

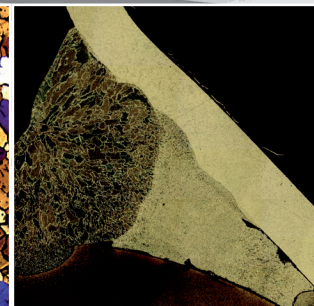
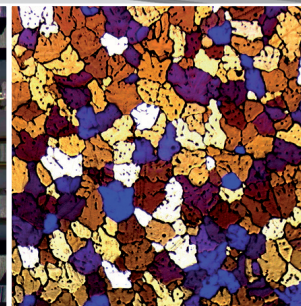
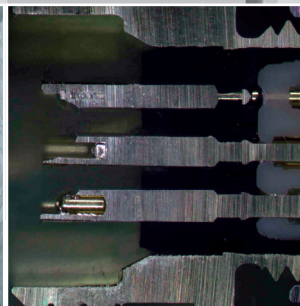
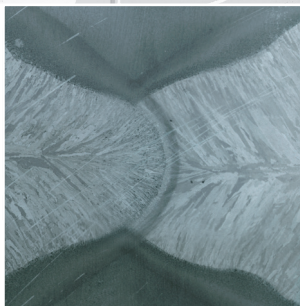
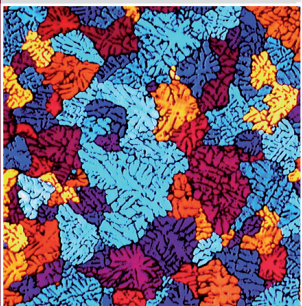


Advanced Materialography

Sample preparation

**Standard preparation methods
for materialographic analysis**

Practical experience ATM-Lab



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NOTES:

The preparation methods can be applied for proper sectioned and burred specimens. Parameters like pressure (given as force in newton) are referred to single pressure and depend on specimen size. For specimens \neq 40mm these values have to be adjusted with the help of table „Pressure parameters and specimen size“.

Instead of the Dia Complete diamond suspensions common diamond suspensions in combination with lubricants (water or alcohol based) can be used. Mind right dosage!

The velocity of the sample holder is 100 rpm and can vary depending on the specific material.

Due to the diversity of materials and examination aims the provided standard preparation methods might not cover all applications. In this case contact our application lab; our team will support you with customized preparation methods.

lab@atm-m.com

**Grit conversion chart**

FEPA (P)	grain size [µm]	ANSI/CAMI	grain size [µm]
60	269	60	268
80	201	80	188
100	162	100	148
120	127	120	116
180	787	180	78
240	58.5	220	66
280	52.2	240	51.8
320	46.2		
360	40.5	280	42.3
400	35	320	34.3
500	30.2	360	27.3
600	25.8	400	22.1
800	21.8		
1000	18.3	500	18.2
1200	15.3	600	14.5
1500	12.6	800	12.2
2000	10.3	1000	9.2
2500	8.4	1200	6.5
4000	5		


















*Reference:**Analytical Characterization of Aluminum, Steel, and Superalloys**D. Scott MacKenzie, George E. Totten**October 10, 2005 by CRC Press**ISBN: 9780824758431***Pressure parameters and specimen size**

Specimen diameter [mm]	25	30	40	50	60
Divergence in pressure used in the preparation methods	- (5N...10N)	- 5N	0	+ 5N	+ (5N...10N)

NOTES:

The preparation methods can be applied for proper sectioned and burred specimen. Parameters like pressure (given as force in newton) are referred to single pressure and depend on specimen size. For specimens ≠ 40mm these values have to be adjusted.

EXPLANATION OF SYMBOLS

Symbol	Meaning	Symbol	Meaning
	Cutting		Single pressure
	Mounting		Speed grinding disc
	Grinding / Polishing		Speed sample holder
	Grinding / Polishing		Sample holder clockwise
	Etching		Sample holder anti-clockwise
	Pre-polishing		Time
	Polishing / diamond		Dosing lubricant
	Final polishing		Lubricant waterbased
			Lubricant alcohol based

MATERIAL
Aluminum ($\geq 99,7\%$) and wrought aluminum alloy

CUTTING
Equipment
Brillant

Consumable

Cut-off wheel: corundum, resin bond
Anti-corrosion coolant

MOUNTING
Equipment
Opal

Consumable












Bakelite red/black
KEM 20, KEM 30

Method

Hot mounting
Castable

**GRINDING/
POLISHING**











Specimen size \varnothing 40 mm

STEP	MEDIUM		 rpm		 N	 min
 Planar grinding	SiC-paper/foil** P320 (280)	H ₂ O	250-300	▶▶	20	Until plane
 Grinding	SiC-paper/foil** P600 (400)	H ₂ O	250-300	▶▶	20	1:00
 Grinding	SiC-paper/foil** P1200 (600)	H ₂ O	250-300	▶▶	20	1:30 (change SiC paper/foil after 45s)
 Polishing	GAMMA	Dia Complete Poly, 3 μ m	120-150	▶▶	30	6:00
 Final polishing	LAMBDA/OMEGA	Eposil F 0.1 μ m	120-150	◀▶	20	2:00 (H ₂ O for last 0:30)
 Etching (electrolyt.)	Barker's reagent					30V

** To reduce the contamination of the specimen by SiC particles, it should be coated with paraffin wax before grinding.

MATERIAL**Aluminum alloy****CUTTING****Equipment**
Brillant**Consumable**Cut-off wheel: corundum, resin bond
Anti-corrosion coolant**MOUNTING****Equipment**
Opal**Consumable**Bakelite black/red
KEM 20**Method**Hot mounting
Castable**GRINDING/
POLISHING**

Specimen size Ø 40 mm

STEP	MEDIUM		 rpm		 N	 min
 Planar grinding	SiC-paper/foil P320 (280)	H ₂ O	250-300	▶▶	25	Until plane
 Pre-polishing	BETA	Dia Complete Poly, 9µm	120-150	◀▶	25	5:00
 Polishing	SIGMA	Dia Complete Poly, 3µm	120-150	▶▶	30	5:00
 Final polishing	LAMBDA/OMEGA	Eposil F 0.1µm	120-150	◀▶	20	2:00 (H ₂ O for last 0:30)
 Etching (chem.)	Kroll's reagent					0:30

MATERIAL
Carbon/glass fiber reinforced composites (CFC/GFC)

CUTTING
Equipment

Brillant

Consumable

Cut-off wheel: diamond, metal bond (bronze)
Anti-corrosion coolant

MOUNTING
Equipment

Pressure vessel

Consumable










KEM 15 plus

Method

Castable


**GRINDING/
POLISHING**

Specimen size Ø 40 mm

STEP	MEDIUM		 rpm		 N	 min
 Planar grinding	SiC-paper/foil P320 (280)	H ₂ O	250-300	▶▶	35	Until plane
 Pre-polishing	ALPHA/BETA	Dia Complete Poly, 9µm	120-150	◀▶	30	5:00
 Polishing	GAMMA/DELTA	Dia Complete Poly, 3µm	120-150	▶▶	30	5:00
 Final polishing	LAMBDA/OMEGA	Eposal 0.06µm	120-150	◀▶	20	1:30 (H ₂ O for last 0:30)

MATERIAL **Cast iron (GJS/GJL)**

CUTTING
Equipment
Brilliant

Consumable

Cut-off wheel: corundum, resin bond
Anti-corrosion coolant

MOUNTING
Equipment
Opal

Consumable












Bakelite red/black
KEM 30

Method

Hot mounting
Castable

**GRINDING/
POLISHING**

Specimen size Ø 40 mm

STEP	MEDIUM		 rpm		 N	 min
 Planar grinding	SiC-paper/foil P320 (280)	H ₂ O	250-300	▶▶	30	Until plane
 Grinding	SiC-paper/foil P600 (400)	H ₂ O	250-300	▶▶	30	1:00
 Grinding	SiC-paper/foil P1200 (600)	H ₂ O	250-300	▶▶	30	1:00
 Polishing	SIGMA	Dia Complete Poly, 3µm	120-150	▶▶	25	5:00
 Final polishing	LAMBDA/OMEGA	Eposal 0.06µm	120-150	◀▶	20	1:00 (H ₂ O for last 0:10)*
 Etching (chem.)	Nital					0:03-0:10

* Rinsing with water can cause corrosion.

MATERIAL
Soft to medium-hard steel (5-35 HRC/350HV)

CUTTING
Equipment
Brillant

Consumable

Cut-off wheel: corundum, resin bond
Anti-corrosion coolant

MOUNTING
Equipment
Opal

Consumable











Epo black, Bakelite red/black
KEM 15 plus

Method

Hot mounting
Castable

**GRINDING/
POLISHING**









Specimen size Ø 40 mm

STEP	MEDIUM		 rpm		 N	 min
 Planar grinding	SiC-paper/foil P320 (280)	H ₂ O	250-300	▶▶	30	Until plane
 Pre-polishing	BETA	Dia Complete Poly, 9µm	120-150	◀▶	35	5:00
 Polishing	SIGMA/GAMMA	Dia Complete Poly, 3µm	120-150	▶▶	30	6:00
 Final polishing	LAMBDA/OMEGA	Eposal 0.06µm	120-150	◀▶	20	1:00 (H ₂ O for last 0:30)
 Etching (chem.)	Nital (micro) Adler's reagent (macro)*					0:03 0:03

* for weld analysis

MATERIAL**Medium-hard to hard steel (30-65 HRC/850HV)****CUTTING****Equipment**
Brillant**Consumable**Cut-off wheel: corundum, resin bond
Anti-corrosion coolant**MOUNTING****Equipment**
Opal**Consumable**Epo black
KEM 15 plus**Method**Hot mounting
Castable**GRINDING/
POLISHING**

Specimen size Ø 40 mm

STEP	MEDIUM		 rpm		 N	 min
 Planar grinding	GALAXY red	H ₂ O	250-300	▶▶	30	Until plane
 Pre-polishing	BETA	Dia Complete Poly, 9µm	120-150	◀▶	30	5:00
 Final polishing	IOTA	Dia Complete Poly, 3µm	120-150	◀▶	30	4:00

MATERIAL
Stainless steel (austenitic/ferritic)

CUTTING
Equipment
Brillant

Consumable

Cut-off wheel: corundum, resin bond
Anti-corrosion coolant

MOUNTING
Equipment
Opal

Consumable











Epo black, Bakelite red/black
KEM 15 plus

Method

Hot mounting
Castable









**GRINDING/
POLISHING**

Specimen size Ø 40 mm

STEP	MEDIUM		 rpm		 N	 min
 Planar grinding	SiC-paper/foil P320 (280)	H ₂ O	250-300	▶▶	30	Until plane
 Pre-polishing	ALPHA/BETA	Dia Complete Poly, 9µm	120-150	◀▶	25	5:00
 Polishing	GAMMA	Dia Complete Poly, 3µm	120-150	▶▶	25	5:00
 Final polishing	LAMBDA/OMEGA	Eposal 0.06µm	120-150	◀▶	20	2:00 (H ₂ O for last 0:30)
 Etching (chem.)	V2A reagent					0:05-0:30










MATERIAL**Steel and welded steel (macro)****CUTTING**
Equipment
 Brillant
Consumable
 Cut-off wheel: corundum, resin bond
 Anti-corrosion coolant
**MOUNTING**
Equipment
 Opal
Consumable
 Epo black, Bakelite red/black
 KEM 15 plus
Method
 Hot mounting
 Castable
**GRINDING/
POLISHING**

Specimen size Ø 40 mm

STEP	MEDIUM		 rpm		 N	 min
 Planar grinding	SiC-paper/foil P180 (180)	H ₂ O	250-300	▶▶	30	Until plane
 Grinding	SiC-paper/foil P320 (280)	H ₂ O	250-300	▶▶	35	1:00
 Etching (chem.)	Adler's reagent (macro)					0:03-0:10

**MATERIAL****Nitrided steel****CUTTING****Equipment**
Brillant**Consumable**Cut-off wheel: corundum, resin bond
Anti-corrosion coolant**MOUNTING****Equipment**
Opal**Consumable**Epo black**
KEM 15 plus**Method**Hot mounting
Castable**GRINDING/
POLISHING**

Specimen size Ø 40 mm

STEP	MEDIUM		 rpm		 N	 min
 Planar grinding	GALAXY green	H ₂ O	250-300	▶▶	25	Until plane
 Pre-polishing	ALPHA/BETA	Dia Complete Poly, 9µm	120-150	◀▶	25	5:00
 Polishing	GAMMA/DELTA	Dia Complete Poly, 3µm	120-150	▶▶	30	5:00
 Final polishing	LAMBDA/OMEGA	Eposal 0.06µm	120-150	◀▶	15	1:00 (H ₂ O for last 0:30)










** before hot mounting the specimen should be wrapped in aluminum foil to stabilize the nitrided layer

MATERIAL**Ceramics****CUTTING**
Equipment
 Brilliant
Consumable
 Cut-off wheel: diamond, metal bond (bronze)
 Anti-corrosion coolant
**MOUNTING**
Equipment
 Vacuum
Consumable
 KEM 90 (porous material)
 KEM 35 (high-density, solid material)
Method

Castable











**GRINDING/
POLISHING**

Specimen size Ø 40 mm

STEP	MEDIUM		 rpm		 N	 min
 Planar grinding	GALAXY red	H ₂ O	250-300	▶▶	30	Until plane
 Grinding	GALAXY blue	H ₂ O	250-300	▶▶	30	2:00
 Pre-polishing	BETA	Dia Complete Poly, 9µm + diamond paste	120-150	◀▶	40	6:00
 Final polishing	GAMMA	Dia Complete Poly, 3µm + diamond paste	120-150	▶▶	30	5:00










**MATERIAL****Cobalt based alloy****CUTTING****Equipment**
Brillant**Consumable**Cut-off wheel: corundum, resin or rubber bond
Anti-corrosion coolant**MOUNTING****Equipment**
Opal**Consumable**Epo black
KEM 15 plus**Method**Hot mounting
Castable**GRINDING/
POLISHING**

Specimen size Ø 40 mm

STEP	MEDIUM		 rpm		 N	 min
 Planar grinding	SiC-paper/foil P320 (280)	H ₂ O	250-300	▶▶	30	Until plane
 Pre-polishing	BETA	Dia Complete Poly, 9µm	120-150	◀▶	30	8:00
 Polishing	GAMMA	Dia Complete Poly, 3µm	120-150	▶▶	30	6:00
 Polishing	ZETA/IOTA	Dia Complete Poly, 1µm	120-150	▶▶	30	3:00
 Final polishing	LAMBDA/OMEGA	Eposal 0.06µm	120-150	◀▶	20	2:00 (H ₂ O for last 0:30)

MATERIAL **Nickel based alloy**
**CUTTING**
Equipment
 Brillant
Consumable
 Cut-off wheel: corundum, resin or rubber bond
 Anti-corrosion coolant
**MOUNTING**
Equipment
 Opal
Consumable
 Epo black
 KEM 15 plus
Method
 Hot mounting
 Castable
**GRINDING/
POLISHING**

Specimen size Ø 40 mm

STEP	MEDIUM		 rpm		 N	 min
 Planar grinding	GALAXY green	H ₂ O	250-300	▶▶	30	Until plane
 Pre-polishing	BETA	Dia Complete Poly, 9µm	120-150	◀▶	30	6:00
 Polishing	GAMMA	Dia Complete Poly, 3µm	120-150	▶▶	30	5:00
 Final polishing	LAMBDA/OMEGA	Eposal 0.06µm	120-150	◀▶	20	1:30-2:00 (H ₂ O for last 0:30)

MATERIAL

Spray coatings (metallic, ceramic)



CUTTING

Equipment
Brillant

Consumable

Cut-off wheel: diamond, resin bond
Anti-corrosion coolant



MOUNTING

Equipment
Vacuum

Consumable












KEM 90

Method

Castable


GRINDING/
POLISHING















Specimen size Ø 40 mm

STEP	MEDIUM		 rpm		 N	 min
 Planar grinding	SiC-paper/foil P180 (180)	H ₂ O	250-300	▶▶	30	Until plane
 Grinding	SiC-paper/foil P320 (280)	H ₂ O	250-300	▶▶	30	1:30
 Pre-polishing	ALPHA/BETA	Dia Complete Poly, 9µm	120-150	◀▶	30	5:00-8:00**
 Polishing	GAMMA	Dia Complete Poly, 3µm	120-150	▶▶	30	5:00-8:00**
 Polishing	ZETA	Dia Complete Poly, 1µm	120-150	▶▶	20	2:00
 Final polishing	LAMBDA	Eposal 0.06µm	120-150	◀▶	20	1:30 (H ₂ O for last 0:30)

** Until constant porosity → next polishing step

MATERIAL **Magnesium**
**CUTTING**
Equipment
 Brillant
Consumable
 Cut-off wheel: diamond, resin bond
 Anti-corrosion coolant
**MOUNTING**
Equipment
 Opal
Consumable
 Bakelite red/black, Thermoplast,
 KEM 20
Method
 Hot mounting
 Castable
**GRINDING/
POLISHING**

Specimen size Ø 40 mm

STEP	MEDIUM		 rpm		 N	 min
 Planar grinding	SiC-paper/foil* P600 (400)	H ₂ O	250-300	▶▶	15	Until plane
 Polishing	BETA	 Diamond suspension (alcohol or oil based) 9µm, poly	120-150	▶▶	15	5:00
 Polishing	SIGMA	 Diamond suspension (alcohol or oil based) 3µm, poly	120-150	▶▶	15	5:00
 Polishing	ZETA	 Diamond suspension (alcohol or oil based) 1µm, poly	120-150	▶▶	15	5:00
 Final polishing	OMEGA**	Etosil E 0.06µm	120-150	◀▶	15	4:00 (ethanol for last 30s)
 Etching (chem.)	3% nitric acid					0:03-0:10 (ethanol for 30s)

* To reduce the contamination of the specimen by SiC particles, it should be coated with paraffin wax before grinding

** wet the polishing cloth with ethanol before polishing

**MATERIAL****Printed circuit board (non assembled)****CUTTING****Equipment**
Brillant**Consumable**Cut-off wheel: corundum, resin bond
Anti-corrosion coolant**MOUNTING****Equipment**
Pressure vessel**Consumable**











KEM 20

Method

Castable

**GRINDING/
POLISHING**

Specimen size Ø 40 mm

STEP	MEDIUM		 rpm		 N	 min
 Planar grinding	SiC-paper/foil P180 (180)	H ₂ O	250-300	▶▶	30	Until plane (slightly before point of interest)
 Grinding	SiC-paper/foil P800 (500)	H ₂ O	250-300	▶▶	25	1:00 (until point of interest)
 Grinding	SiC-paper/foil P1200 (600)	H ₂ O	250-300	▶▶	25	1:00 (until point of interest)
 Polishing	GAMMA/DELTA	Dia Complete Poly, 3µm	120-150	▶▶	30	3:00
 Final polishing	ZETA/LAMBDA	Eposal 0.06µm	120-150	◀▶	25	2:00 (LAMBDA: H ₂ O for last 0:30)

MATERIAL**Printed circuit board (assembled)****CUTTING**
Equipment
 Brilliant
Consumable
 Cut-off wheel: diamond, metal bond
 Anti-corrosion coolant
**MOUNTING**
Equipment
 Vacuum
 Pressure vessel
Consumable












KEM 90, KEM 20

Method

Castable

**GRINDING/
POLISHING**

Specimen size Ø 40 mm

STEP	MEDIUM		 rpm		 N	 min
 Planar grinding	SiC-paper/foil P320 (280), GALAXY green**	H ₂ O	250-300	▶▶	30	Until plane
 Grinding	SiC-paper/foil P600 (400), GALAXY blue**	H ₂ O	250-300	▶▶	30	1:00
 Grinding	SiC-paper/foil P1200 (600), GALAXY yellow**	H ₂ O	250-300	▶▶	30	1:00
 Pre-polishing	ALPHA/BETA	Dia Complete Poly, 9µm	120-150	◀▶	25	4:00
 Polishing	GAMMA/DELTA	Dia Complete Poly, 3µm	120-150	▶▶	25	4:00
 Final polishing	ZETA/OMEGA	Eposal 0.06µm	120-150	◀▶	20	1:30 (LAMBDA: H ₂ O for last 0:30)

** for printed circuit boards with ceramic components

MATERIAL
Copper and copper alloy

CUTTING
Equipment
Brillant

Consumable

Cut-off wheel: corundum, resin bond
Anti-corrosion coolant

MOUNTING
Equipment
Opal

Consumable












Bakelite red/black, Thermoplast
KEM 20, KEM 30

Method

Hot mounting
Castable

**GRINDING/
POLISHING**










Specimen size Ø 40 mm

STEP	MEDIUM		 rpm		 N	 min
 Planar grinding	SiC-paper/foil P320 (280)	H ₂ O	250-300	▶▶	30	Until plane
 Grinding	SiC-paper/foil** P600 (400)	H ₂ O	250-300	▶▶	30	1:30
 Grinding	SiC-paper/foil** P1200 (600)	H ₂ O	250-300	▶▶	30	1:30
 Polishing	SIGMA	Dia Complete Poly, 3µm	120-150	▶▶	30	4:00
 Final polishing	OMEGA	Eposil F 0.1µm**	120-150	◀▶	15	2:00 (H ₂ O for last 0:30)
 Etching (chem.)	Klemm's I reagent					0:02

** 50mL Eposil F + 1mL H₂O₂ + 1mL NH₃

MATERIAL**Titanium (commercial pure: grade 1-4)****CUTTING****Equipment**
Brilliant**Consumable**Cut-off wheel: corundum, resin bond
Anti-corrosion coolant**MOUNTING****Equipment**
Opal**Consumable**Epo black
KEM 20, KEM 15 plus**Method**Hot mounting
Castable**GRINDING/
POLISHING**

Specimen size Ø 40 mm

STEP	MEDIUM		 rpm		 N	 min
 Planar grinding	SiC-paper/foil P320 (280)	H ₂ O	250-300	▶▶	25	Until plane
 Pre-polishing	ALPHA/BETA	Dia Complete Poly, 9µm	120-150	◀▶	20	10:00
 Final polishing	LAMBDA	Eposil F 0.1µm**	120-150	◀▶	20	10:00 – 15:00* (H ₂ O for last 0:30)
 Etching (chem.)	Kroll's reagent					0:45

* Depends on grade of titanium

** Eposil F has to be mixed with hydrogen peroxide (35%) in a ratio of 5:1 (safety advice: use personal protective equipment)

MATERIAL
Titanium alloy

CUTTING
Equipment
Brillant

Consumable

Cut-off wheel: corundum, resin bond
Anti-corrosion coolant

MOUNTING
Equipment
Opal

Consumable











Epo black
KEM 20, KEM 15 plus

Method

Hot mounting
Castable

**GRINDING/
POLISHING**

Specimen size Ø 40 mm

STEP	MEDIUM		 rpm		 N	 min
 Planar grinding	SiC-paper/foil P320 (280)	H ₂ O	250-300	▶▶	25	Until plane
 Grinding	SiC-paper/foil P600 (400)	H ₂ O	250-300	▶▶	25	1:30
 Pre-polishing	ALPHA/BETA	Dia Complete Poly, 9µm	120-150	◀▶	20	5:00
 Final polishing	LAMBDA	Eposil F 0.1µm**	120-150	◀▶	20	5:00 – 10:00* (H ₂ O for last 0:30)
 Etching (chem.)	Kroll's reagent					0:45

* Depends on the alloy

** Eposil F has to be mixed with hydrogen peroxide (35%) in a ratio of 5:1 (safety advice: use personal protective equipment)



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