1. MICROSCOPICAL EXAMINATION

The microstructural study of a material can provide information regarding the morphology and distribution of constituent phases as well as the nature and pattern of certain crystal imperfections. Optical metallography is a basic tool of material scientists, since the equipment is relatively inexpensive and the images can be obtained and interpreted easily. Distribution and morphology of the phases can be studied and, if their properties are known, a quantitative analysis of the micrographs provides some information about the bulk properties of the specimen. A limited study of line and surface informations is also possible with the optical microscope.

In order to obtain reproducible results, with good contrast in the image, the specimen surface is polished and subsequently etched with appropriate reagents before microscopic examination. In a polished specimen, the etching not only delineates grain boundaries, but also allows the different phases to be distinguished by differences in brightness, shape, and color of the grain. Differences in contrast may result from differences in light absorption characteristics of the phases. Etching results in preferential attack or preferential colouring of the surface. The preferential attack is electrochemical corrosion; it is well known that different materials corrode at different rates. Grain boundaries are often anodic to the bulk metal in the interior of the grain and so are etched away preferentially and delineated. Staining is produced by the deposition of solid etch product on the specimen surface. This is formed by chemical reaction between the etchant and the specimen. Under favorable conditions the use of a proper etchant enables the identification of constituents. Failure analysis depends a great deal on metallographic examination.

Microstructural examination can provide quantitative information about the following parameters:
1) The grain size of specimens
2) The amount of interfacial area per unit volume
3) The dimensions of constituent phases
4) The amount and distribution of phases.

1.1. Metallurgical (Optic) Microscope

The microstructure of the metals and alloys is investigated by metallurgical microscopes. An optic microscope has the maximum 2000x magnification and 1000Å separation efficiency (lateral dissolution). For higher magnification analyses, electron microscopy has to be used,
which is not in the scope of this study. Unlike biological microscopes, metallurgical microscopes must use reflected light. Figure 3 presents a simplified ray diagram of the illuminating and imaging system of a metallurgical microscope.

Light incident upon the specimen is reflected back from the specimen surface. Any light that reflects back from specimen features which are approximately normal to the optical axis (i.e. features that are perpendicular to the incident light beam) will enter the objective, pass through the plane glass reflector, travel on to the eyepiece, and will form the bright portion of the image one sees. Any light that is reflected back from features inclined to the optical axis (i.e. features that are not perpendicular to the incident light beam) will be scattered and will not enter the objective. Such features will thereby appear dark in the image one sees. The final image of the specimen, formed by the eyepiece(s) of the microscope, is thus bright for all features normal to the optical axis and dark for inclined features. In this way, the various microstructural features of a metallographic specimen (such as grain boundaries that have been etched to produce grooves with inclined edges, precipitate particles, and non-metallic inclusions) are all revealed in the image of the specimen. Figure 4 presents a schematic diagram showing bright and dark image areas corresponding to reflection from normal or inclined features on the specimen surface.

Figure 1. Specimen image under bright-field illumination.
**Figure 2.** Schematic representation of an etched sample having two phases.

**HOMEWORK**

1. Draw schematically the view of the sample detected under the optical microscope with 100x magnification, before and after the etching processes.

2. Please indicate precisely the problems that you faced while preparing the your sample for the microscopic examination. Moreover, explain in detail the solution that you find to resolve all those problems.