MetPrep Application Notes – Application Note – 002

The Preparation of Spheroidal Cast Iron using a Semi-automatic Preparation System

Kevin Smith - March 2020

Introduction

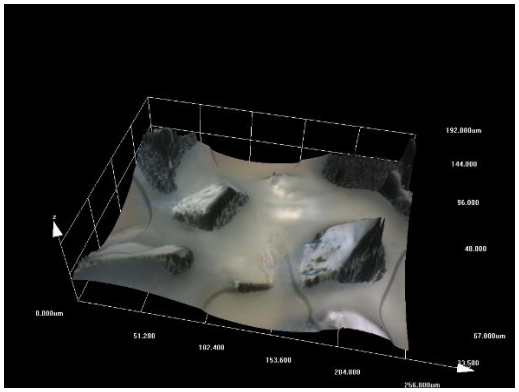
To prepare a sample for metallographic examination requires an understanding of both your sample properties and the properties of your consumables. This allows you to create a preparation procedure from first principles.

S G iron is a medium hardness metallic material consisting of an iron and iron carbide structure, a ferritic / pearlitic matrix but also including individual nodules of graphite. On cutting cut it behaves in a ductile manner though it is necessary to consider the soft brittle nature of the graphite.

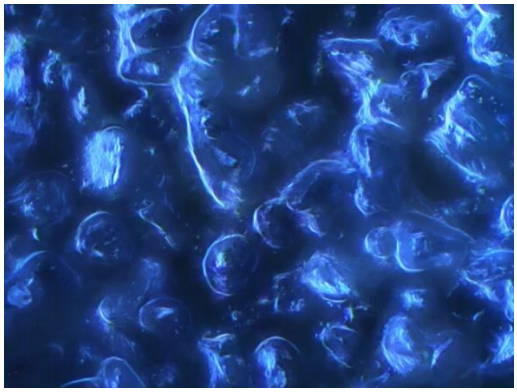
Primary grinding.

Primary grinding is employed for several reasons. Removal of damage created by sectioning, removal of excess mounting material which may have encroached over the sample surface, or if central pressure is being employed to get your samples planar. Let's consider the choices for the primary grinding stage.

SG iron can be easily ground by Silicon Carbide, Zirconia and Fixed Diamond. It is known that Silicon Carbide is the sharpest abrasive and is also both very efficient and economical. Diamond is hard but relatively blunt as is Zirconia. In the event of a lot of material is required to be removed from the surface, then the latter grinding options have a place. If you have a correctly sectioned sample, Silicon Carbide will provide an excellent cutting action through both the matrix and the graphite nodules, causing as little damage as possible. An effective sized abrasive size will be needed to remove any cutting damage and excess moulding material but care is required to minimise damage. There is no point in cutting carefully to reduce damage to then put in more damage in the primary grinding stage. With this in mind a P240g (58 um) size would be an ideal compromise. That said should you need to use two papers then maybe P180g (78 um) may be more suitable. The choice will be dependent of existing surface finish and the amount of material needed to be removed.

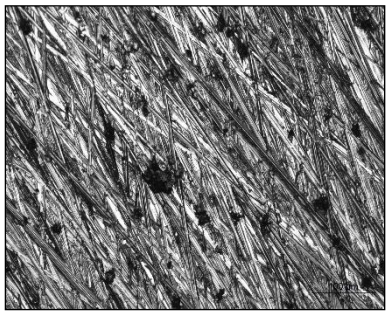


P240g Silicon Carbide – LEXT LSCM

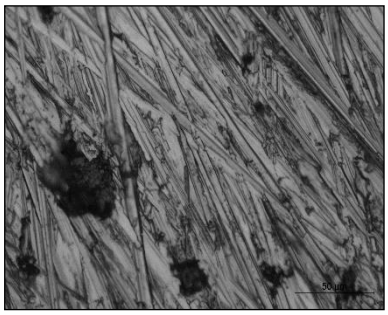


P240g Silicon Carbide – DMLM 20x Obj

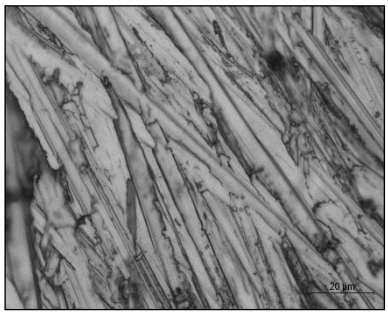
Being a sharp abrasive silicon carbide will have more chance of cutting both the metallic & graphite material equally and at a similar rate. Following this stage, the sample can be examined under a metallurgical microscope and when confirmed the sample surface is as good as it can be at this stage it can be considered for the next stage. A clean sharp scratch pattern is clearly obtained.



P240g - 20x Objective



P240g - 50x Objective

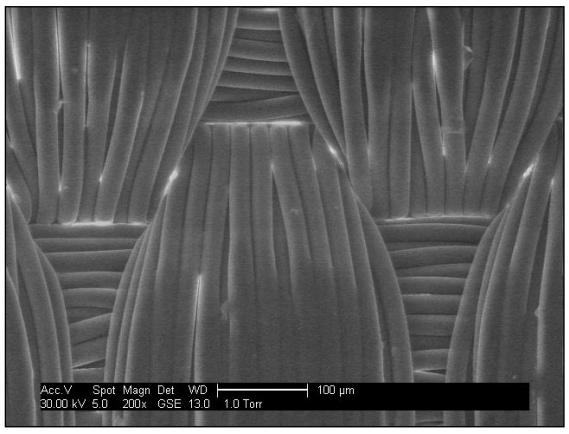


P240g - 100x Objective

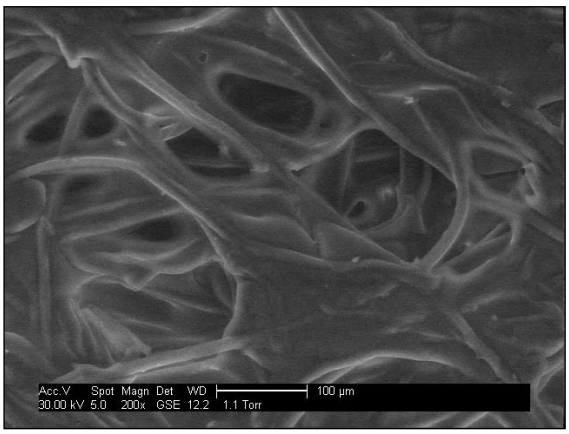
Secondary Grinding

As we are preparing the sample with a semi-automatic preparation system whilst we could continue through the grades of Silicon Carbide to maybe P1200g (16um) but this will require several paper changes and multiple washings.

Therefore what are the options for a secondary grinding stage? MetPrep provide two cloths typically employed for secondary grinding stages, the coarse cross woven polyester - Abracloth and the more forgiving and less aggressive chemotextile - Planocloth H. Both cloths are hard wearing and ideal for the secondary grinding stages for metallic materials. As the Spheroidal Graphite Cast Iron contains these isolated graphite nodules, and graphite being quite brittle it is good practice to err on the side of caution and use the less aggressive cloth, the Planocloth H.

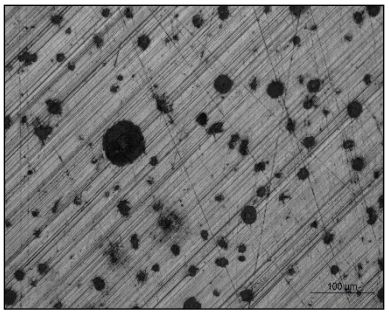


Abracloth 200x SEM

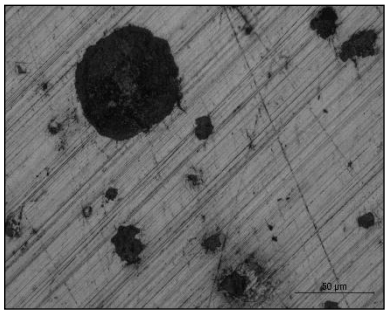


Planocloth H 200x SEM

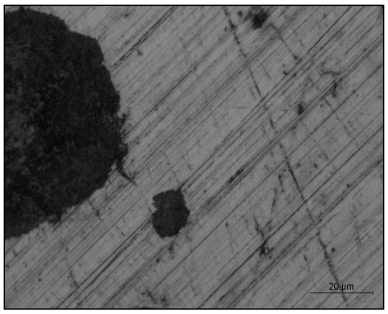
Stepping down from a P240g (58 um) silicon carbide stage to a 9um diamond abrasive is a typical step but it will require some time to remove the damage from the previous stage. Whilst it may take a few minutes the stock removal rate is very consistent and no intermediate washing is required thus saving on time. If the preparation is for just one or two samples then an initial time of 3 minutes preparation is a good start. Follow this with a microscopical examination to determine what damage remains. Taking a series of photomicrographs at this point will allow comparison to any further steps viewed. Having assessed the surface microscopically after 3 minutes at this stage the samples should be should further prepared for a couple more minutes and again examined accordingly. When microscopical examination confirms that further work is not improving the surface only then should a tertiary grinding stage can be considered.



Planocloth H - 20x Objective



Planocloth H - 50x Objective



Planocloth H - 100x Objective

Tertiary grinding

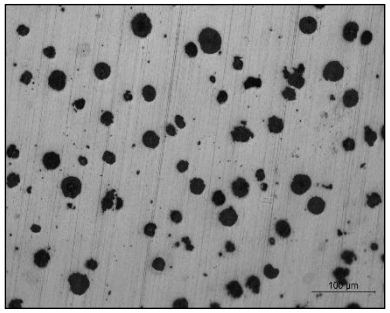
Having determined the sample is correctly prepared at the 9um stage we can now consider the tertiary stage. MetPrep provide a choice of three cloths useful the tertiary grinding stages of ductile materials, Planocloth, Nylap, and Durasilk. All these cloths are suitable for the tertiary stages but again there are differences. The more aggressive Planocloth that is chemotextile in nature could possibly cause rubbing which could be an issue with the brittle graphite nodules at this stage, the fine woven Durasilk is designed more for the softer ductile materials as it is less aggressive and less hardwearing, therefore the compromise cloth would be the Nylap. Nylap is a fine cross woven cloth and should remove material without leaving excessive damage in the more brittle nodules but still remove material from the whole sample efficiently. It will certainly have less chance of rubbing like the smoother chemotextile Planocloth option.

Planocloth 40x

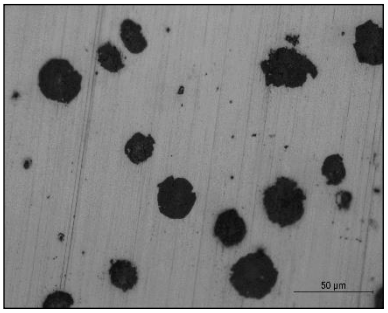
Nylap 40x

Durasilk 40x

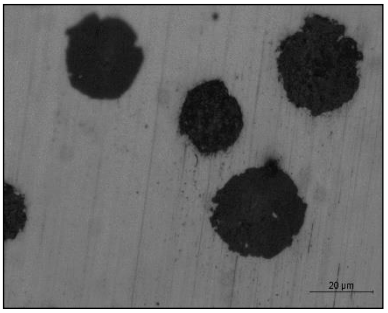
Again, the process of preparing for a short time followed by microscopical examination, recording of micrographs and returning to the preparation surface for a short time is recommended. Completion is determined by microscopical examination confirming the surface is damage free. If the surface isn't free of damage a Quaternary stage would be needed where the aggressive nature of the cloth and the abrasive is reduced even further. Assuming now that a surface free of structural damage has been produced it will no doubt still have some scratches. It is now acceptable to consider using a polishing cloth if a scratch finish is required.



Nylap 20x Objective

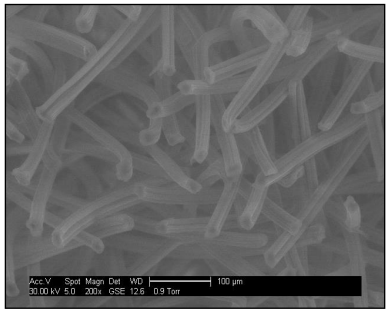


Nylap 50x Objective

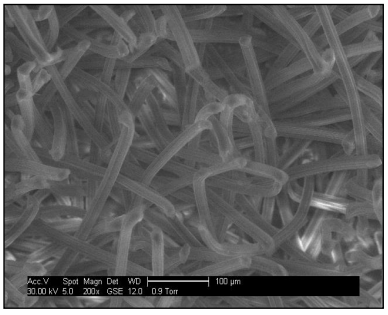


Nylap 100x Objective

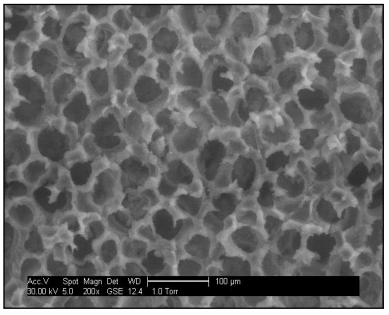
When it comes to a final polish with dissimilar materials in the sample it is best to consider a cloth with a short nap or no nap and a fine abrasive. From our microscopical evaluation we can see that Multicloth and Memphis are low napped in nature and will leave less relief when compared to the longer napped Alphacloth . In addition, the Chemicloth with Colloidal Silica is an option. The nature of the Chemicloth is completely different being more sponge like and having next to no nap but giving a good surface finish with increased flatness and reducing problems associated with polishing samples containing dissimilar materials.



Alphacloth SEM 200x



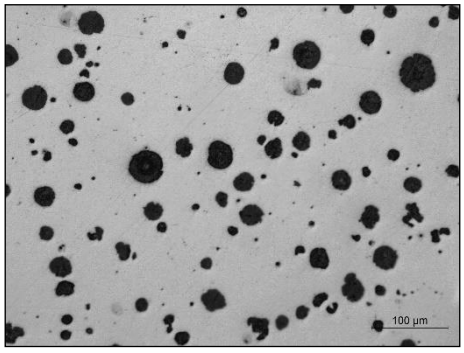
Multicloth SEM 200x



Chemicloth SEM 200x

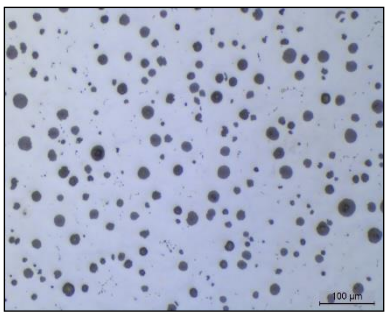
Keeping the relief to a minimum and wanting to get the finest scratch free finish the latter combination would be best. There will be some chemical attack by the Colloidal Silica on the surface due to the pH but this isn't usually a problem. The result should be a scratch free surface, free of damage and showing the true microstructure. All will give a good final finish.

Whilst the structure produced would be acceptable in most laboratories above there is still some very minimal damage left in some of the graphite nodules. In fact, the surface finish at 9um is actually capable of allowing for image analysis for size and shape evaluation.



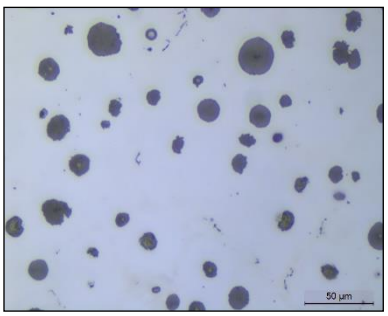
Multicloth & 0.06um Silco 20x Objective

In the final polished condition, the soft napped cloth with colloidal Silica has removed the scratches but not this last minimal damage in the graphite. One has to always remember - final polishing cloths are designed for removing scratches not damage. If the same abrasive, Colloidal silica is used, but instead used on a 'hard' cloth such as the Planocloth - a chemotextile cloth with no nap, then the colloidal Silica will operate in a grinding mode due to the nature of the cloth. This fine grinding is capable of removing the final damage in the graphite. Whilst the chemotextile Planocloth can cause problems by rubbing with a diamond suspension, the more viscous nature of the colloidal silica solution means this does not occur.



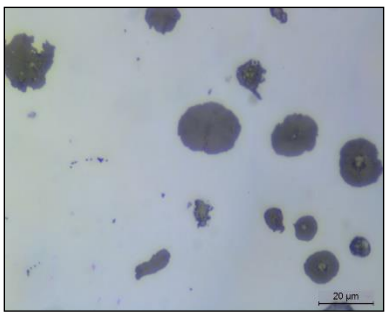
Planocloth 20x Objective

Brightfield only



Planocloth 50x Objective

Brightfield only

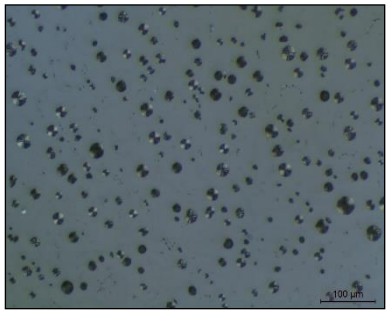


Planocloth 100x Objective

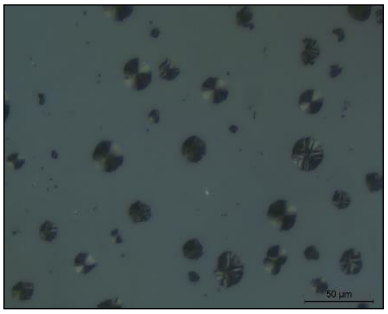
Brightfield only

Comparison between the 'final as polished' stage using a napped cloth – Multicloth and the 'quaternary grinding' stage with the 'hard' cloth – Planocloth shows that the fine grinding quaternary stage results in less damage present in the graphite nodules and additionally reflectivity. A final polishing stage can also be employed if required eg Multicloth or Chemicloth with Silco or OPUS solution would fit the task.

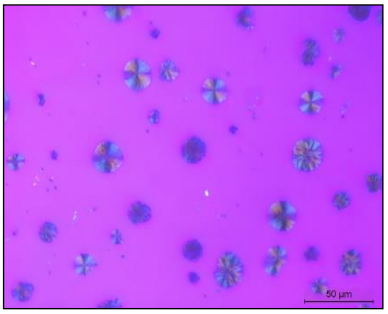
Consequently, having less damage in the graphite nodules allows the use of alternative contrast techniques to Brightfield illumination. As graphite is a birefringent material it is classed as optically active and will respond well to polarised light illumination. This technique is only possible when the surface damage is completely removed.



Planocloth 20x Objective
Brightfield - Polarised



Planocloth 50x Objective
Brightfield - Polarised



Planocloth 50x Objective
Brightfield - Polarised + Waveplate

Completed Preparation Procedure for Spheroidal Graphite Cast Iron

	Surface	Abrasive	Pressure		Speed – Dir	Time
Primary Grinding Stage	Paper	P180g SiC	Psi	N	150 – Comp	Until Planar
			5	25		

	Surface	Abrasive	Pressure		Speed – Dir	Time
Additional Grinding Stages	Planocloth H	9 µm (WB) Diamond	Psi	N	250 – Comp	5 mins
			5	25		
	Nylap	3 µm (WB) Diamond	5	25	250- Comp	4 mins
	Planocloth	0.06µm Silco*	5	25	100 – Comp	3 mins

	Surface	Abrasive	Pressure		Speed – Dir	Time
Polishing Stage	Multicloth	0.06µm Silco	Psi	N	80 – Comp	2 mins
			3	15		

*Colloidal Silica stage only required if detail in the graphite is required

Summary

By using the understanding of a materials properties and the properties of the metallographic consumables it is possible to prepare a sample of Spheroidal Graphite correctly from first principles.

Understanding the difference of using cloths in both grinding modes as well has the polishing mode allows the use of multiple grinding stages effectively carried out with a semi-automatic preparation system such as the Saphir 250 A1 eco. Minimising time and improving quality is the main benefit of using such a system. Add to that removing operator variability, it is the ideal way to generate correct preparation results. It is also worth reminding oneself that an abrasive is just an abrasive and it depends on the surface it is used on as to how it will perform.

Kevin Smith – March 2020