

Optics 513 - Optical Testing and Testing Instrumentation Lab

Lab #6 - Interference Microscopes

The purpose of this lab is to observe the samples provided using two different interference microscopes -- the polarization differential microscope (Nomarski) and the two-beam Mirau. White light fringes should be observed using both instruments. By the time you complete this lab you should love white light fringes.

Procedure:

Nomarski

- Read the attached write-up on the Nomarski microscope.
- Place the ball bearing under the objective. Before finding focus adjust the sample so it is too close to the objective, and then find focus by moving the sample away from the objective. This procedure will minimize the chances of crashing the objective into the sample. Adjust the eyepieces so you are comfortable looking at the microscope image.
- After you think the sample is in focus, move the sample to make sure the image moves and you are really looking at the sample. Adjust the angle of polarization of the incident light and note the effect of changing the direction of polarization.
- Turn the ring on the objective to move the prism and vary the path difference between the two interfering beams. Note the direction of shear.
- Repeat the above procedure for looking at the magnetic hard disk. Note both the grooves on the hard disk and surface defects.

Mirau

- Place the flat mirror under the objective. Before finding focus adjust the objective so it is too close to the sample, and then find focus by moving the objective away from the sample. This procedure will minimize the chances of crashing the objective into the sample. Adjust the eyepieces so you are comfortable looking at the microscope image. The easiest way to find focus is to first put in the red filter and then close down the field stop. A bright circular region of light will be seen from the light reflected from the reference surface. Next adjust the objective-sample distance until a faint halo is seen around the bright region of light from the reference. Further adjustment of focus will cause the halo to collapse into the bright region. At this point fringes should be seen. Open the field stop to see the entire field.

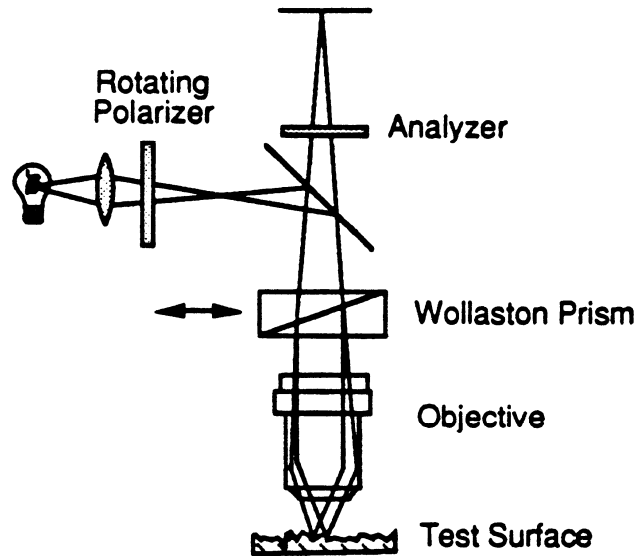
- Adjust the two knobs on the objective to vary the tip-tilt of the reference surface.
- Adjust the focus to see the fringe contrast change. Take out the red filter and look at the white light fringes. Adjust the tip-tilt and focus. Fluff the fringes and vary focus. You should see some beautiful colors. By now you should love white light fringes.
- Repeat the above procedure for looking at the ball bearing, the Ronchi ruling, the curved diffraction grating, and any other sample you want to look at.

Questions:

- 1) The two interferometers give you different data. Describe the difference.
- 2) The differential interferometer does not detect grooves in a surface if they have a particular orientation. Why?
- 3) Why do you see different colors with the differential microscope as the polarizer is rotated?
- 4) Why does translating the Wollaston prism cause different colors to appear?
- 5) How can you increase the contrast of what you see in the differential interferometer?
- 6) What condition must be satisfied in the Mirau interferometer to obtain white light fringes?
- 7) Is the central fringe dark or bright for the Mirau interferometer? Why? Does your answer depend upon the sample?
- 8) What is the coherence length of the white light source used in the Mirau interferometer?
- 9) How would the fringes change if the objective lens in the Mirau interferometer had spherical aberration?
- 10) How would the fringes change if the objective lens in the Mirau interferometer had chromatic aberration?
- 11) How would you determine if there is a bump or a hole on the test surface?
- 12) What is the effect of the aperture stop in the Mirau interferometer microscope?
- 13) Do both interferometers have to be placed on a vibration isolation table? Explain.

Nomarski Microscope

The diagram below shows a drawing of the optical layout of a Nomarski microscope. The Nomarski microscope is sometimes called a differential interference contrast (DIC) microscope or a polarization interference contrast microscope.



A polarizer after a white light source is used to set the angle of the polarized light incident upon a Wollaston prism. The Wollaston splits the light into two beams having orthogonal polarization, which are sheared with respect to one another. After reflection off the test surface the Wollaston recombines the two beams. A fixed analyzer placed after the Wollaston transmits like components of the two polarizations and generates an interference pattern.

The resulting image shows the difference between two closely spaced points on the test surface. The point separation (shear at the test surface) is usually comparable to the optical resolution of the microscope objective and hence only one image is seen. The image shows slope changes and it appears as though the surface has been illuminated from one side. Like a shearing interferometer, only detail in the direction perpendicular to the shear is seen. In other words, if the shear is in the x direction, only features parallel to the y-axis will be seen. Detail parallel to the x direction will not be visible without rotating the test surface or the Wollaston prism.

The path difference between the two beams can be adjusted by laterally translating the Wollaston prism. When the axes of the polarizer and analyzer are parallel and the prism is centered, the path lengths are equal and white light is seen for a perfect test surface with no tilt. When the polarizer and analyzer are crossed and the prism centered, no light gets through. When the prism is translated sideways, the two beams have unequal paths

and different colors are seen. The color for a specific feature on the test surface depends upon the path difference between the two beams for that point. The color changes indicate the surface slopes. When the polarizer before the prism is rotated, the relative intensities of the two orthogonal polarized beams change, and the colors change.

Optical Profiler for Measurement of Surface Microstructure

