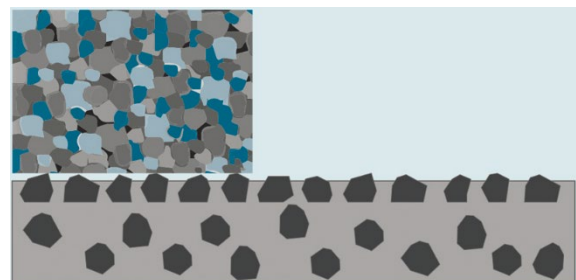


FIGURE 3: ABRASIVE GRAINS EMBEDDED IN THE SURFACE PASSING THE SPECIMEN SURFACE DURING PLANE GRINDING.

2. Fine Grinding

- Abrasives are incorporated into the surface and added to the surface.
- Produces a surface with little deformation that can easily be removed during polishing.
- Ensures that the surfaces of all specimens are similar.
- Keeps multiple specimens in same plane.
- Rigid disc system - ensures edge retention and minimises deformation.

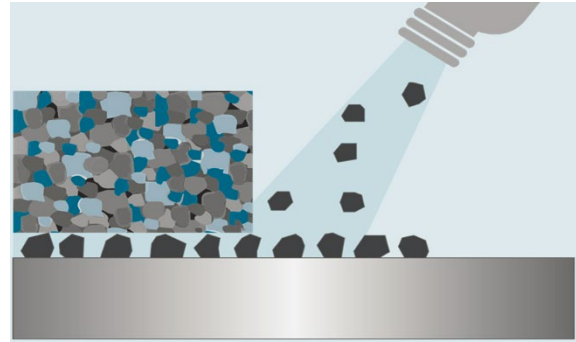


FIGURE 4: ABRASIVE GRAINS EMBEDDED AND ADDED TO THE SURFACE PASSING THE SPECIMEN SURFACE DURING FINE GRINDING.

Abrasives

The abrasives used for grinding must be 2 – 3 times harder than the material being prepared. There are three types of abrasives; Aluminium oxide (Al_2O_3), silicon carbide (SiC), and diamonds. The use of a rigid disc system provides is essential when edge retention is a necessity. The use of a rigid disc reduces fine grinding to one step rather than the normal grinding steps with SiC paper #500, #1000, #2400 and 4000 grits, and can be performed both manually and automatically. However, there are some materials that require the use of SiC paper as its fine grinding step(s).

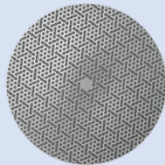
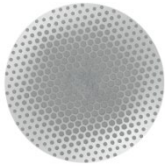
MD-Rigid Disc Selection Guide

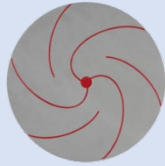

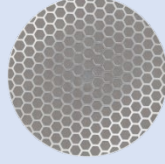
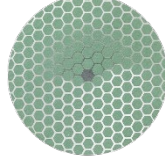
The choice of rigid disc is very important in order to obtain a high, consistent material removal rate, short grinding times, maximum flatness and to minimise post-processing. Table 1 outlines the required disc for grinding and its properties based on sample material.

After determining the method required for your sample material, if you require any MD grinding discs you will need to organise their purchase with the [project budget form](#). The MD-disc size for the LaboPol and Tegramin is 25mm. Pricing for these items can be found in the pricing guide.

[MD-System Selection guide](#)

Table 1: Recommended MD-Rigid disc for different sample materials.

Sample Material	Hardness Range	Disc	Abrasive	Bond
Ferrous metals and hard materials	150 – 2000HV	MD-Piano 80, 120, 220, 500, 1200, 2000, 4000 	Diamond	Resin
Non-ferrous metals and soft materials	40 – 250HV	MD-Primo 120 or 220 	Silicon Carbide	Resin

Sample Material	Hardness Range	Disc	Abrasive	Bond
Aluminium alloys & hard materials containing aluminium	50 – 2000HV	MD-Molto 220 	Diamond	Resin
Titanium Alloys	150 – 450HV	MD-Mezzo 220 	Diamond	Resin
Fine grinding materials harder than 150 HV	>150HV	MD-Allegro 	15 – 6µm added as suspension or spray	
Fine grinding of soft materials, composites with soft matrix	40 – 250HV	MD-Largo 	9 – 3 µm added as suspension or spray	

Polishing

There are two types of polishing processes in mechanical preparation:

1. Diamond Polishing

- A diamond abrasive is added and incorporated into to a cloth surface.
- A smaller chip size is desirable to ultimately achieve a specimen surface without scratches and deformation.
- More resilient cloths are used, along with smaller grain sizes, such as 3 or 1 µm, to obtain a chip size approaching zero.
- A lower force is used on specimens to reduce the chip size during polishing.

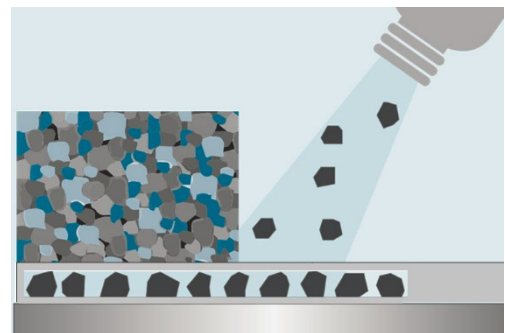


FIGURE 5: ABRASIVE DIAMOND GRAINS ARE ADDED AND INCORPORATED INTO THE CLOTH PASSING THE SPECIMEN SURFACE DURING POLISHING.

2. Oxide Polishing

- Uses colloidal silica, with a grain size of approximately 0.04 μm and a pH of about 9.8.
- Combines chemical activity and fine, gentle abrasion to produce scratch-free and deformation-free specimens.
- Required for certain materials, especially those that are soft and ductile
- Required when preparing sample for microstructure visualisation.

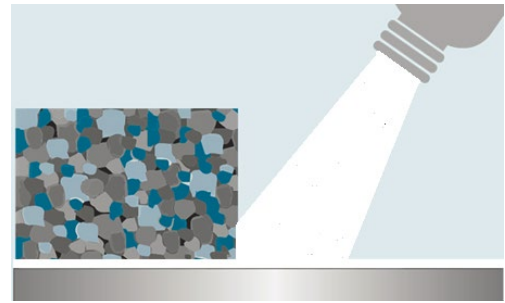


FIGURE 6: COLLOIDAL SILICA IS ADDED AND INCORPORATED INTO THE CLOTH PASSING THE SPECIMEN SURFACE DURING OXIDE POLISHING.






MD-Cloth Selection Guide






The choice of cloth material vs sample material is very important in order to obtain a high quality result free of scratches, deformation, edge rounding and relief. Hard polishing cloths offer low resilience and Soft polishing cloths offer high resilience. Table 2 outlines the required disc for polishing and its properties based on application.

After determining the method required for your sample material, if you require any MD cloth discs you will need to organise their purchase with the [project budget form](#). The MD-disc size for the LaboPol and Tegramin is 25mm. Pricing for these items can be found in the pricing guide.

[MD-Cloth Selection guide.](#)

Table 2: Recommended MD-Cloth disc for different applications.

Application	Resilience	Hardness Range	Disc	Abrasive	Cloth material
Fine grinding of soft material Pre-polishing of hard materials	Very low	Hard	MD-Plan 	15 – 3 μm	Coated, woven polyester
Fine grinding of soft metals Pre-polishing and polishing of hard and brittle materials	Very low	Hard	MD-Pan 	15 – 1 μm	Impregn. Non-woven technical textile
Fine grinding and polishing of ferrous metals, non-ferrous metals, coatings and plastics	Medium	Hard	MD-Sat 	9 – 3 μm	Woven acetate
Fine grinding and polishing of ferrous metals, non-ferrous metals, coatings and plastics	Medium	Hard	MD-Dur 	9 – 1 μm	Satin woven natural silk
Polishing of all materials	Medium	Hard	MD-Dac 	6 – 3 μm	Satin woven acetate

Application	Resilience	Hardness Range	Disc	Abrasive	Cloth material
Polishing of ferrous and non-ferrous metals and polymers	High	Soft	MD-Mol 	$\leq 3 \mu\text{m}$	Taffeta woven 100% wool
One step polishing for sintered carbides and steels	High	Soft	MD-Plus 	$\leq 3 \mu\text{m}$	Synthetic nap
Polishing of all materials	High	Soft	MD-Floc 	$\leq 3 \mu\text{m}$	Synthetic nap
Final Polishing of all materials	Very high	Very soft	MD-Nap 	$\leq 1 \mu\text{m}$	Synthetic short nap
Final Polishing of all materials	High	Soft	MD-Chem 	$< 1 \mu\text{m}$	Porous neoprene

Use figure 7 when the determined method produces relief, edge rounding, scratches or deformation.

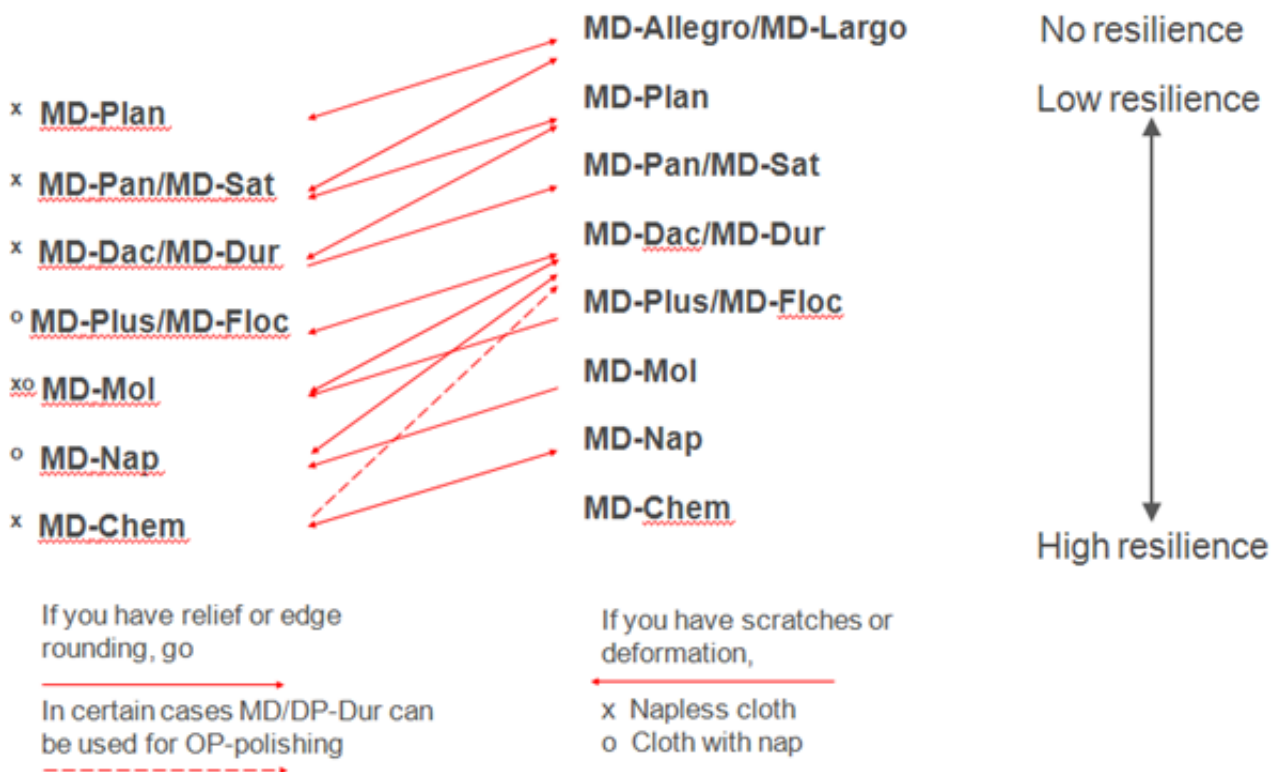


FIGURE 7: TROUBLESHOOTING GUIDE FOR MD-DISCS AND MD-CLOTHS WHEN METHOD DOESN'T PRODUCE HIGH QUALITY SURFACE OF THE SPECIMEN.

Preparation Parameters

There are nine parameters that need to be considered during mechanical preparation; Disc surface, abrasive, grit/grain size, lubricant, rotational direction, rotational speed, force, time and specimen holder positioning. The first four parameters are covered above, the later five are addressed below. The first eight parameters are outlined in the determined method for a given sample material and are dependent on the disc size, specimen size, and number of specimens.

1. Rotational Direction

- Co-direction is recommended.
- Counter-rotation is only used when extreme abrasion is required.
- Counter-rotation can be used during oxide polishing to minimise suspension loss.

2. Rotational Speed

The requirements are outlined in your determined method, however, in general;

- The sample holder is always rotated at a speed of 150rpm
- 300rpm disc speed is used for grinding (higher removal)
- 150rpm disc speed is used for polishing

3. Force

The requirements are outlined in your determined method based on preparing six individual specimens with a diameter of 30mm. However, in general;

- Grinding: 20 – 40 N
- Polishing: 15 – 30 N
- OP-Polishing: 10 – 15 N

These can be adjusted according to the number of samples and their size using table 3.

Table 3: Conversion factors for adjusting the amount of force to apply during mechanical preparation based total sample surface area.

No. of Samples	1	3	6
25mm dia.	5cm ²	15cm ²	29cm ²
30mm dia.	7cm ²	21cm ²	42cm ²
40mm dia.	13cm ²	38cm ²	75cm ²
50mm dia.	20cm ²	59cm ²	118cm ²
Samples combinations			
3 samples 25mm dia. = 15cm ² – divide the force by 3			
3 samples 30mm dia. = 21cm ² – divide the force by 2			
3 samples 40mm dia. = 38cm ² – same force as stated			
6 samples 25mm dia. = 29cm ² – divide the force by 1.5			
6 samples 30mm dia. = 42cm ² – same force as standard sample size			
6 samples 40mm dia. = 75cm ² – increase force slightly, extend preparation time			

4. Time

The requirements are outlined in your determined method.

5. Specimen Holder Positioning

- The specimen holder should be no more than 1-1.5mm above the surface.
- The specimen holder should be slightly over the edge of the disc and not over the centre line (figure 8).
- Correct positioning of the specimen holder ensures planeness by preventing halfmooning and pencil shaping.

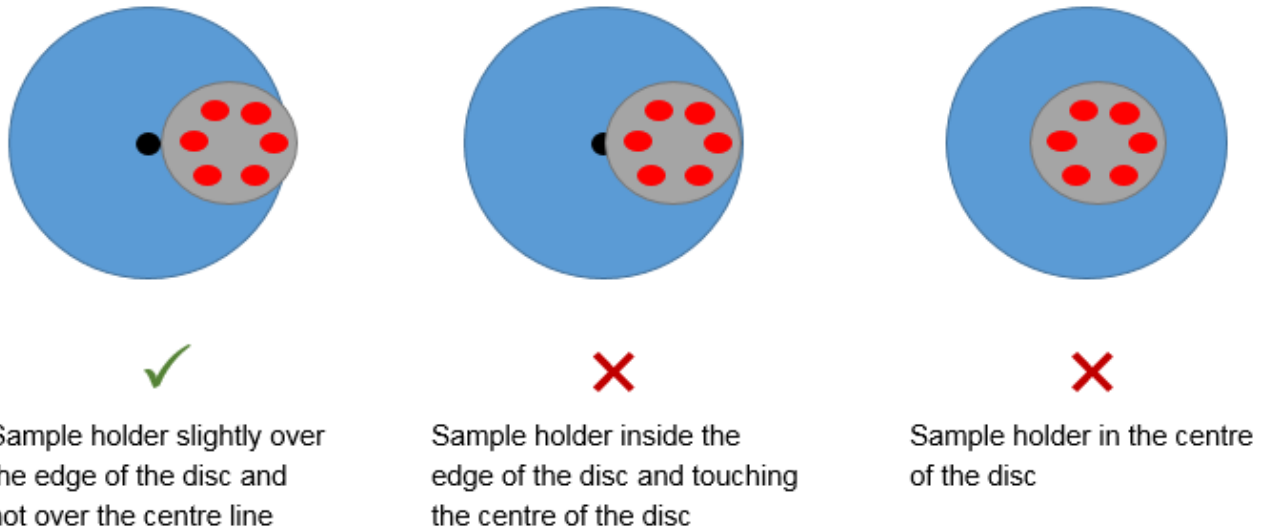


FIGURE 8: CORRECT POSITIONING OF THE SPECIMEN HOLDER.

Troubleshooting Tips & Tricks

For this section please refer to specific examples and the expert system as detailed on [Struers's website](#).

Grinding and Polishing

- To improve the preparation of a particular material, make sure that it has been prepared according to a suitable method from the Metalogram.
- If the material is being prepared for the first time, it is important to examine the specimen after every step with a microscope. This makes it easier to see when preparation artifacts occur.
- Before proceeding to the next step, be sure that all damage from the previous step, such as scratches, pull-outs, or embedded grains, are removed completely. If this is not done, artifacts from an early step might show up on the finished surface, in which case it would be impossible to be sure where they originated. It must be known when artifacts begin to occur to be able to improve the method.
- Keep preparation times as short as possible. Unnecessarily long preparation times waste consumables and may even damage the specimen, by causing edge rounding, comet tails, and relief, for example.
- New polishing cloths or grinding disks may need to be "run in" for a short time, or dressed or cleaned before use, to give the best results.

Scratches

- Scratches are grooves in the surface of a sample, produced by the points of abrasive particles.
- Make sure that after PG the surface of all samples in the specimen holder shows the same uniform scratch-pattern over the whole surface.
- Repeat PG if necessary.

Mechanical Preparation of Materials

- To avoid contamination of the grinding/polishing surface through large abrasive particles from a previous step, clean the samples and sample holder carefully after every step.
- If there are still scratches left over from the previous step after finishing the current step, increase the preparation time by 25% to 50% as a first measure. If that does not help, use the expert system.

Smearing

The plastic deformation of larger sample areas is called smearing. Instead of being cut away or removed, material is pushed across the surface. Smearing occurs because of an incorrect application of abrasive, lubricant, polishing cloth, or a combination of these, which makes the abrasive act as if it was blunt. There are three ways to avoid smearing:

- Lubricant: Check the amount of lubricant and, if necessary, increase it as smearing often occurs when the lubricant level is too low.
- Polishing cloth: Due to high resilience of the cloth, the abrasive can be pressed deep into the cloth and it cannot cut. Change to a cloth with lower resilience.
- Abrasive: The diamond grain size might be too small, which means the particles cannot cut. Use a larger grain size.

Staining

- Staining is often seen after cleaning or etching specimens.
- When there is a gap between the sample and resin, water or alcohol or etchant can bleed out.
- Areas on the specimen surface can be discoloured and make the examination difficult or even impossible.
- Clean and dry specimens immediately after each preparation step.
- Avoid the use of compressed air when drying your specimens after final polishing, because compressed air can contain oil or water.
- OP polishing can result in a white film left on the specimen surface if the cleaning is not carried out correctly.

If your polisher is not equipped with automatic water flushing after the oxide polishing step during the last ten seconds of OP polishing, flush the polishing cloth with water to clean both the specimens and the cloth.

- Do not use hot water for cleaning specimens, because hot water is more aggressive than cold water and subsequent etching will be intensified.
- Never leave specimens in normal room conditions because humidity might attack the specimen. Always store specimens in a desiccator if you want to keep them.

Deformation

There are two types of deformation: elastic and plastic. Elastic deformation disappears when the applied load is removed. Plastic deformation, which may also be referred to as cold work, can result in subsurface defects after grinding, lapping, or polishing. Remaining plastic deformation can first be seen after etching.

Only deformation introduced during the preparation is covered here. All other types from previous operations like bending, drawing, and stretching are not considered, because they cannot be changed or improved by changing the preparation method.

- Deformations are artifacts which first show up after etching (chemical, physical, or also optical etching).
- If a supposed deformation line also is visible in brightfield in unetched condition, please see the scratches section on how to improve the preparation method first.

Edge-Rounding

Using a polishing surface with high resilience will result in material removal from both the sample surface and the sides. The effect of this is edge rounding and can be seen with mounted specimens if the resin wears at a higher rate than the sample material. Please check your samples after each step to see when the fault occurs so you can determine what changes you will need to make in the preparation.

Relief

Material from different phases is removed at different rates due to varying hardness or wear rate of the individual phases.

Relief is usually not noted until polishing begins, so it is important to begin the preparation with grinding media that will keep the samples as flat as possible. However, for the best possible starting conditions, MD-Largo should be used for fine grinding of materials with a hardness below 150 HV, and MD-Allegro should be used for fine grinding of materials with a hardness of 150 HV and higher.

- Plane grinding with diamond is the best choice to ensure flat samples from the very beginning of the preparation.
- Fine grinding with either MD-Largo or MD-Allegro will provide the best possible planeness.
- To avoid relief, preparation time and the type of polishing cloth used are the most important parameters.
- The preparation time should be kept as short as possible. When developing a new method, the samples have to be checked at short intervals (one to two minutes).
- The polishing cloths have a strong influence on the planeness of the samples. A polishing cloth with low resilience produces samples with less relief than a cloth with high resilience.
- See Edge Rounding for the correct way to change preparation parameters.
- To avoid relief with layers and coatings, mounting may help to improve the result. Look in the "About Mounting" section for more detailed information.

Pull-Outs

Pull-out is a general term used to describe a number of material irregularities such as:

- Loss of structural elements (for example: unsupported particles in spray coatings, longitudinal fibers in composites).
- Cavities or pits that remain after water-sensitive inclusions have been dissolved or eroded.
- Holes created when inclusions such as oxides have been broken out of the matrix material.
- Damage caused by aggressive grinding that has not been removed yet (such as broken grains in brittle ceramics and other hard/brittle materials that do not suffer plastic deformation).

The above-described issues normally occur during the early steps of materials preparation: sectioning, mounting, and plane/coarse grinding. Avoid these situations by:

- Take care during cutting and mounting not to introduce excessive stress that could damage the specimens.
- Use MD-Largo when possible to avoid pull-outs. as it is less aggressive than MD-Allegro.
- Do not use higher forces or more coarse abrasives than needed for plane grinding or fine grinding.
- The margins between each abrasive grain size should not be too large so that it would prolong the preparation time unnecessarily.
- A napless polishing cloth should be used when possible, as it does not tend to "pluck" particles out of the matrix. Also most of the napless cloths have a lower resilience providing higher removal rates.
- Every step has to remove the damage from the previous one and has to introduce as little damage as possible of its own.
- Check the samples after every step to find out when pull-outs occur.

Gaps

Gaps are voids between the mounting resin and sample material. When examining samples with a microscope, it is possible to see if there is a gap between the resin and the sample. Gaps can result in a variety of preparation faults: edge rounding, contamination of polishing cloth, problems when etching, and staining.

- Vacuum impregnation using epoxy will provide the best result.
- The samples should always be cleaned and degreased to improve the adhesion of the resin to the sample.
- Hot mounting: choose the correct resin and cool the samples in the press under pressure to avoid gaps.
- Cold mounting: avoid too high curing temperatures. For large mounts, use a stream of cold air for cooling or place the molding cups in a shallow tray of cool water.
- To save a sample with a gap, try to fill the void with epoxy under vacuum. Clean and dry the sample carefully, put it into the vacuum chamber, and use a small amount of epoxy to fill the gap. The preparation has to be started all over again to remove any excess epoxy on the sample surface.

Cracks

Cracks are fractures in brittle materials and materials with different phases. The energy used to machine the sample is greater than can be absorbed. The surplus energy results in the cracks.

Cracks occur in brittle materials and samples with layers. Care has to be taken throughout the complete preparation process.

This section does not deal with cracks in ductile materials, as these are not caused by the preparation but are already present in the sample prior to preparation.

- Cutting: The appropriate cutoff wheel has to be chosen, and a low feed rate should be used.
- When cutting coated samples, the wheel should pass through the layer(s) first, so that the base material can act as support.
- Clamping of the sample should be carried out in a way that no damage can occur. If necessary, use padding between sample and clamp.
- Mounting Avoid hot compression mounting for fragile materials or samples. Use, instead, cold mounting, preferably with vacuum impregnation. The only exception is ClaroFast, Struers' thermoplastic resin which can be used in either CitoPress-15/-30 or any mounting press in which the resins can be pre-heated and softened without pressure.

Note: Vacuum impregnation will only fill cracks and cavities connected with the surface. Be careful not to use mounting materials with high shrinkage. They might pull layers away from the base material.

False Porosity

Some materials have natural porosity, for example, cast metals, spray coatings, or ceramics. It is important to get the correct values, and not to provide incorrect readings because of preparation faults.

Depending on the properties of a material, two contrary effects regarding porosity can be seen:

- Soft and ductile materials can be deformed easily. Therefore, pores can be covered by smeared material. An examination might show porosity percentage that is too low.
- The surface of hard, brittle materials is easily fractured during the first mechanical preparation steps, thus exhibiting more porosity than is actually the case.

Contrary to the ductile material, where the initial porosity seems to be low and pores have to be opened, brittle materials seem to have a high porosity. The apparent fracturing of the surface has to be removed.

- Polishing with diamonds is necessary, regardless of the material hardness or ductility. Examine the specimens every two minutes with a microscope, inspecting the same area each time to determine

if there is improvement. One way to make sure you are looking at the same area is to mark an area with a hardness indentation (for brittle materials, care has to be taken not to introduce additional stress).

- Once there are no further changes in porosity, proceed to the next polishing step.
- If needed, to remove the last of any smeared metal, the final step should be an oxide polish to remove material slowly, without introducing new deformation.

Hard/Brittle Materials

Hard brittle materials often get fractured at the surface during the first mechanical preparation steps. The surface might show a porosity higher than the real one.

Contrary to the ductile material, where the initial porosity seems to be low and pores have to be opened, brittle materials seem to have a high porosity. The apparent fracturing of the surface has to be removed.

Comet Tails

Comet tails occur adjacent to inclusions or pores, when the motion between sample and polishing disk is unidirectional. Their characteristic shape earns the name "comet tails." A key factor in avoiding comet tails is the polishing dynamics.

1. During polishing, use the same rotational speed for the samples and the disk.
2. Decrease the force.
3. Polishing for extended time on a soft cloth is a contributing factor. Ensure that as little deformation as possible must be removed by the next polishing step, especially when a cloth with high resilience is needed.

Contamination

Material from a source other than the sample itself, which is deposited on the sample surface during mechanical grinding or polishing, is called contamination.

- Contamination can occur on all types of materials.
- During polishing, dirt particles or material removed during a previous step can be deposited on the specimen or on the polishing cloth.
- Microscopic examination can show "inclusions" or phases in a structure which are anomalies or deformation.
- Be sure to store polishing disks in a dustproof cabinet to avoid contamination of the disk surface.
- Should there be any doubt if a phase or particle is correct, please clean or change the polishing cloth and repeat the preparation from the fine grinding step.
- Above all, make sure that the specimens are cleaned well between preparation steps

Embedded Abrasive

An embedded abrasive is a loose abrasive particle pressed into the surface of a specimen. With soft materials, abrasive particles can become embedded. Embedded abrasives can occur because of a small abrasive particle size, the grinding or polishing cloth used has a low resilience, or a lubricant with a low viscosity is used. Often, a combination of these reasons takes place.

- When plane grinding, abrasive particles can become embedded in soft materials. Continue with a somewhat finer grit surface (i.e. MD/DP-Pan with DiaPro Pan 15 um) as a second plane grinding step and MD-Largo for fine grinding. Embedded particles should be removed after the fine grinding step.
- MD-Molto 220 for Aluminum and Al alloys, or MD-Mezzo for Titanium and Ti alloys should be used for plane grinding those specific nonferrous metals/alloys.

- MD-Allegro should not be used for materials with hardness lower than 150 HV. Instead of being pressed into the disk, the abrasive particles will be pressed into the sample and stay there, firmly embedded. Use the MD-Largo instead of MD-Allegro.
- When polishing soft materials, grain sizes of 3.0 μm and smaller should only be used on cloths with high resilience.
- For the last diamond polishing steps of soft materials, when fine abrasive particles are used:
 1. DiaPro NAP R 1.0 μm when MD/DP-Nap cloth is used
 2. DiaPro Mol R 3.0 μm when MD/DP-Mol cloth is used
 3. DP-Lubricant, Red, a lubricant with high viscosity, is used with the diamond abrasive.
 4. If the material is water sensitive, use DP-Lubricant, Yellow with the diamond abrasive.

Lapping Tracks

Lapping tracks are indentations on the sample surface made by abrasive particles moving freely on a hard surface. These are not scratches, like from a cutting action, but are the distinct tracks of particles tumbling over the surface without removing material.

- If an abrasive particle is not held in a fixed position while the sample is passing over it, it will start rolling. Instead of removing material, the grain is forced into the sample material, creating deep deformation and only chipping small particles out of the sample surface.
- Lapping tracks can be produced during both grinding and polishing.
- The causes are: incorrect disk/cloth surfaces for the actual operation or the wrong force. Also, combinations of these faults can cause lapping tracks.