University of Saskatchewan
Department of Mechanical Engineering
Standard Operating Procedure # Mat0003

Procedure Title: Grinding and Polishing Metallic Samples

Minimum Review Requirements:	**Annually**
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1. Version History

Version #: .1
Supersedes: n/a

Handwritten amendments to the official procedures can be made by a single line through the text, along with the date, and initialed by the authorized individual making the correction. Changes are to be noted below. Formal changes to this SOP are made on the date of revision or sooner, where required.

Section	Changes made to official copy	Date	Initials

2. Introduction

This SOP provides general instructions to grind and polish metallic samples for metallographic etching or use as a substrate in thin film deposition.

3. Definition

SOP:	Standard Operating Procedure
MSDS:	Material Safety Data Sheet
WHMIS:	Workplace Hazardous Materials Information System
PPE:	Personal Protective Equipment
WSEP:	Workplace Safety and Environmental Protection

4. Personnel

Persons authorized to perform this SOP:

By signing this form I acknowledge that I have read and understand this SOP, as well as the applicable MSDS's and that I will conduct myself in accordance with this SOP and the general laboratory rules.

NOTE: ALL SIGNATURES MUST BE PRESENT ON THE SOP LOCATED IN THE YELLOW BINDER IN ROOM 2C26 – Mechanical Engineering Materials Lab, digital copies of SOP's are made available for reference and convenience only. Printed SOP's are valid for 24 hours only, after that time their accuracy must be verified with the **OFFICIAL HARDCOPY VERSION**.

Name (Print)	NSID	Dep't	Signature	Date

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5. Safety

5.1 Physical Hazards

- **No sample under 5mm thick can be held by hand, thin specimens must be mounted onto a holder either by the procedure described in Mat0004 for heat activated glue, or by water proof double sided adhesive (tape).**
- The polishing wheels rotate at a high speed and represent a potential entanglement hazard.
- The Si-C discs and diamond abrasives are an abrasion hazard; care should be taken to avoid scraping your skin.
- Liquid on a rotating disc could potentially splash into your eye; therefore safety glasses are required for this procedure.

5.2 Chemical and Toxicological Hazards

- The diamond slurries and lubricants are skin, eye and lung irritants and their MSDS's or PDS's should be consulted prior to polishing.
- The water based Diamond suspensions can be disposed of in a general sink and their waste does not need to be collected as hazardous waste.
- For alcohol based diamond suspensions (used with water sensitive materials such as magnesium) Mat0025 must be followed with respect to waste collection and safety protocol, SOP Mat0025 takes precedence with respect to any contradiction between this SOP and Mat0025.

6. Procedure

Stage 1: Setting Up

1. Depending on the starting roughness of the specimen, some pre-grinding on the belt grinder in the heat treatment lab may be required. If so, follow the procedure outlined in the belt grinder SOP.
2. Depending on the size of the specimen (thickness in particular) it may be required to be cold mounted or "temporarily stub mounted" (Mounting Metallographic Samples SOP, Mat0004)

Stage 2: Procedure

3. See the accompanying tables for a general guide on the abrasives and discs/cloths to be used, these depend on the type of specimen being prepared.

NOTE: The DiaPro diamond suspensions are labeled with an Owner such as: Prof. Yang, Prof. Oguocha, Prof. Szpunar, Prof. Odeshi etc. You MUST use the bottle designated for your supervisor/lab contact as the use of these consumables needs to be tracked.

4. Coarse Grinding:
    a. Belt grinder – Not recommended
        i. Pull out some new Si-C paper and turn on the water to the belt grinder.
        ii. Slowly push and pull the specimen across the wetted Si-C paper in a back and forth motion, do not apply a lot of force or you will round the specimen.
        iii. Repeat until you can see linear grooves of all the same size in the same direction that you are grinding.
        iv. If a second grit of SiC paper is required rotate the specimen 90° and repeat the above steps i->iii, rinsing with running water between grits.
    b. Rotational polishing wheel – SiC paper
        i. Using either:
            1. a PSA backed Si-C paper applied directly to a brass polishing platen, or to a MD-Rondo disk (blue) for use on a magnetic platen. **NEVER apply a PSA backed paper or cloth to a MD-Gekko disk (red).**
            2. or a non-PSA backed Si-C foil on a MD-Gekko (red disk).

            Turn on the polishing wheel to low speed, then to HIGH speed (if higher speed is required).
        ii. Turn on the flowing water and wet the entire abrasive paper.
        iii. Rotate the specimen in the same direction as the wheel rotates until the surface finish is entirely the grit being used.
    c. Rotational polishing wheel – MD Piano
        i. Place the appropriate Disc onto a magnetic backed platen and insert the platen onto the polishing head, and turn to LOW speed, then High speed if required.
        ii. Turn on the flowing water and wet the entire abrasive paper.
        iii. Rotate the specimen in the same direction as the wheel rotates until the surface finish is entirely the grit being used.

5. Rinse the specimen in running water.
    a. NOTE: with alcohol or oil based suspensions the water must be collected as hazardous waste so a water squirt bottle should be used over a funnel draining into a waste disposal container.
6. Rinse the specimen with alcohol and blow dry.
7. Fine Grinding: MD-System.
    a. Place the appropriate Disc onto a magnetic backed platen and insert the platen onto the polishing head, and turn to LOW speed.
    b. Pour some abrasive onto the Disc (do not overuse the abrasive as it is very expensive).
    c. Rotate the specimen in the same direction as wheel rotation, indicated by >> in the tables.
8. Rinse the specimen in running water.
    a. NOTE: with alcohol or oil based suspensions the water must be collected as hazardous waste so a water squirt bottle should be used over a funnel draining into a waste disposal container.
9. Rinse the specimen with alcohol and blow dry.
10. Coarse Polishing: MD-System.
    a. Place the appropriate Disc onto a magnetic backed platen and insert the platen onto the polishing head, and turn to LOW speed.
    b. Pour some abrasive onto the Disc (do not overuse the abrasive as it is very expensive).
    c. Rotate the specimen in the same direction as wheel rotation, indicated by >> in the tables.
11. Rinse the specimen in running water.
    a. NOTE: with alcohol or oil based suspensions the water must be collected as hazardous waste so a water squirt bottle should be used over a funnel draining into a waste disposal container.
12. Rinse the specimen with alcohol and blow dry.
13. Final Polish: MD-System.
    a. Place the appropriate Disc onto a magnetic backed platen and insert the platen onto the polishing head, and turn to LOW speed.
    b. Pour some abrasive onto the Disc (do not overuse the abrasive as it is very expensive).
    c. Rotate the specimen in the same direction as wheel rotation, indicated by >> in the tables.
14. Rinse the specimen in running water.

a. NOTE: with alcohol or oil based suspensions the water must be collected as hazardous waste so a water squirt bottle should be used over a funnel draining into a waste disposal container.

15. Rinse the specimen with alcohol and blow dry.

Stage 3: Clean-up

16. The MD-Largo, MD Allegro and MD-Piano discs must be fully rinsed with running water prior to being returned to the storage container; in addition the back side should be dried with paper towel. These discs can be cleaned under running water with the nylon brushes provided and labeled for use on Ferrous or Non-Ferrous discs only.
    a. NOTE: with alcohol or oil based suspensions the water must be collected as hazardous waste so a water squirt bottle should be used over a funnel draining into a waste disposal container.
17. The MD-Dac , MD-Mol, MD-Dur, MD-Chem and MD-Nap discs can be returned immediately after use, simply wipe the metal side dry if it is wet and return to the storage container in the appropriate labeled shelf.
18. Ensure that all abrasive containers are closed tightly and returned to the appropriate shelf or drawer.

STEELS

Specimen Type	Pre-Grind >>	Fine Grind 1 >>	Polish 1 >>	Polish 2 >>	Optional Polish ><
Low Carbon Steel	SiC – 320 grit Water High speed (300) 1 min	MD-Largo DiaPro Allegro/Largo Low speed (150) 5 min	MD-Dac DiaPro Dac Low speed (150) 4 min	MD-Nap DiaPro Nap Low speed (150) 1 min	MD-Chem OP-S (colloidal silica) Low speed (150) 1 min
Medium Carbon Steel - Softer	SiC – 220 grit Water High speed (300) 1 min	MD-Largo DiaPro Allegro/Largo Low speed (150) 5 min	MD-Dac DiaPro Dac Low speed (150) 4 min	MD-Nap DiaPro Nap Low speed (150) 1 min	MD-Chem OP-S (colloidal silica) Low speed (150) 1 min
Medium Carbon Steel - Harder	MD-Piano 220 Water High speed (300) 2 min	MD-Allegro DiaPro Allegro/Largo Low speed (150) 4 min	MD-Dur DiaPro Dur Low speed (150) 3 min	MD-Nap DiaPro Nap Low speed (150) 1 min	MD-Chem OP-U Low speed (150) 1 min
High Carbon Steel	MD-Piano 220 Water High speed (300) 2 min	MD-Allegro DiaPro Allegro/Largo Low speed (150) 5 min	MD-Dur DiaPro Dur Low speed (150) 4 min	MD-Nap DiaPro Nap Low speed (150) 1 min	MD-Chem OP-U Low speed (150) 1 min
Low Alloyed Heat Treated Steels – Softer	SiC – 220 grit Water High speed (300) 2 min	MD-Largo DiaPro Allegro/Largo Low speed (150) 4 min	MD-Dac DiaPro Dac Low speed (150) 4 min	MD-Nap DiaPro Nap Low speed (150) 1 min	MD-Chem OP-S (colloidal silica) Low speed (150) 1 min
Low Alloyed Heat Treated Steels – Harder	MD-Piano 220 Water High speed (300) 2 min	MD-Largo DiaPro Allegro/Largo Low speed (150) 4 min	MD-Dac DiaPro Dac Low speed (150) 4 min	MD-Nap DiaPro Nap Low speed (150) 1 min	MD-Chem OP-S (colloidal silica) Low speed (150) 1 min
High Alloyed Heat Treated Steels	MD-Piano 220 Water High speed (300) 1 min	MD-Allegro DiaPro Allegro/Largo Low speed (150) 3 min	MD-Dac DiaPro Dac Low speed (150) 3 min	MD-Nap DiaPro Nap Low speed (150) 1 min	N/A
High Alloyed Steel – Short Method	SiC – 220 grit Water High speed (300) 1 min	MD-Largo DiaPro Allegro/Largo Low speed (150) 5 min	MD-Dac DiaPro Dac Low speed (150) 4 min	N/A	MD-Chem OP-S (colloidal silica) Low speed (150) 2 min
High Alloyed Steel – Long Method	SiC – 220 grit Water High speed (300) 1 min	MD-Largo DiaPro Allegro/Largo Low speed (150) 5 min	MD-Mol DiaPro Mol Low Speed (150) 4 min	MD-Nap DiaPro Nap Low speed (150) 1 min	MD-Chem OP-S (colloidal silica) Low speed (150) 2 min

STEELS CONTINUED					
Specimen Type	**Pre-Grind >>**	**Fine Grind 1 >>**	**Polish 1 >>**	**Polish 2 >>**	**Optional Polish ><**
HSLA Steel	SiC – 220 grit Water High speed (300) 1 min	MD-Largo DiaPro Allegro/Largo Low speed (150) 5 min	MD-Dac DiaPro Dac Low speed (150) 4 min	MD-Nap DiaPro Nap Low speed (150) 1 min	MD-Chem OP-S (colloidal silica) Low speed (150) 1 min
Tool Steel	MD-Piano 220 Water High speed (300) 1 min	MD-Largo DiaPro Allegro/Largo Low speed (150) 5 min	MD-Dac DiaPro Dac Low speed (150) 4 min	N/A	MD-Chem OP-S (colloidal silica) Low speed (150) 1 min
Stainless Steels	SiC – 220 grit Water High speed (300) 1 min	MD-Largo DiaPro Allegro/Largo Low speed (150) 5 min	MD-Dac DiaPro Dac Low speed (150) 4 min	N/A	MD-Chem OP-S (colloidal silica) Low speed (150) 2 min
Iron based Super Alloys	SiC – 220 grit Water High speed (300) 1 min	MD-Largo DiaPro Allegro/Largo Low speed (150) 5 min	MD-Dac DiaPro Dac Low speed (150) 4 min	N/A	MD-Chem OP-S (colloidal silica) Low speed (150) 2 min

CAST IRONS

Specimen Type	Pre-Grind >>	Fine Grind 1 >>	Polish 1 >>	Polish 2 >>	Optional Polish ><
White Cast Iron	MD-Piano 220 Water High speed (300) 2 min	MD-Allegro DiaPro Allegro/Largo Low speed (150) 5 min	MD-Dac DiaPro Dac Low speed (150) 4 min	MD-Nap DiaPro Nap Low speed (150) 2 min	N/A
Malleable (Ductile) Iron	SiC – 220 grit Water High speed (300) 1 min	MD-Largo DiaPro Allegro/Largo Low speed (150) 5 min	MD-Dac DiaPro Dac Low speed (150) 4 min	MD-Nap DiaPro Nap Low speed (150) 2 min	MD-Chem OP-U Low speed (150) 1 min
Nodular Cast Iron	SiC – 220 grit Water High speed (300) 1 min	MD-Largo DiaPro Allegro/Largo Low speed (150) 5 min	MD-Dac DiaPro Dac Low speed (150) 4 min	MD-Nap DiaPro Nap Low speed (150) 2 min	MD-Chem OP-U Low speed (150) 1 min
Grey Cast Iron	SiC – 220 grit Water High speed (300) 1 min	MD-Largo DiaPro Allegro/Largo Low speed (150) 5 min	MD-Dac DiaPro Dac Low speed (150) 4 min	MD-Nap DiaPro Nap Low speed (150) 2 min	MD-Chem OP-U Low speed (150) 1 min
Other Cast Irons	SiC – 220 grit Water High speed (300) 1 min	MD-Largo DiaPro Allegro/Largo Low speed (150) 3 min	MD-Dac DiaPro Dac Low speed (150) 3 min	N/A	MD-Chem OP-U Low speed (150) 1 min

NON-FERROUS METALS

Specimen Type	Pre-Grind >>	Fine Grind 1 >>	Polish 1 >>	Polish 2 >>	Optional Polish ><
Cast Aluminum Alloys	SiC – 320 grit Water High speed (300) 1 min	MD-Largo DiaPro Allegro/Largo Low speed (150) 4 min	MD-Mol DiaPro Mol Low speed (150) 3 min	N/A	MD-Chem OP-S (colloidal silica) Low speed (150) 1 min
Wrought Aluminum Alloys	SiC – 320 grit Water High speed (300) 1 min	MD-Largo DiaPro Allegro/Largo Low speed (150) 4 min	MD-Mol DiaPro Mol Low speed (150) 3 min	N/A	MD-Chem OP-S (colloidal silica) Low speed (150) 1 min
Very Soft Aluminum Alloys	SiC – 800 grit Water High speed (300) 1 min	SiC – 1200 grit Water High speed (300) 1 min	SiC – 4000 grit Water High speed (300) 1 min	MD-Mol DiaPro Mol Low speed (150) 4 min	MD-Chem OP-S (colloidal silica) Low speed (150) 1 min
Generic Copper Alloys	SiC – 320 grit Water High speed (300) 1 min	MD-Largo DiaPro Allegro/Largo Low speed (150) 3 min	MD-Mol DiaPro Mol Low speed (150) 5 min	N/A	MD-Chem OP-S (colloidal silica) Low speed (150) 1 min
Bronze	SiC – 220 grit Water High speed (300) 1 min	MD-Largo DiaPro Allegro/Largo Low speed (150) 3 min	MD-Dac DiaPro Dac Low speed (150) 3 min		MD-Chem OP-S (colloidal silica) Low speed (150) 2 min
Brass	SiC – 220 grit Water High speed (300) 1 min	MD-Largo DiaPro Allegro/Largo Low speed (150) 3 min	MD-Dac DiaPro Dac Low speed (150) 3 min		MD-Chem OP-S (colloidal silica) Low speed (150) 2 min

COATINGS

Specimen Type	Pre-Grind >>	Fine Grind 1 >>	Polish 1 >>	Polish 2 >>	Optional Polish ><
Galvanized Steel	SiC – 320 grit Water High speed (300) 1 min	MD-Largo DiaPro Allegro/Largo Low speed (150) 4 min	MD-Dac DiaPro Dac Low speed (150) 3 min	MD-Nap DiaPro Nap Low speed (150) 3 min	MD-Chem OP-U Low speed (150) 0.5 min

7. Equipment or Materials Required

The following Personal Protective Equipment (PPE) is required for this procedure:

- Gloves (latex or Nitrile) (Disposable) – Polishing suspension dependent
- This SOP
- Lab Coat
- Closed Toed Shoes
- Safety Glasses
- Long Pants
- MSDS and PDS Information
- Operational Eye Wash Station
- Polishing wheels
- Various SiC grinding discs and polishing cloths
- Various diamond suspensions
- **NOTE: NONE OF THE GLOVES USED IN THE LABORATORY ARE INTENDED FOR SUBMERSION USE, THEY ARE FOR SPLASH/SPILL PROTECTION ONLY.**

8. Highlights / Critical Control Points

Proper rinsing between steps will ensure that cloths do not become contaminated with a larger abrasive; once a cloth is contaminated it is ruined.

9. Regulatory / Standards

All Waste disposal standards must be followed along with Mat0001 and Mat0002.

10. Trouble Shooting

If a clogged drain occurs do not continue polishing, notify the Departmental Assistant who will arrange for this to be repaired.

11. References

University of Saskatchewan DHSE Documents:

Laboratory Safety Manual:
http://www.usask.ca/dhse/file_view/download.php/Laboratory_Safety_Manual.pdf?id=32&view=1

Struers E-Gate: E-Metalog, Ferrous Metals, High Alloy Steels, Stainless Steels (DiaPro, AN)