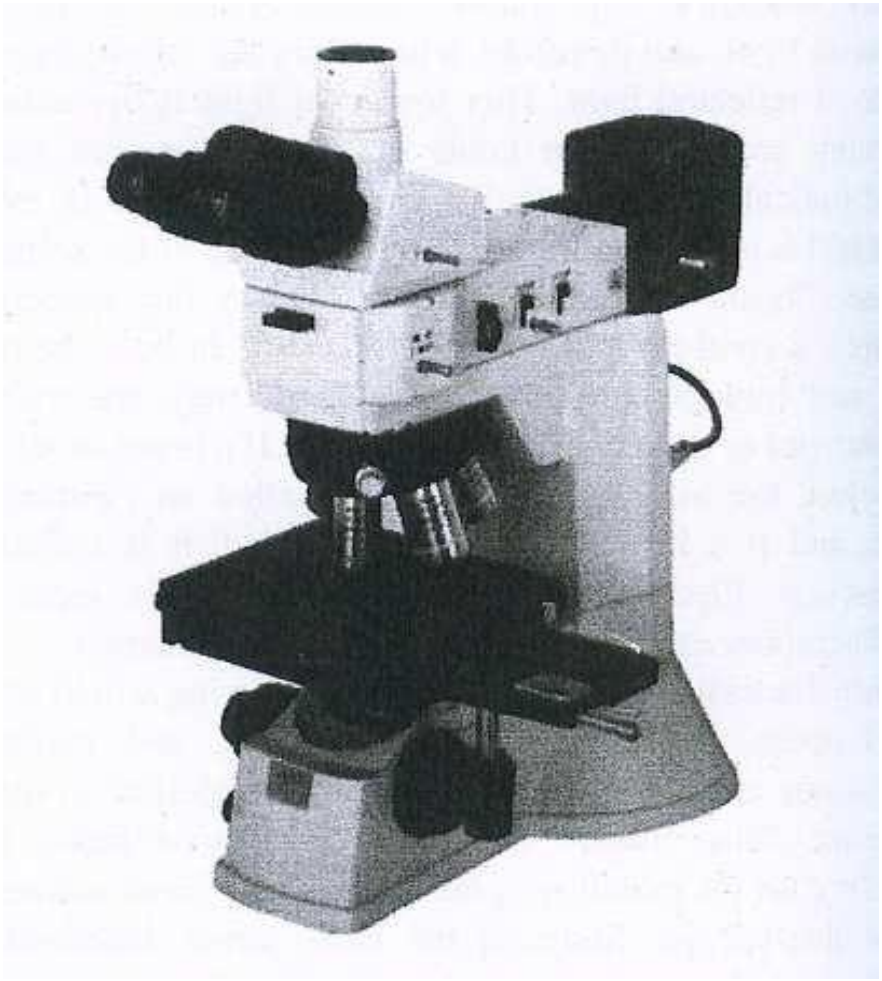
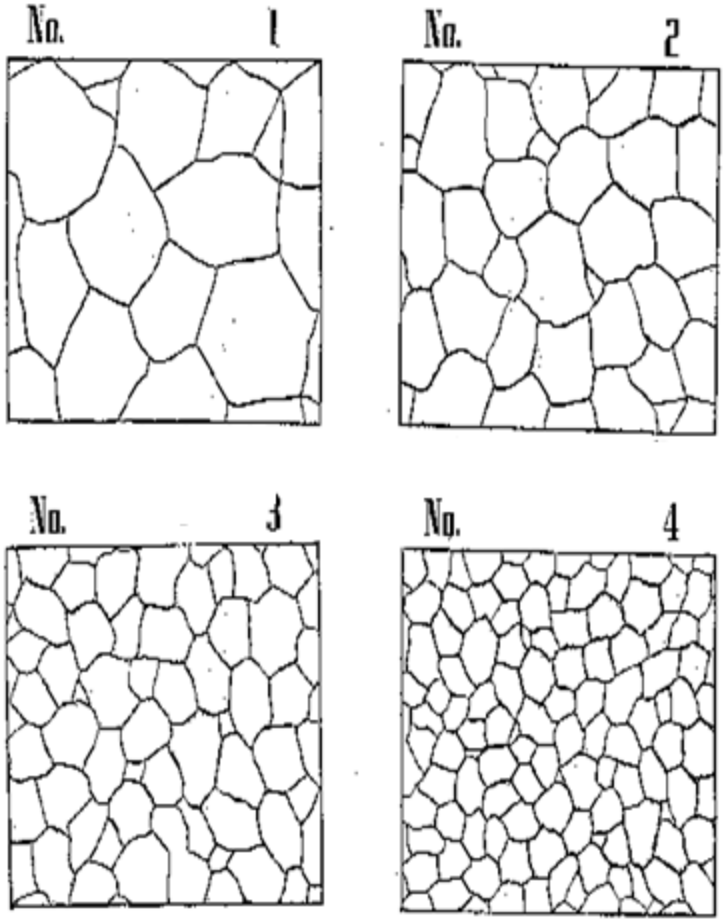
MICRO & MACRO-EXAMINATION





INTRODUCTION

- Full information regarding structure can not be obtained without the metallography examination of prepared sections
- The method adopted for metallography examination can be divided in to two groups:
  - Macro examination- either with the naked eye or under a very low magnification (x5-10)
  - Micro examination- at high magnification (x20-2000)

MICROGRAPHY

*The branch of materials science dealing with microscopic examination of polished metals and alloys specimen is called Micrography

INTRODUCTION TO MICROGRAPHY

- Aloys Beck Von Widmanstatten, an Editor in Graz, originated micrographic examination
- Study of metallic microstructures is done by using metallurgical microscope
- Can be used to determine
  - Heat treatment
  - mechanical processing
  - material properties and
  - phases present
  - Case Depth
  - Surface decarburisation
  - Coating / Plating
  - Presence of weld defects, if any

PREPARATION OF MICRO SAMPLE

SAMPLE PREPARATION

Microscopic examination begins with:

- Selection of specimen from a suitable location
- Cutting
- Grinding
- Polishing
- Etching
- Examination through microscope

SELECTING THE SPECIMEN

SELECTING OF SPECIMEN FOR MICRO-EXAMINATION

- A larger body of metal may not be homogeneous either in composition or crystal structure
- A specimen approx. 20 mm diameter or 20 mm square in a convenient size to handle is cut parallel to the method of manufacturing by saw/abrasive cutter using coolant from an edge or wherever required



Cutting m/c using coolant



SELECTING OF SPECIMEN FOR MICRO-EXAMINATION

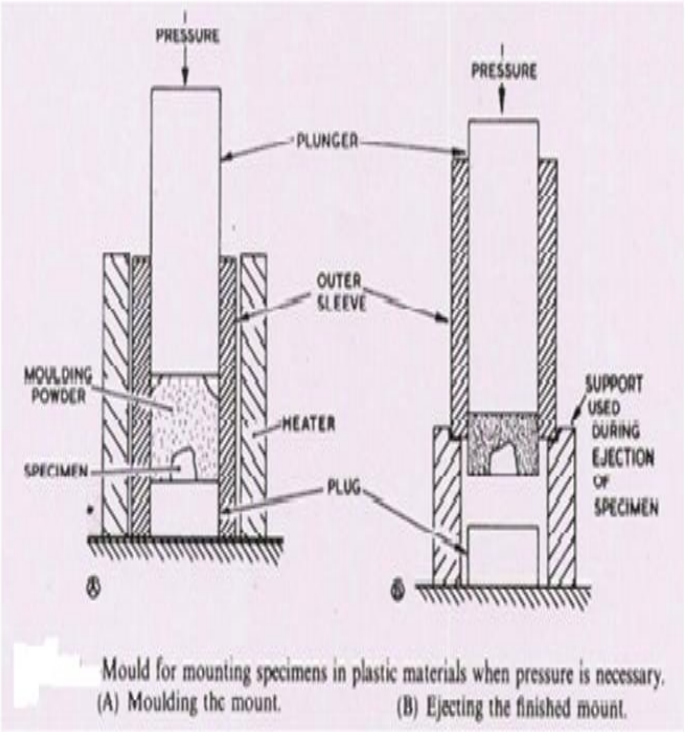
- When it is necessary to preserve an edge or when a specimen is so small or unhandy (like razor blade, etc) that it is difficult to hold it flat on the emery cloth/paper, the specimen is embedded in a plastic case by mounting process
- The edges of the metal specimens to be beveled off to avoid damaging polishing cloths/papers

MOUNTING THE SPECIMEN

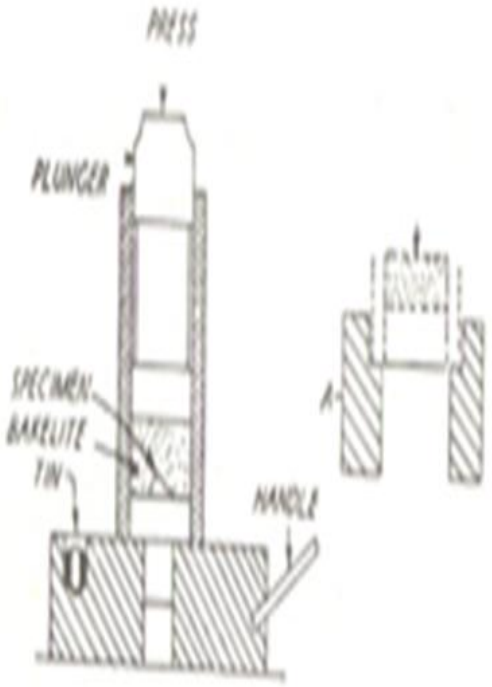
MOUNTING THE SMALL SPECIMEN

- Very small specimens are difficult to polish & this can best be done by mounting them in resin such as Bakelite, etc [epoxy resin(perfect penetration), acrylic resin (very rapid cooling time), polyster resin(very economical)
- Mounting a specimen provides a safe, standarised & ergonomic way by which to hold a sample during grinding & polishing operations
- The specimen is placed to the matched & cleaned cylinderical tube, 2/3rd of which is filled with resin powder keeping the desired face down ward, resting slightly above the base

MOUNTING THE SMALL SPECIMEN



Mould for mounting specimens in plastic materials when pressure is necessary.
(A) Moulding the mount. (B) Ejecting the finished mount.





MOUNTING THE SMALL SPECIMEN

- A suitable pressure is applied to compress it in to a solid mass
- A thermometer is placed upward in to the die
- The apparatus is heated to about the MP of resin used (230C, when bakelite is used)
- When the powder has completely melted & the resin has set. The apparatus is cooled usually
- The mount is then taken out from the cylinder by replacing the anvil by the stand & by applying pressure

FILING/GRINDING THE SPECIMEN

GRINDING & POLISHING M/C



FILING/GRINDING THE SPECIMEN

- It is first necessary to obtain a reasonably flat surface on the specimen
- This can best be done either by using a fairly coarse file or preferably by using a motor driven emery belt
- If file is used, it will be found easier to obtain a flat surface by rubbing the specimen on the files than by filing using vice





FILING/GRINDING THE SPECIMEN

- Whatever method is used, care must be taken to avoid over heating the specimen by quicker grinding methods, since this may lead to alteration in the micro structure
- Both the specimen & hands between each step should thoroughly be washed in order to prevent carry over of filings & dirt to the polishing cloths/papers for successful preparation

FILING/GRINDING THE SPECIMEN

- Water proof emery papers or emery cloths must be of the very best quality, particularly in respect of particle size
- It is carried out on revolving wheels fitted with a series of water proof silicon carbide abrasive papers (the first method of grinding & is still used today) of increasing fineness to achieve scratch free mirror finish, free from smear, drag or pulls-out
- It starts with emery cloths (No.80-coarser & No.120-finer) & then emery paper No.1/0, 2/0, 3/0 & 4/0

FILING/GRINDING THE SPECIMEN

- The specimen is held on paper/cloth placed on a glass plate so that the scratches from the abrasive should form in one direction only, at right angles to the file marks
- The specimen is rubbed down until latter scratches are removed
- The specimen is then transferred to next fine paper turning it through right angle & rubbed down until all scratches from previous paper are removed

FILING/GRINDING THE SPECIMEN

- The same is repeated similarly on remaining papers using vary light pressure
- The direction of grinding is changed from paper/cloths to papers/cloths so that the removal of previous grinding/paper/cloth marks can easily be observed
- During polishing, the specimen to be held firmly in contact with the polishing wheel avoiding undue pressure to have an even polish
- Light pressure to be used at all stages otherwise it will cause deep scoring marks on the surface of the specimen & these will take longer time to remove

POLISHING

POLISHING THE SPECIMEN

- After grinding the specimen, polishing operation is performed
- Polishing can best be carried out by holding the specimen against a rotating disc fitted with woolen cloth
- Numerous expensive polishing powders of finer grades are used (polishing powder such as Alumina, Chromium oxide, Magnesia & Ferric oxide)
- A constant drip of powder suspended in distilled water is fed to the rotating disc moving at a lower speed
- Light pressure to be used at all times otherwise it will cause deep score marks on the surface of the specimen & may necesstiate returning to coarser papers

POLISHING THE SPECIMEN

- When the specimen appears to be free from scratches, it is thoroughly cleaned & examined under microscope. If satisfactorily found free from scratches, the specimen is examined for inclusions
- The fine flaky powders from the specimen, if any, are removed using chamois leather moist with distilled water

ETCHING THE SPECIMEN

ETCHING THE SPECIMEN

- The specimen is rubbed from the sides of the specimen with fingers but care must be exercised in touching the polished face
- The specimen should first be washed free of any adhering polished compound
- The micro structural constituents of the specimen are revealed by using a suitable chemical reagents

ETCHING THE SPECIMEN

- This is generally accomplished by etching the polished specimen
- The specimen is etched by being plunged in to the etching reagent & agitated vigorously for several seconds
- The time required for etching varies with different alloys & etching reagents. Some alloys can be etched sufficiently in a few seconds whilst some SS, being resistance to attack by most reagents, require a much as 30 mts

ETCHING THE SPECIMEN

- The etchant attacks various parts of the specimen at different rates due to:
  - Variation in chemical composition
  - Method of manufacturing
  - HT and
  - Many other variables
- If specimen, after a first attempt is found to be sufficiently etched, the surface will appear slightly dull

ETCHING THE SPECIMEN

- If the surface is still bright, the etching process can usually be repeated without further preparation of the surface
- If the specimen is over etched, it can only be corrected by re-polishing & then re-etching for a shorter time
- The grain boundary is attacked at a greater rate than the proper grain due to higher energy content of the grain boundaries

ETCHING THE SPECIMEN

- The specimen is removed by means of nickel tongs & thoroughly rinsed in running water
- Alcohol is sprayed over the surface of the etched specimen & dried untouched by holding in a stream of hot air from hair drier
- The specimen must be dried evenly & quickly otherwise it will stain



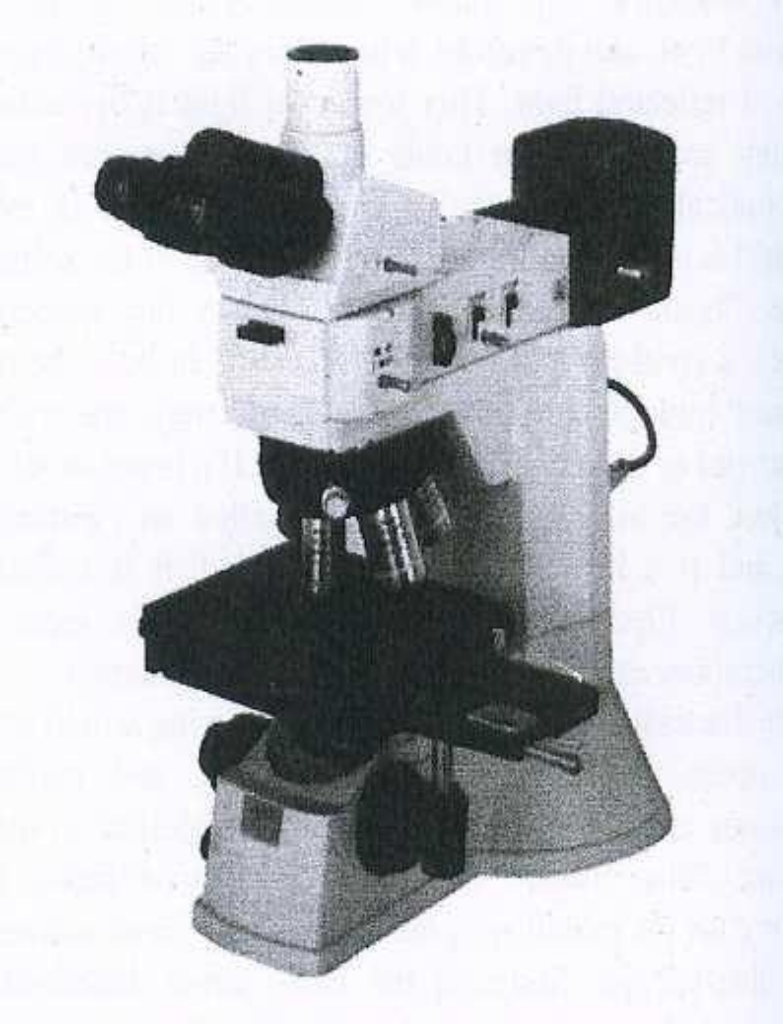
LIST OF ETCHANTS

- A number of different etching reagents may be used
- List of Etchants Used for Various Metals/Alloys:

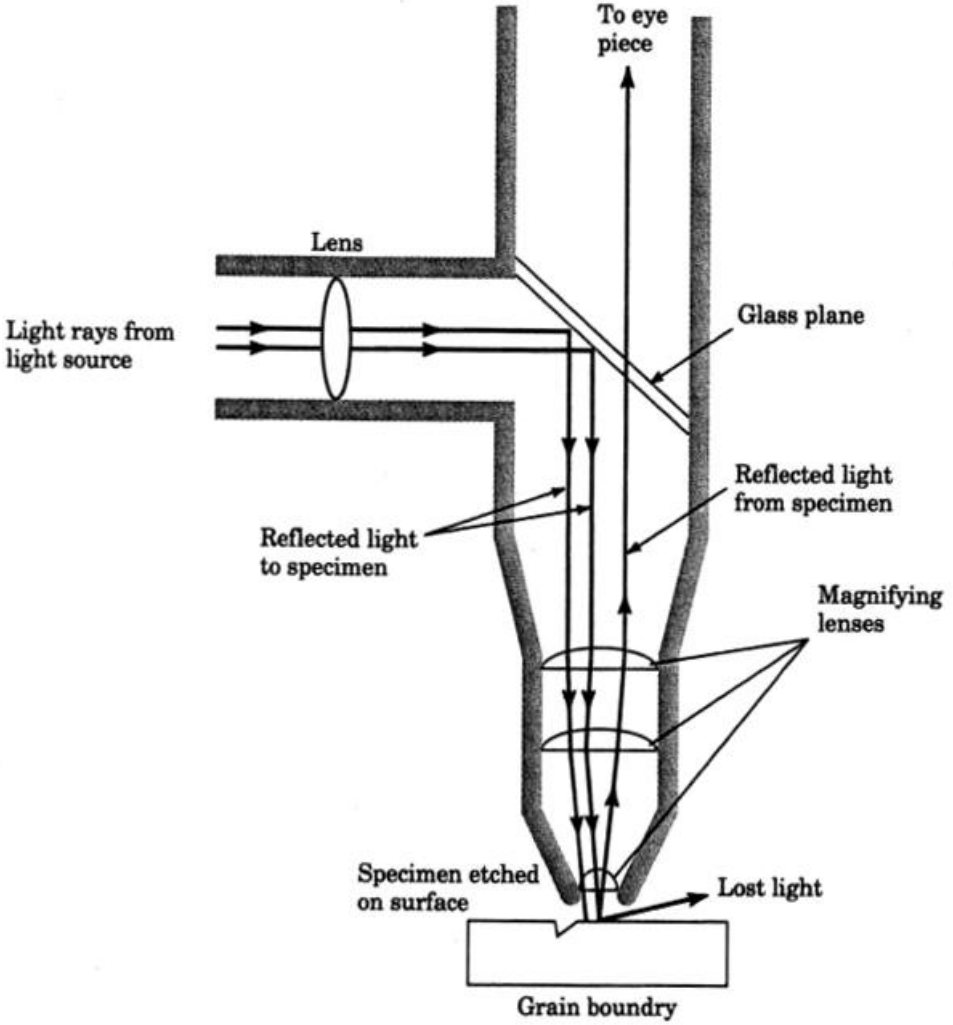
METAL	REAGENT	ACTION
Iron and Carbon Steels	HNO_3 (conc)-2 cc Ethyl alcohol-98 cc	Time reqd is 10-30 sec. Used preferably for grain bdy etching
Iron and Carbon Steels	1-5% HNO_3 in alcohol, wash in alcohol.	Time reqd is 10-30 sec. Outlines grains, cleans surface, develops pearlite,does not attack cementite.
Iron and Carbon Steels	%5 picric acid in alcohol, wash in alcohol.	Time reqd is 10-30 sec. Develops pearlite and related structures
Austenitic Stainless Steels	25 parts HCl, 5-50 parts of 10% CrO_3 in water.	Microstructure of heat treated steels.
Stainless Steel	$FeCl_3$ in HCl (saturated solution), add few drops of	HNO_3 . Structure of stainless steel.
Aluminum and Alloys	0.5% HF in water, 15 seconds, wash in water.	Cleaning and grain boundary etchant
Nickel and Alloys	10% HNO_3, 5% CH_3COOH in water, (electrolytic 1.5 volts), 20-60 seconds, wash in water.	Contrast etch for grain boundaries and microconstituents
General Purpose In,Sn,Pb,Cu,Ni,Al,Mg,W,Mo and their Alloys	Solution A: K_2Cr2O_7 - 6 grams, NaCl - 12cc saturated soln. H2SO4 -24 cc. H2O - 300cc. Solution B: CrO_3 - 10% in H_2O.	To bring out grain boundaries and to outline micro constituents. The proportions of the A and B solutions may be varied and water may be added to obtain slower attack.

EXAMINATION

THE METALLURGICAL MICROSCOPE

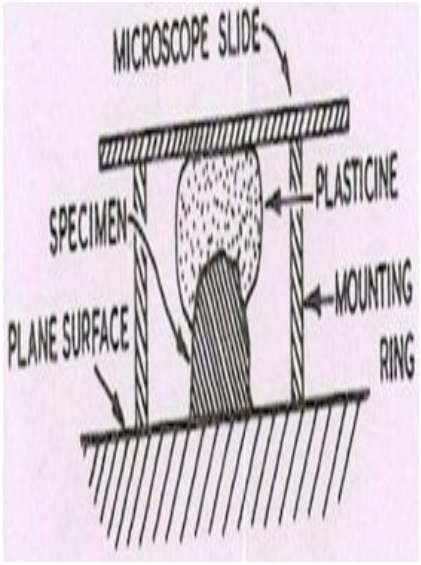


Optical or Light Microscope



USING THE MICROSCOPE

- After polishing, the specimen is examined under the metallurgical microscope by placing it on its table
- It is essential to provide the specimen with an absolutely flat surface & to mount the specimen in such a way so that its surface is normal to the axis of the instrument
- This is most easily achieved by fixing the specimen to a microscope slide by means of a small amount of plasticine (a putty like oil based modeling material made from Ca-salts, petroleum jelly)





USING THE MICROSCOPE

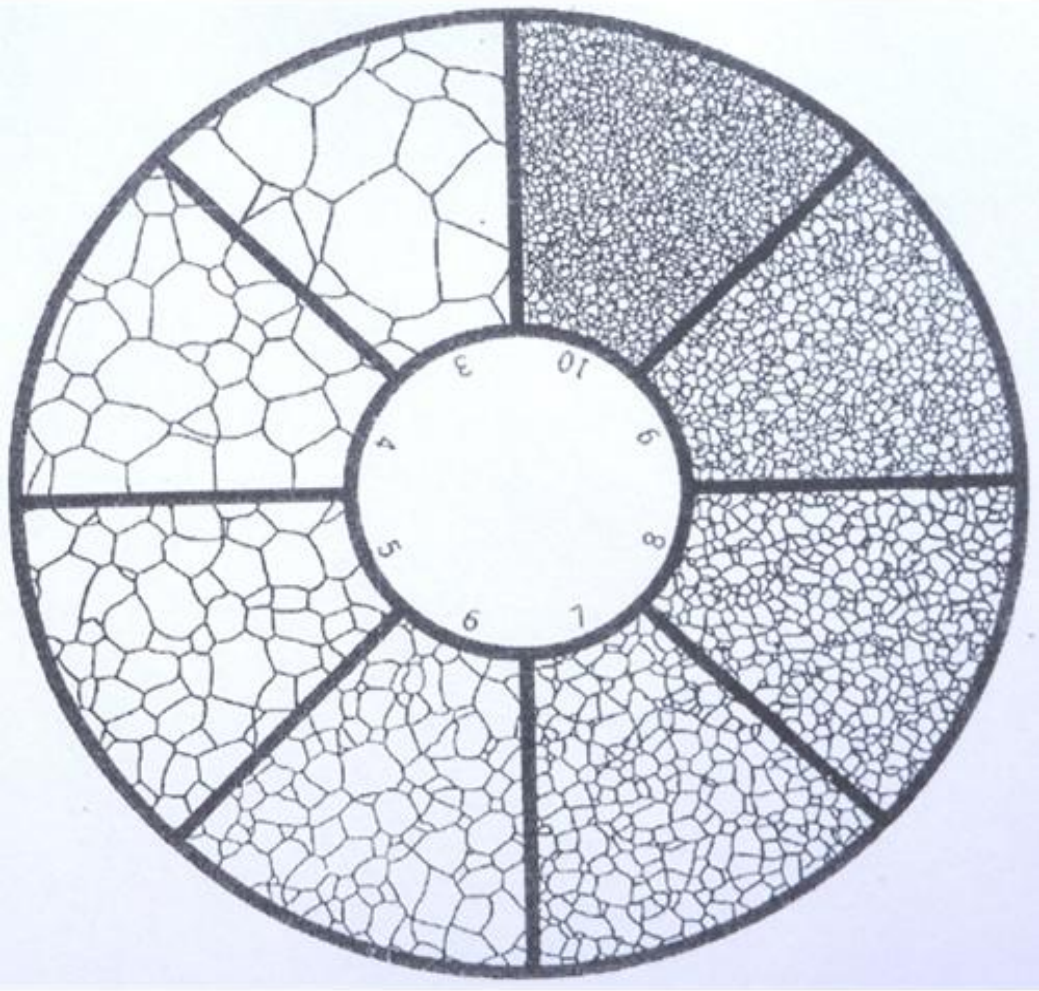
- Mounting may not be necessary for specimens which have been set in resin, since the top & bottom faces of mounted piece are usually parallel so that it can be placed directly on the table of microscope
- The specimen is brought in to focus by using first the coarse adjustment
- Care should be taken not to touch the surface of the optical glass with fingers, since even the most careful cleaning may damage the surface
- This gives rise to contrast in the reflected light intensities & thus the micro structure can easily be identified
- A film of soft grease to be used after seeing the micro structure for future reference

MICRO STRUCTURES OF STEEL

STEEL GRAIN SIZE TO ASTM E-112

Universally accepted standard by which grain sized range form 1 (very coarse) to 8 (very fine).

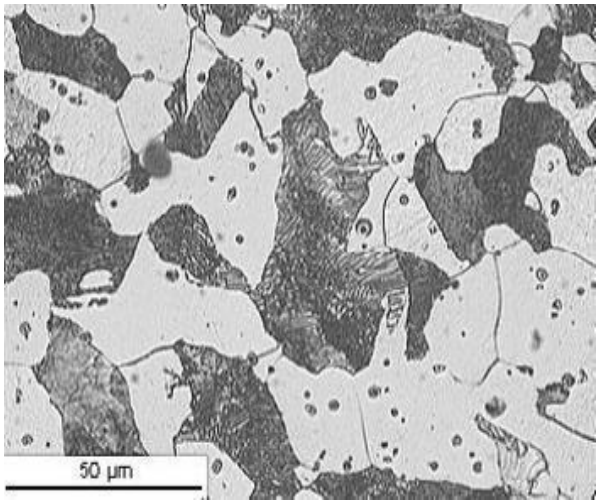
Grain size is normally quantified by a numbering system. Coarse 1-5 and fine 5-8.



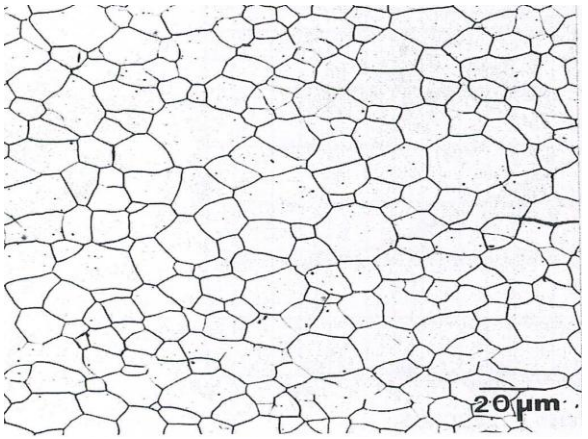
ASTM E112

MICRO STRUCTURE-DISCUSSION

- The light coloured region of the micro structure is the ferrite. The grain boundaries between the ferrite grains can be seen quite clearly.
- The dark regions are the pearlite.
- Small spots within the ferrite grains are inclusions or impurities such as oxides and sulphides.



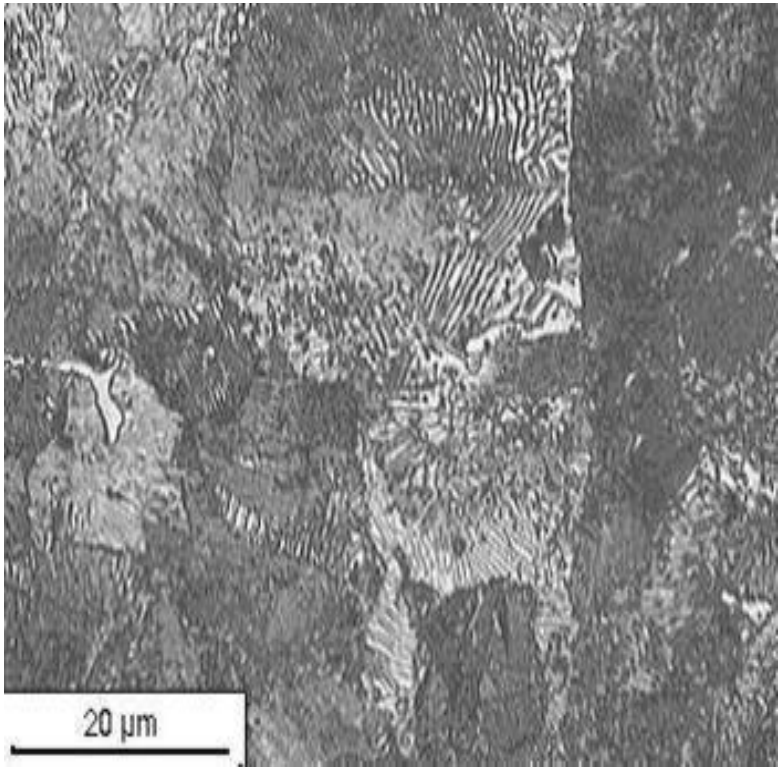
Low C-steel



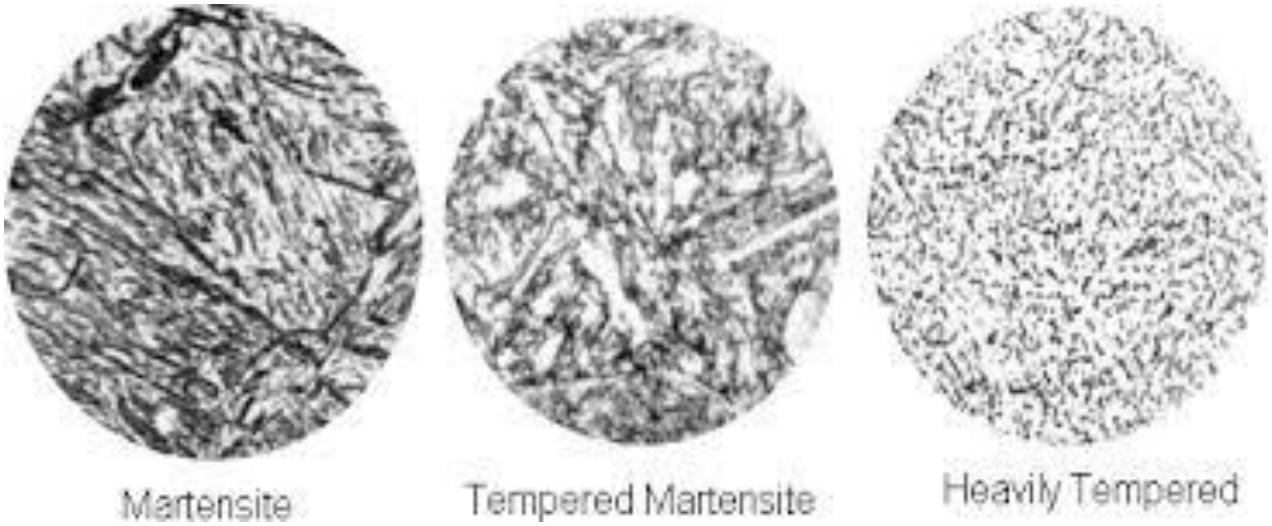
Microstructure of Pure Iron

MICRO STRUCTURE

This is the microstructure of a high carbon steel. It contains about 0.8% C by weight, alloyed with iron. The steel has one major constituent, which is pearlite.

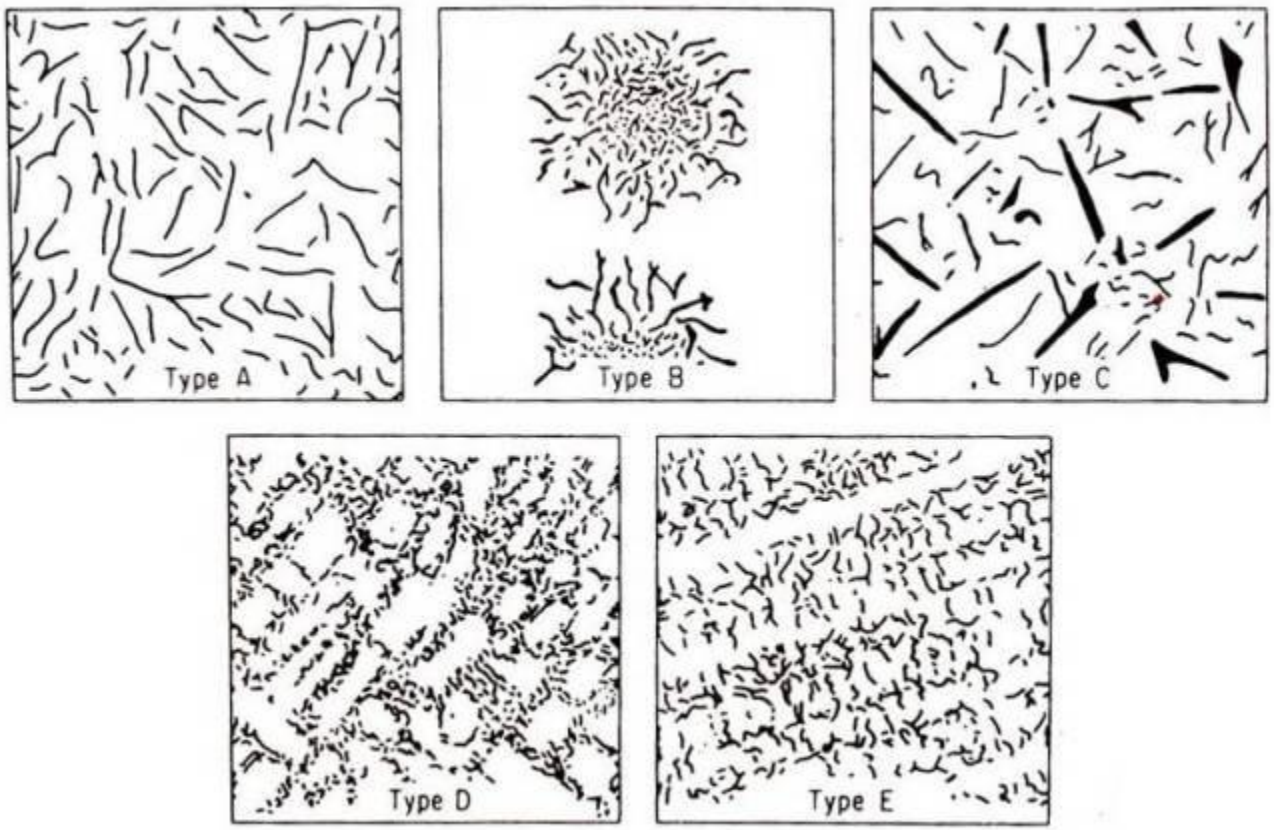


MICRO STRUCTURE OF TEMPERED STEEL



MICRO STRUCTURES OF CI

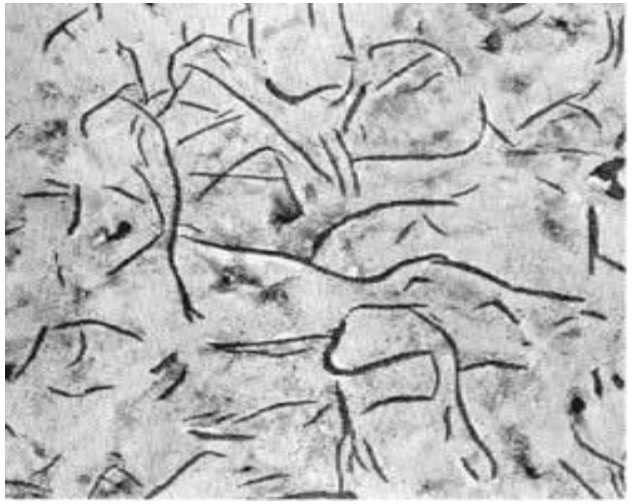
TYPES OF GRAPHITE FLAKE IN CI

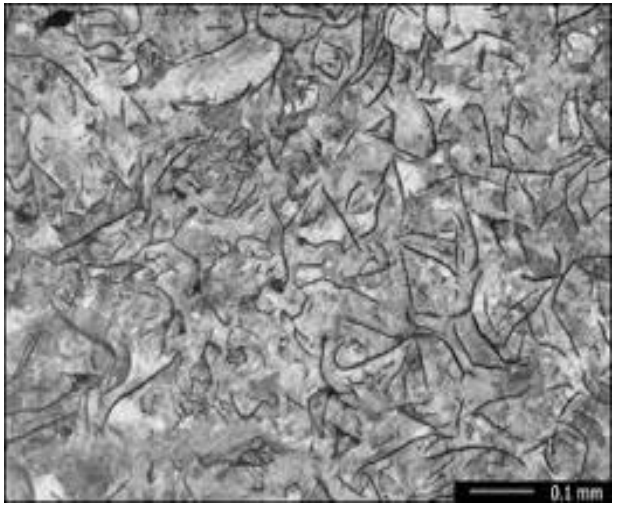


Graphite-flake Types

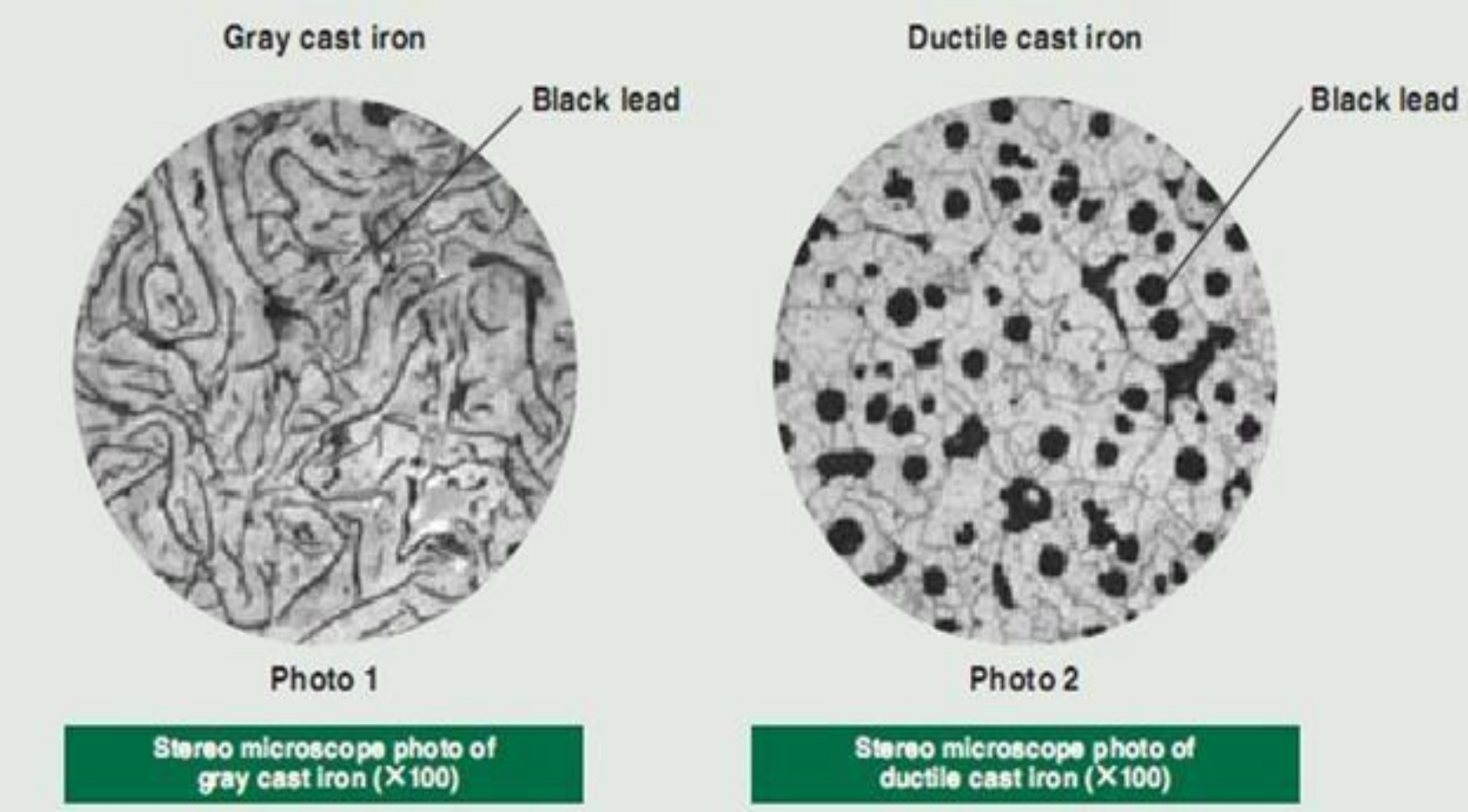
MICRO STRUCTURE OF CAST IRON

This is the microstructure of a grey cast iron. This is an alloy of iron (Fe) with 4% carbon (C) by weight. The microstructure has two main constituents. The long pale regions are flakes of graphite. The background or matrix of the alloy is pearlite.

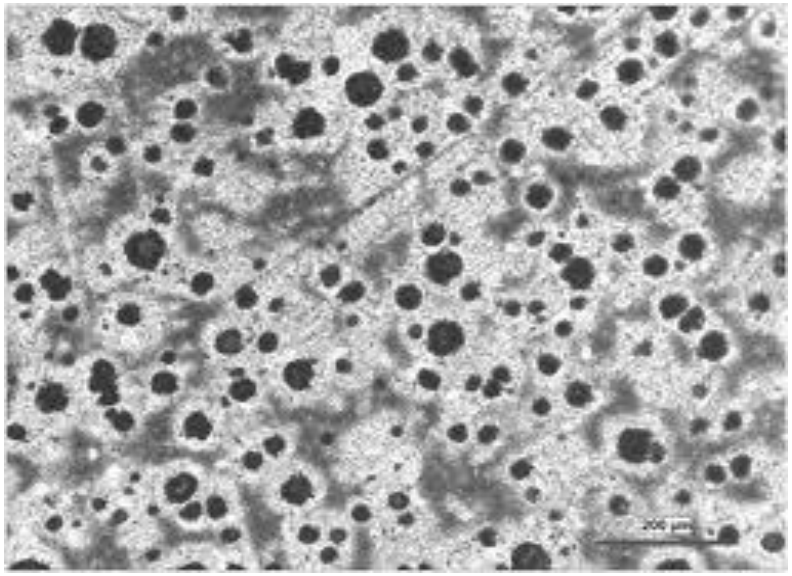


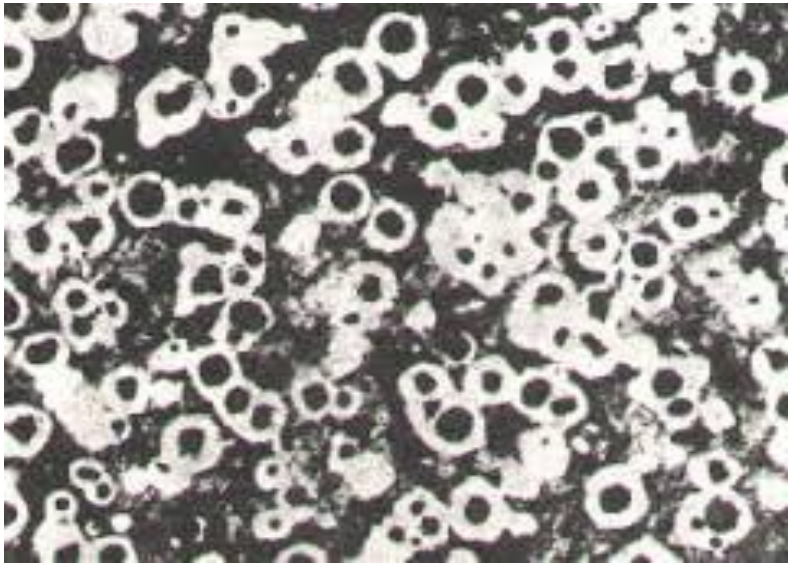


MICRO STRUCTURE OF GCI & SGCI

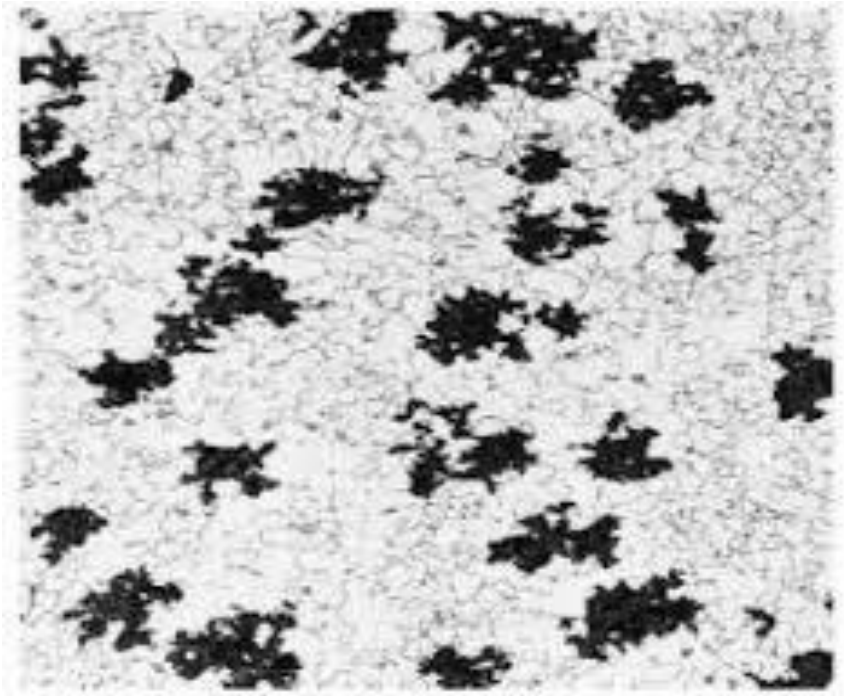


MICRO STRUCTURE OF SGCI





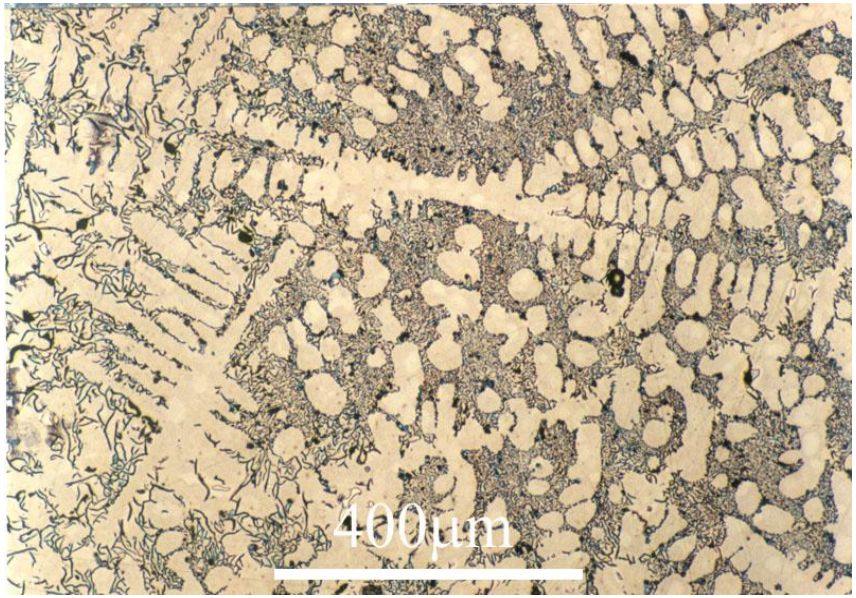
MICRO STRUCTURE OF MCI

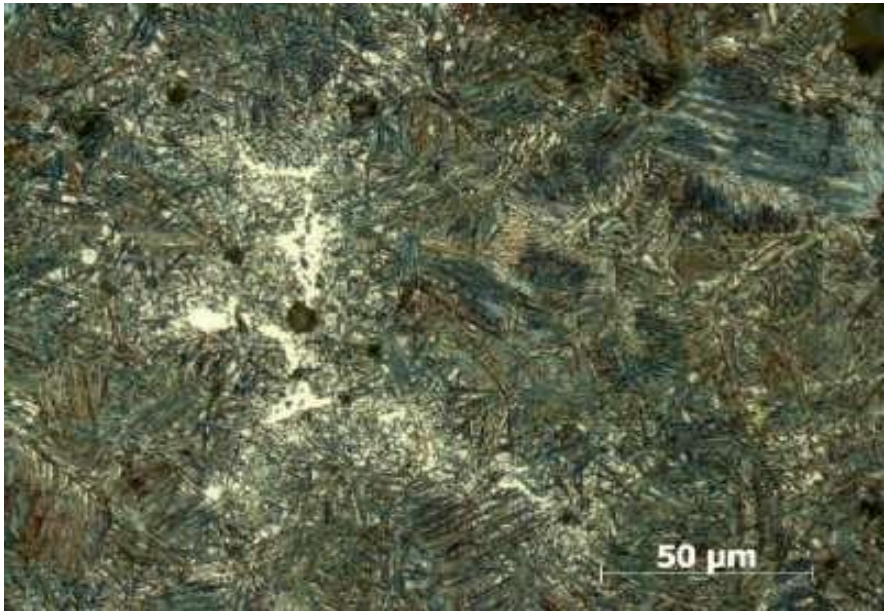


Malleable Cast Iron



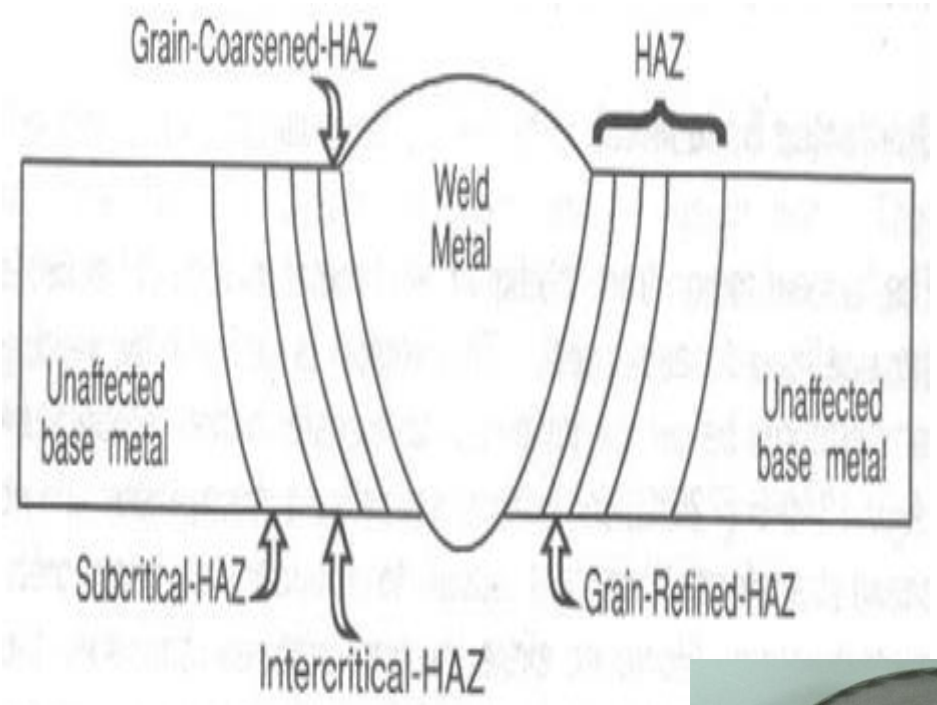
MICRO STRUCTURES OF STEEL

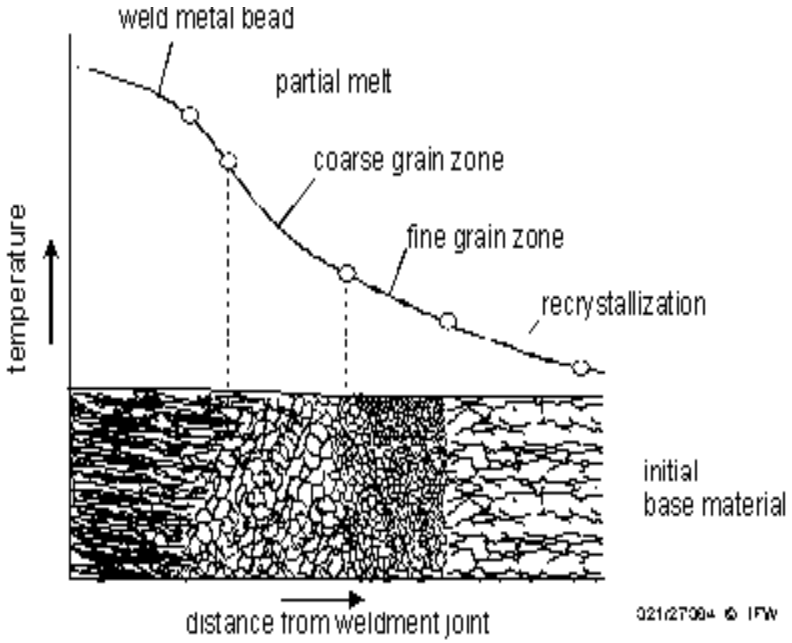


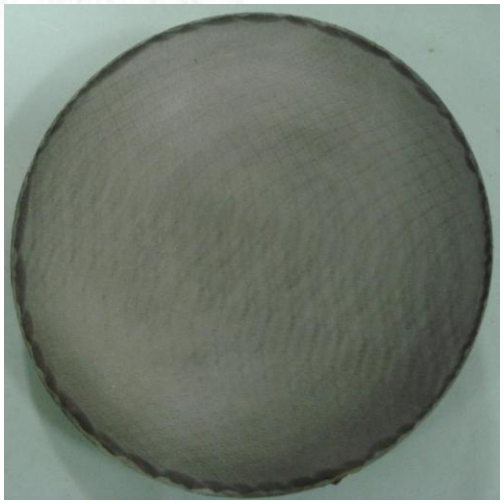




WELDED STRUCTURE







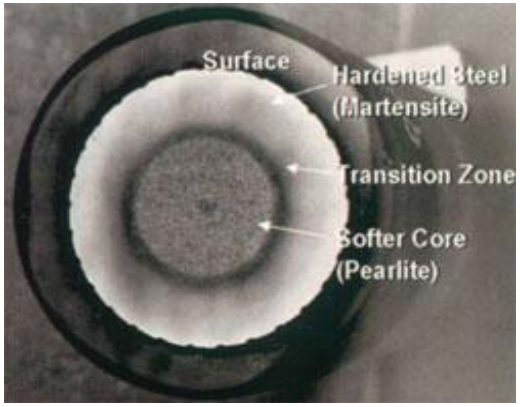
CASE DEPTH

- Case hardening may be defined as a process for hardening a ferrous materials in such a manner that the surface layer (known as the case), is substantially harder than the remaining materials (known as the core).
- This process is controlled through carburizing, nitriding, carbonitriding, cyaniding, induction and flame hardening.

Measuring case depth:

- The method of case depth determination to be carefully selected on the basis of specific requirements.



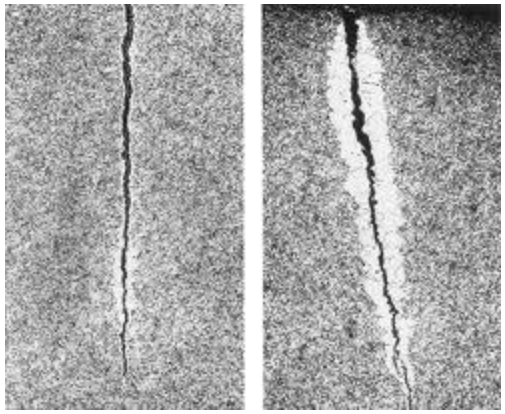




DECARBURIZATION MEASUREMENT

- The depth is determined as the depth where a uniform microstructure, hardness, or carbon content, typical of the interior of the specimen is observed.
- This method will detect surface losses in carbon content due to heating at elevated temperatures, as in hot working or heat treatment.







COATING / PLATING EVALUATION (ASTM B487, ASTM B748)

- A portion of the specimen is cut, mounted transversely, a prepared in accordance with acceptable or suitable techniques.
- The thickness of the cross section is measured with an optical microscope.

An electronic coating thickness gage



Thank You

Have a nice day !