Nomarski Nikon Optiphot 66 Microscope with CCD camera Standard Operating Procedure

Version: 2.0 **July 2013**

UNIVERSITY OF TEXAS AT ARLINGTON

Nanotechnology Research & Education Center

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1.0 INTRODUCTION

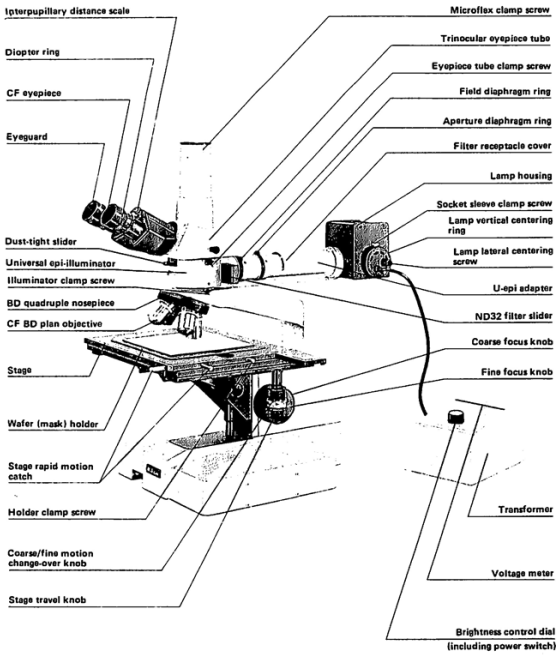
1.1 Scope

These procedures apply to the Nikon Optiphot 66 Microscope and CCD camera located in BAY2. All maintenance should follow the procedures set forth in the manufacturer's maintenance and operations manuals. This document is for

reference only. Users must be trained by Nanofab staff before operating this equipment.

1.2 Description

The Nikon Optiphot 66 Microscope and CCD camera system is a reflected light (Episcopic) microscope wafer inspection station with built-in Halogen light transformer for varying the Tungsten- Halogen lamp intensity for illumination of opaque to semi –transperant 4" diameter wafers, glass slides, and small samples for bright field or darkfield viewing. A variety of lighting schemes can be used ranging from on-axis from above to oblique. The microscope is equiped with adjustable aperature and field diamphram rings , brightness control dial, ND filter, lens and light source polarizer filters and a scaled diopter ring for optimum feature resolution (1µ) and film analyzing. In addition the microscope is connected to Panasonic MR222 color CDD camera with Ultrak color monitor and a dedicated computer/ s-video card utilizing Videum Video Capture software for saving color images to files on the Nanodata server.



For Episcopic Bright Field Microscopy

Nikon Optiphot 66 Microscope

Ultrak Monitor

Videum Video Capture Computer

1.3 Safety

1.3.1 This machine is connected to **HIGH VOLTAGE.** Be very careful and remain aware of electrical hazards. If you encounter any electrical malfunctions, contact NanoFAB staff immediately.

1.3.2 Users are **NOT ALLOWED** to open lamp housing to change bulbs.
HIGH VOLTAGE IS PRESENT IN THE LAMP HOUSING.

1.3.3 Do not touch the lamp housing .Tungsten Halogen lamps get **very hot.**

1.3.4 **Do NOT place COMBUSTIBLE MATERIALS or FLAMMABLE CHEMICALS such as Acetone, Methanol and IPA near the lamp housing.**

1.3.5 Read any posted **NanoFAB Engineering Change Notices (ECN)** for any hardware, process or safety changes before running the tool.

2.0 HARDWARE

2.1 Nikon Reflected Light Stand with an Epi-Illuminator extension tube with 12V//50W variable lamp power supply.

2.2 The Universal Epi-Illuminator with ND32 Filter to protect the eye from dazzle when switching from darkfield to brightfield.

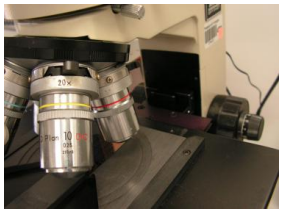
2.3 Nikon Ultra Wide Field "Trinocular" Head for use with Panasonic MR222 color CDD camera with Ultrak color monitor and a dedicated computer/ s-video card utilizing Videum Video Capture.

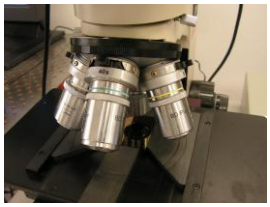
2.4 The large mechanical stage with up to 6 inch travel for the 4 inch wafer holder.

2.5 Adjustable diopters ring with built in scalar to 1um resolution.

2.6 The microscope is equipped with the following objective lenses.

- **5X BD Plan Objective N.A. 0.1 with Polarizer**
- **20X BD Plan Objective N.A. 0.25 with Polarizer**
- **40X BD Plan Objective N.A. 0.65 with Polarizer**
- **100X BD Plan Objective N.A. 0.90 with Polarizer**





3.0 REQUIREMENTS

3.1 Training

All users must be trained and authorized on the Nikon Optiphot 66 Microscope and CCD camera system to use this tool. Training is supplied by a Nanofab staff member please contact the tool owner to schedule training.

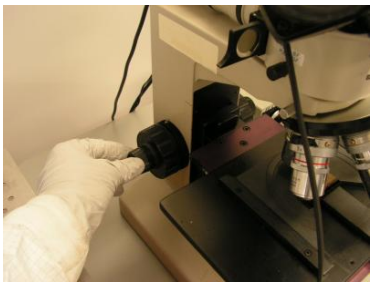
3.2 System Restrictions

3.2.1 The Nikon Optiphot 66 Microscope and CCD camera system in BAY2 are strictly restricted to inspecting Semiconductor substrates, devices, glass slides , thin flat materials for photolithography, etch and final inspection. Very thick (>2 cm) pieces of material may contact the objective lenses and cause scratches on the lens. Be aware of light absorbing films and inspect **ONLY** clean dry samples.

3.2.2 Do not transfer contamination such as dust, dirt, photoresist from the sample surface to the lens surface. This will prevent a clear view of the sample surface.

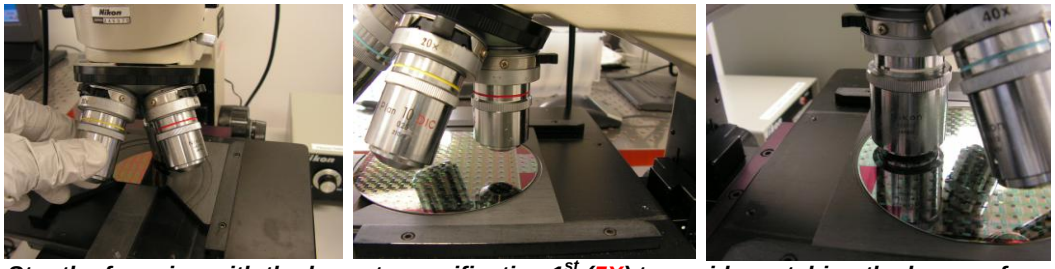
3.2.3 USER are allowed to clean the eyepiece lenses and objective lenses with Isopropanol Alcohol and lint free wipes **ONLY**.

3.2.4 Never attempt to adjust the tightness of the right and left focus knobs by turning one while holding the other.



focus knobs

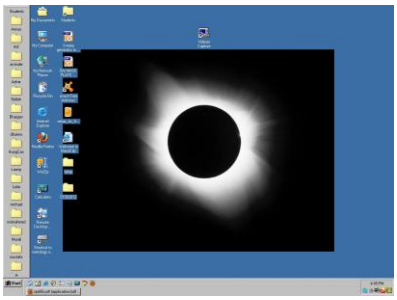
3.2.5 Start the focusing with the lowest magnification 1st (**5X**) to avoid scratching the lens surface. If you need higher resolution rotate the objective lens from lowest to highest and refocus using only the fine focus knob. When you are finished set the objective back to the lowest magnification then lower the stage several mm.



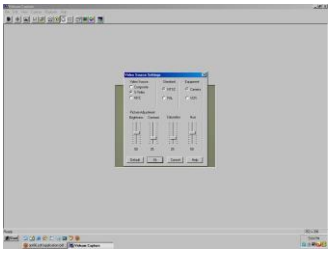
Star the focusing with the lowest magnification 1st (5X) to avoid scratching the lens surface

3.2.6 **DO NOT** rotate the Panasonic MR222 color CDD camera.

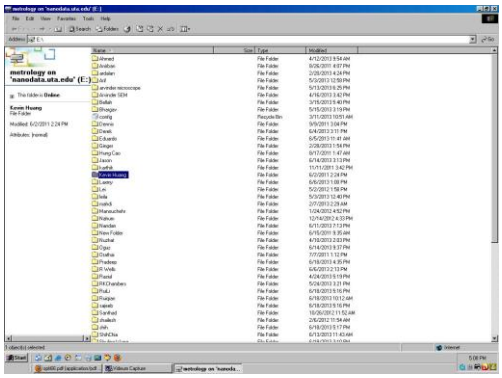
3.2.7 Any computer system errors or Videum Video Capture software faults contact staff to check.



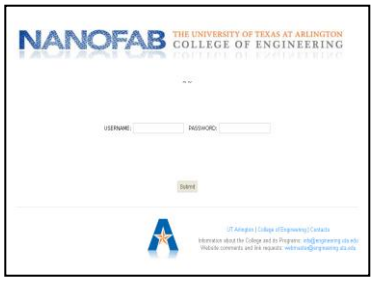
3.2.8 Users are **NOT** allowed to change the Videum Video Capture software configuration settings.



3.2.9 Images can be exported ONLY to the **Nanodata.uta.edu** server. No users USB sticks are allowed to be used.

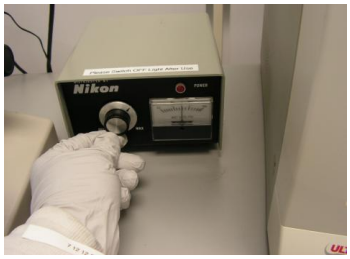


3.2.10 No reservations on the Nanofab Reservation System are required to access this tool

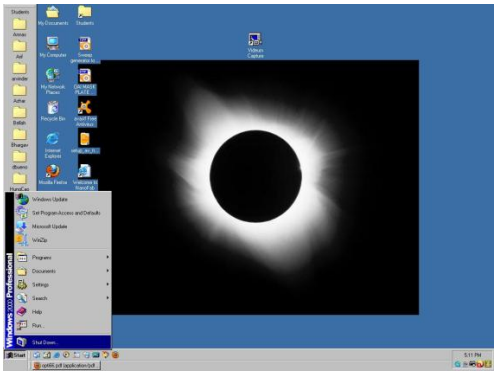


http://nanofabreservation.uta.edu/

3.2.11 User must turn **OFF** the Tungsten lamp power and CCD monitor when you are finished inspecting your wafers.



3.2.12 User must exit the Videum Video Capture software and shutdown the the system when you are fished insepcting your wafers.

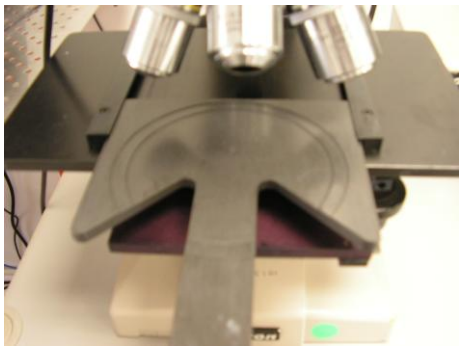


shutdown the the system

4.0 OPERATING PROCEDURES

4.1. System Pre-Checks

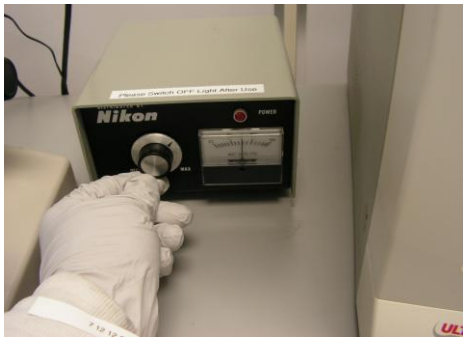
4.1.1. Check to see microscope stage surface is excessively dirty or stained with photoresist. If the stage is excessively stained call staff to schedule a cleaning.

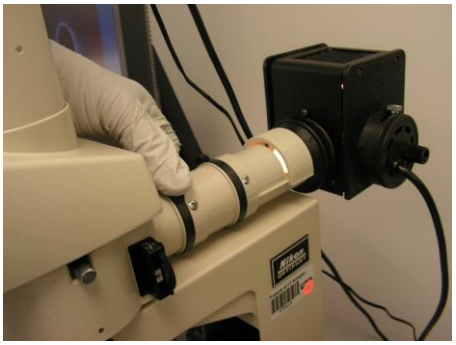


4.1.2. Check to ensure the **5X** objective is in the optical path then lower the stage several mm using the coarse focus knob to give yourself more room to place a wafer on the stage.

4.1.3. Check to ensure the Tungsten lamp is working by rotating the lamp power supply dial in the CW direction to about 8 volts (middle of scale). The lamp light should be visible on the stage, at the lamp housing or epi adapter light tube.

If no light can be seen call staff to check the illuminator.

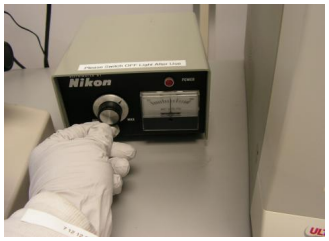


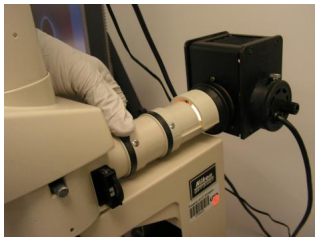


4.2. Operating the Nikon Optiphot 66 Microscope and CCD camera system for Episcopic brightfield or darkfield Microscopy.

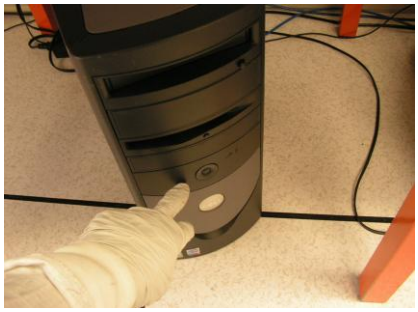
4.2.1. If you have not completed the **System Pre-Checks** in steps 4.1.1 – 4.1.2 then you must complete those before proceeding.

4.2.2. If the illuminator is **OFF** rotate the lamp power supply dial in the CW direction to about 8 volts (middle of scale). The lamp light should be visible on the stage, at the lamp housing or epi adapter light tube.





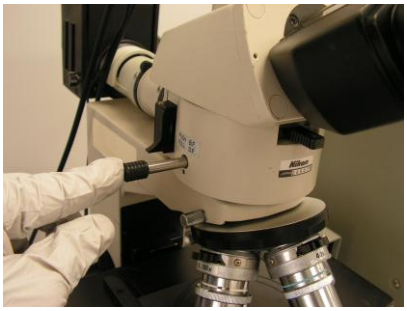
4.2.3. Turn **ON** the microscope's dedicated computer and monitor.
Turn **ON** the Ultrak color monitor.



Videum Video Capture Computer

Ultrak Monitor

4.2.4. **Push in** the optical-path change–over knob to the limit for brightfield illumination or pull out for darkfield illumination.

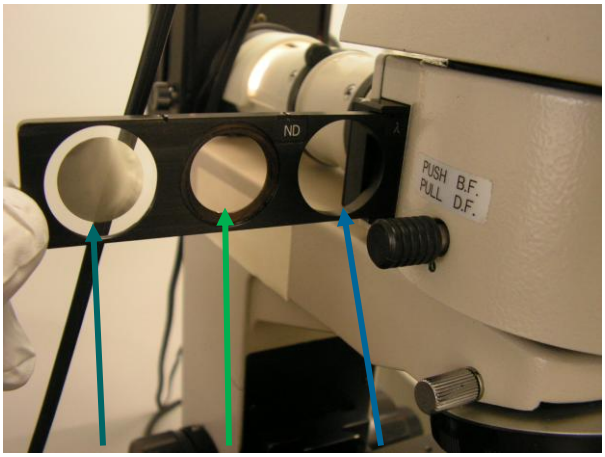


Push in for brightfield

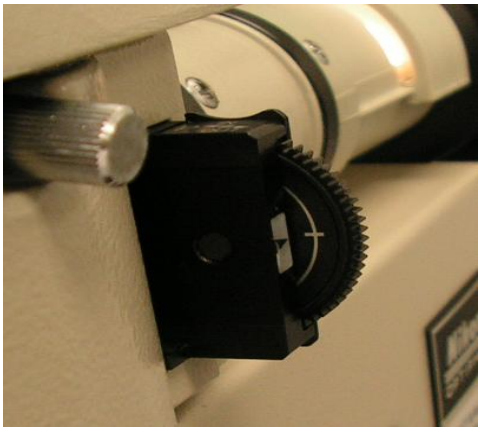
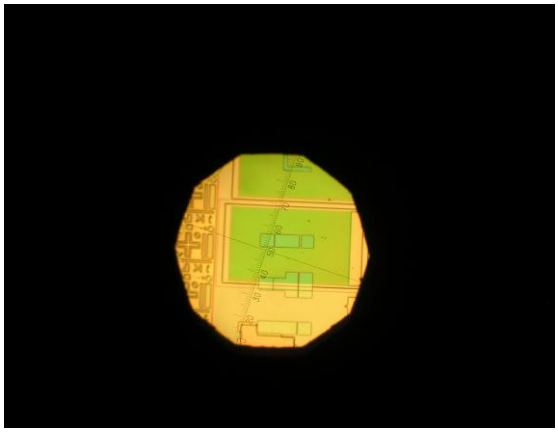
Pull out for darkfield

4.2.5. If the polarizer slider in the U-epi adapter tube , objective lens polarizers (**5X**, **20X**, **40X**,**100X**) , ND filter or the tint plate <u>are in the optical path</u> pull them all out of the optical path.

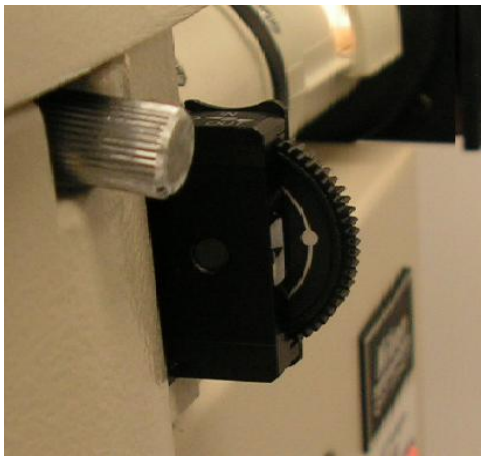
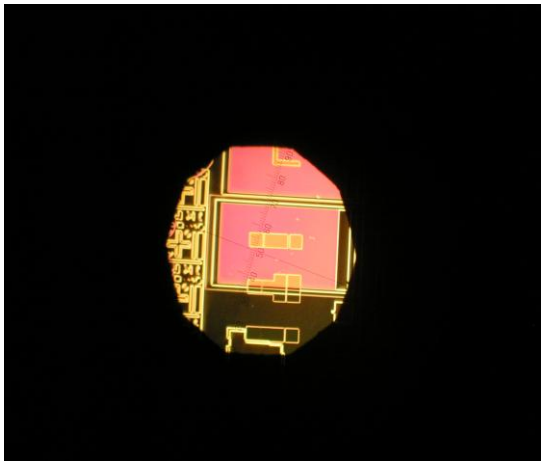
Polarizer push IN is <u>out</u> of optical path



Tint Plate , ND filter, Hole (no filter)

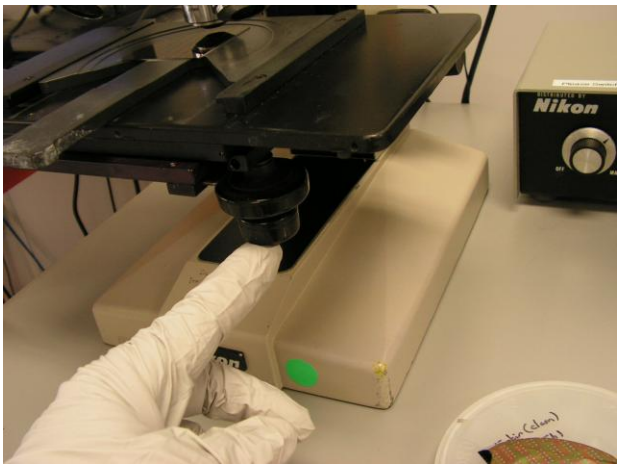



Rotate polarizing wheel until ▬ coincidence with ► to remove polarizer filter

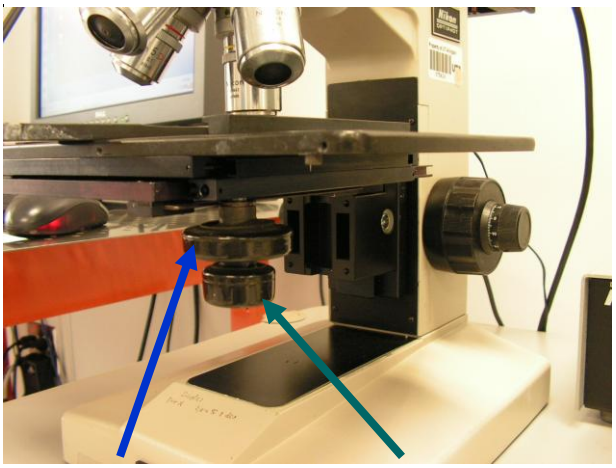



Rotate polarizing wheel until ● coincidence with► to use polarizer filter

4.2.6. Move the stage forward by using the stage travel knobs and gently pull the 4" wafer plate handle out.

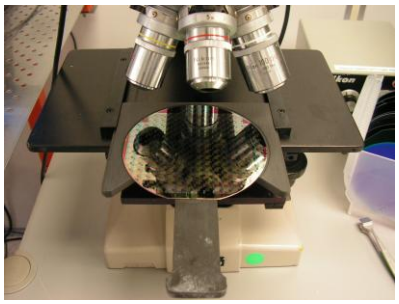
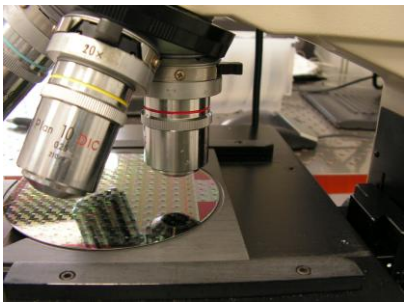
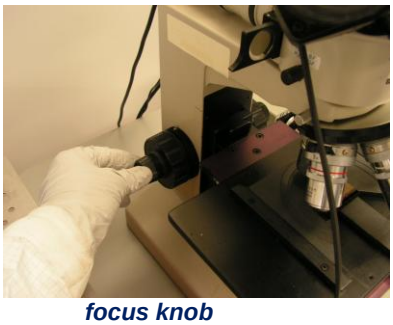


Stage travel knobs



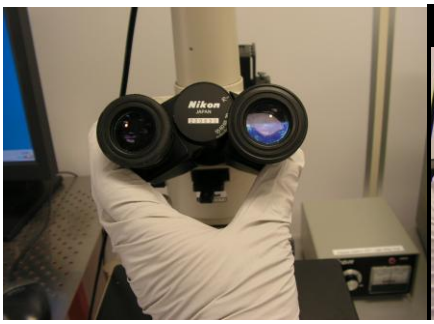
Front/Back ***Left/Right***

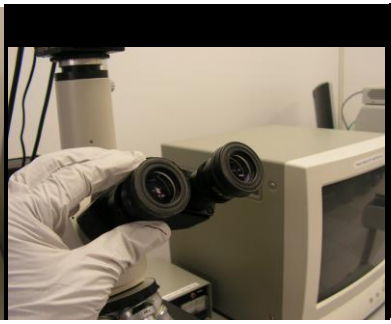
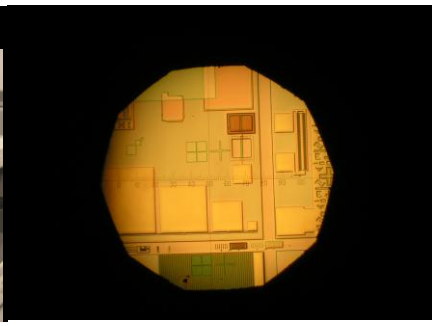
4.2.7. Place the wafer on the stage and focus on the wafer using the **5X** objective.

focus knob

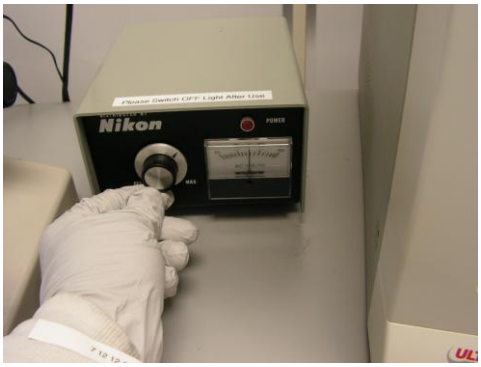
4.2.8. Adjust the interpupillary distance for your eyes and adjust the scaled diopter by rotating the diopter ring. The wafer and scale should be in sharp focus.



interpupillary distance ***rotate the diopter ring. The wafer and scale are in focus.***

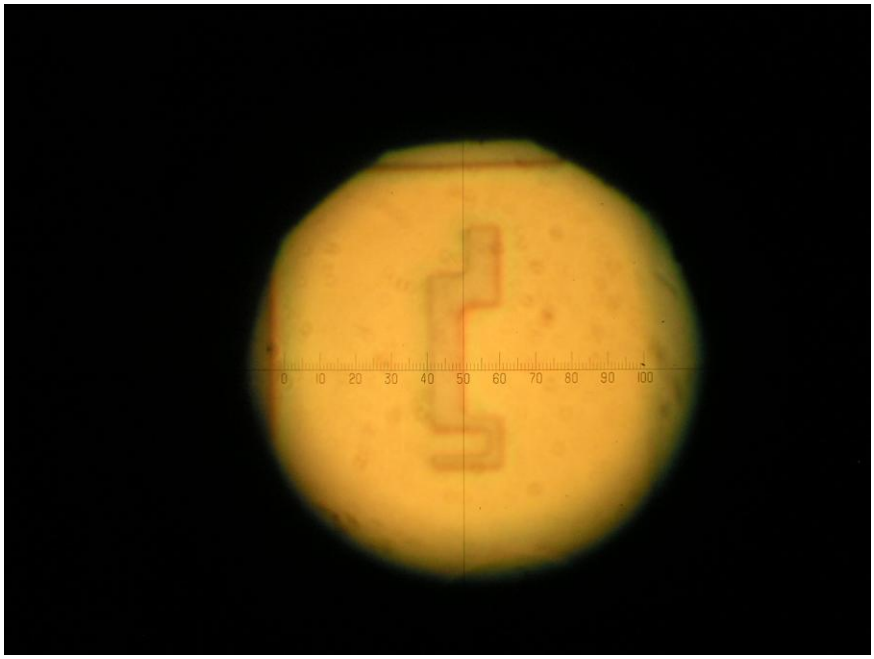
4.2.9. Make sure you have the correct illumination (6v to 9v) and insert any filters or polarizer to be used.



4.2.10. Swing in the objective to be used. Start with the lowest magnification 1st (**5X**) to avoid scratching the lens surface. If you need higher magnification rotate the objective lens from lowest to highest and refocus using only the fine focus knob

4.2.11. Adjust the brightness at the higher magnifications by using the ND filter and/ or by adjusting the lamp voltage.

4.2.12. Readjust and focus the scale diopter if you want to check feature dimensions.



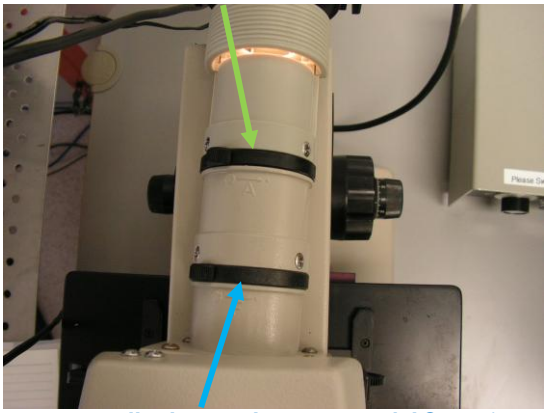
Diopter scaling:

- **5X :** 1 division = 20 µm
- **20X** : 1 division = 10 µm
- **40X :** 1 division = 2.3 µm
- **100X :** 1 division = 1µm

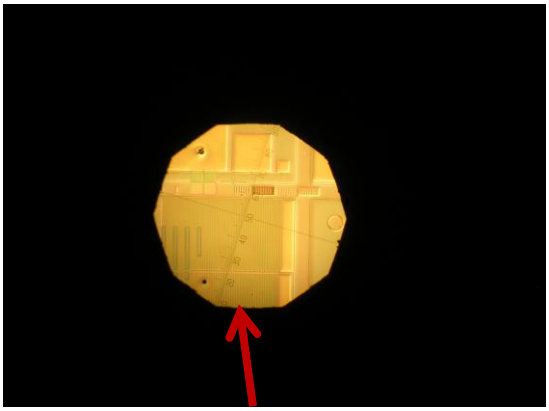
4.2.13. Further adjustments to the total resolution and illuminated area on the wafer can be made by adjusting the aperture diaphragm ($N.A._{diaphragm}$.) and field diaphragm located on the U-epi adapter tube. Stopping down the aperture diaphragm to 70-80% of $N.A._{objective}$ is optimal for episcopic inspection.

O → ● (O is fully open, ● is closed)

Field diaphragm (O → ●)

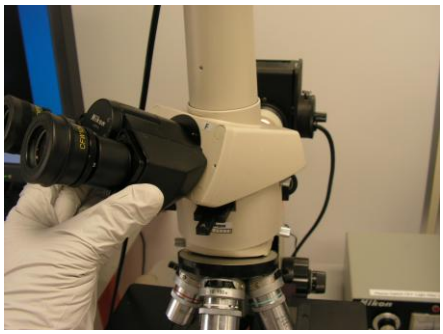


Aperture diaphragm (N.A.$_{diaphragm}$) (O → ●)

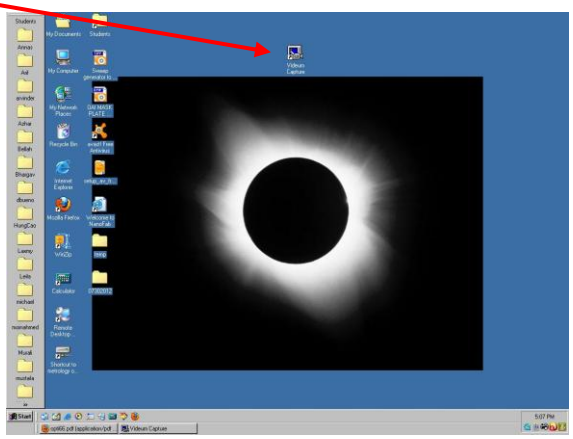


Stopped down to 70-80% of NA. $_{objective}$

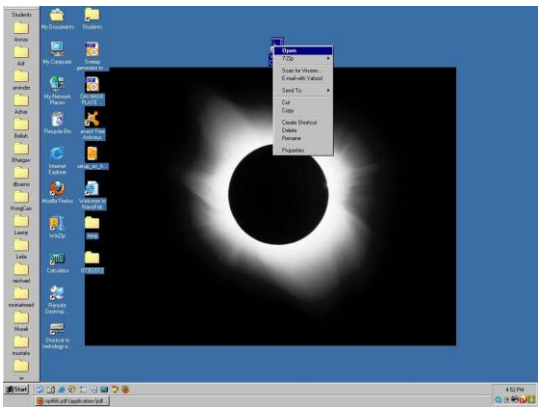
4.2.14. To capture the image using the Ultrak color monitor or Videum Video Capture software gently rotate the Trinocular Head about 45° to the left and refocus using the fine focus knob.

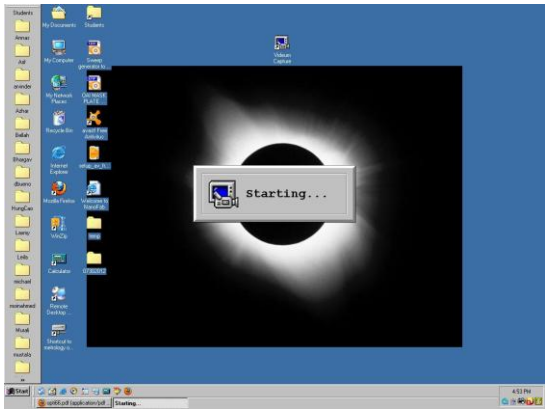


4.2.15. To take a still picture using Videum Video Capture software click on the Videum Video Capture icon on the MS Desktop screen to open the program.

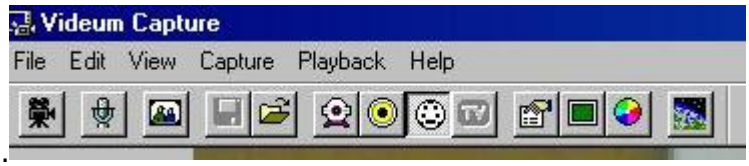


4.2.16. Open and Start the Videum Video Capture program.

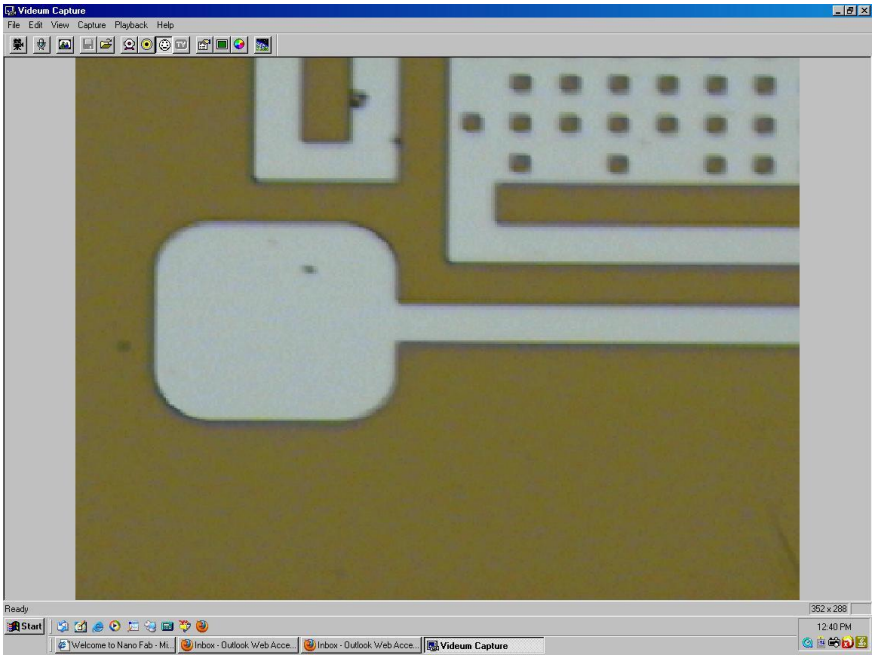




4.2.17. After the program is running and your image is on the screen do any final focusing of the image then click on the **Capture** heading and then click on the **Still** function to take the digital picture.

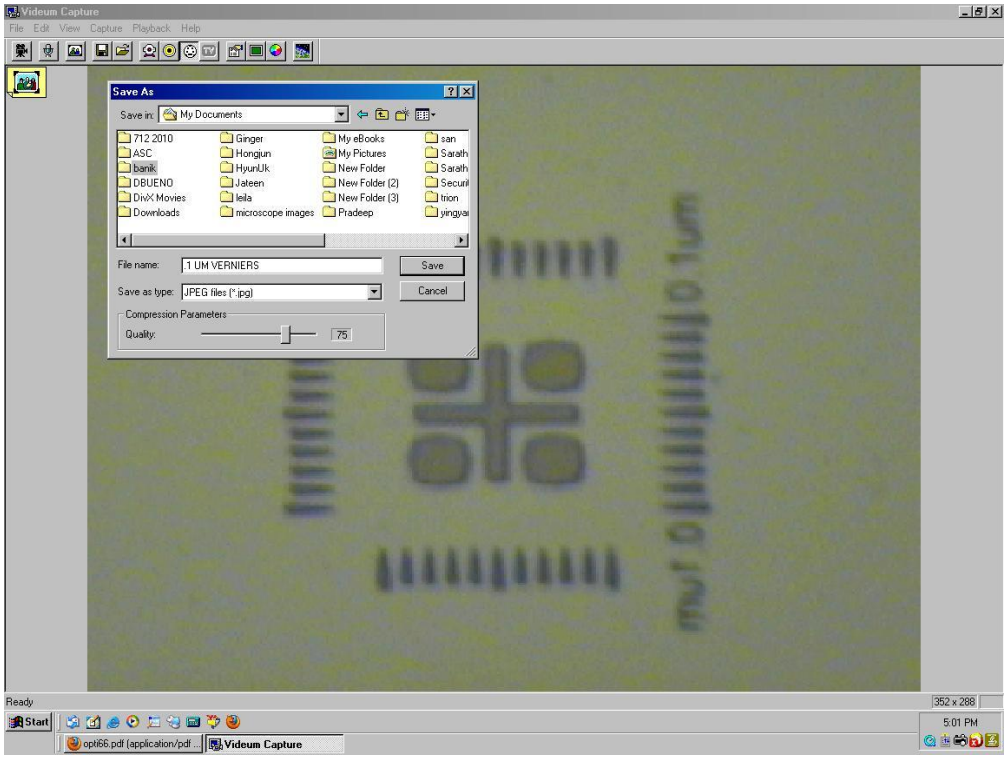


A picture icon will then be displayed on the left side margin 

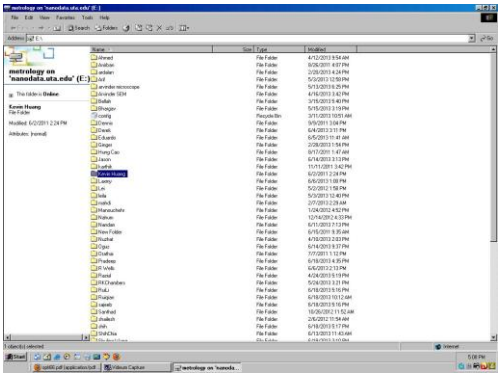


4.2.18. To save the picture to your file, right click on the picture icon.

4.2.19. Then name and save the picture to your file on the computers HD.

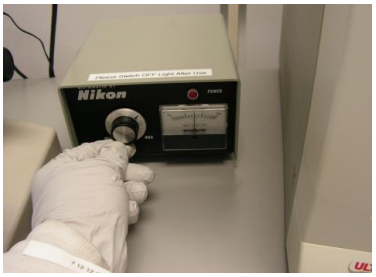


4.2.20. Images can be exported only to the **Nanodata.uta.edu** server. <u>No users USB sticks are allowed to be used.</u>



4.2.21. When you are finished inspecting your wafer and recording images move the Trinocular Head back about 45° to the right, rotate the objective to the **5X** and remove your wafer.

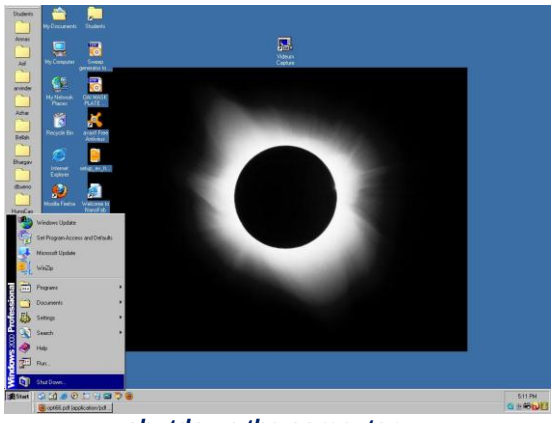
4.2.22. Turn **OFF** the Tungsten illuminator and the Ultrak color monitor.



Turn OFF !

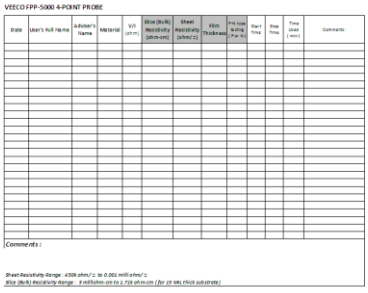
Turn OFF !

4.2.23. Exit the Videum Video Capture software and shutdown the computer.



shutdown the computer

4.2.24. Enter the required information in the logbook.



5 Technical Information

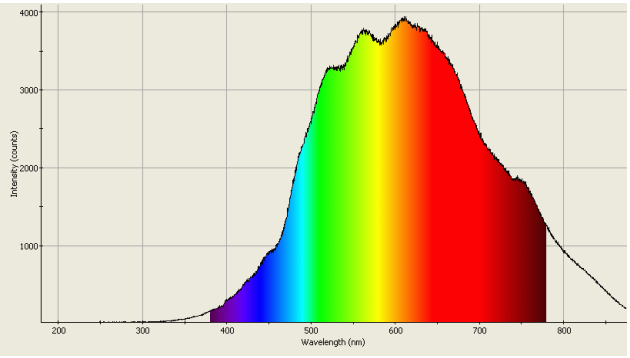
5.1 Reflected (episcopic) light Microscopy / Resolution / Total Magnifying power of the Microscope/ ND filter /Polarizers and Diopter Scaling.

5.1.1 In reflected light microscopy illuminating light reaches the specimen, which may absorb some of the light and reflect some of the light, either in a specular or diffuse manner. Light that is returned upward can be captured by the objective in accordance with the objective's numerical aperture. After entering the objective, light then passes through the partially silvered mirror (or in darkfield, through the elliptical opening). In the case of infinity-corrected objectives, the light emerges from the objective in parallel (from every azimuth) wavefronts projecting an image of the specimen to infinity. The parallel rays enter the tube lens, which forms the specimen image at the plane of the fixed diaphragm opening in the eyepiece.

The illuminator also includes a tube lens. Affixed to the back end of the illuminator is a lamphouse , which is a Tungsten-halogen lamp.
The lamp is powered by an external transformer power supply.

The illuminator also make provision for the insertion of filters for contrast, digital imaging, as well as polarizers and compensator plates for polarized light.

Tungsten-halogen incandescent lamps operate as thermal radiators, meaning that light is generated by heating a solid body (the filament) to a very high temperature. Thus, the higher the operating temperature, the brighter the light will be. All tungsten-based lamps exhibit emission spectral profiles resembling that of a blackbody radiator, and the spectral output profile of tungsten-halogen lamps is qualitatively similar to those of tungsten and carbon filament incandescent lamps. The majority of the emitted energy (up to 85 percent) lies in the infrared and near-infrared regions of the spectrum, with 15-20 percent falling into the visible from approximately 350 nm to 700 nm with the average about 525 nm.



Average about 525 nm.

5.1.2 The Resolution, or resolving power, is the ability to distinguish two separate points as being separate and distinct .The resolving power of a microscope determines the degree of detail that is visible. Resolution is expressed as the minimum distance that can be resolved. Under normal viewing conditions, the resolving power of the human eye is approximately 200 micrometers. Objects separated by less than this distance appear as one object to the unaided eye. The resolution of a typical compound microscope is approximately 0.2 micrometers, 3 orders of magnitude better than the human eye.

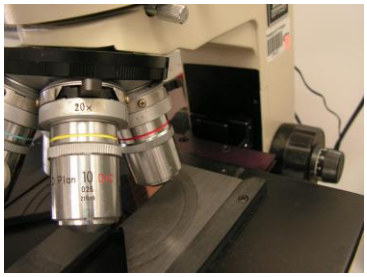
While resolution equations vary slightly among applications, microscope resolution is generally calculated using the following equation formulated by Abbe :

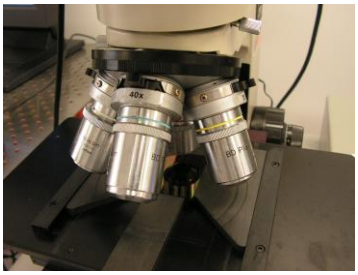
$$d = \lambda / N.A._{objective} + N.A._{aperture\ diaphragm}$$

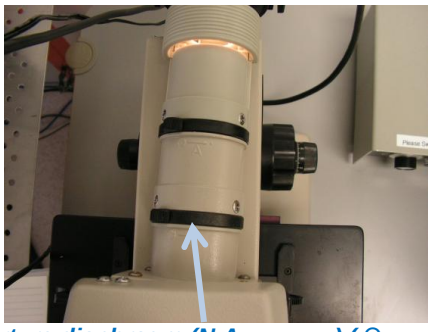
$$(N.A._{system} = N.A._{objective} + N.A_{aperture\ diaphragm})$$

where **d** is the minimum resolution distance (MRD), lambda is the wavelength of illuminating light in use (**average about 525 nm**)., and N.A. is the numerical aperture of the objective and aperture diaphragm in use. The equation shows that microscope resolution depends directly on the wavelength of light used to illuminate the specimen and inversely on the numerical aperture of the objective and aperture diaphragm .

- **5X BD Plan Objective N.A. 0.1 with Polarizer**
- **20X BD Plan Objective N.A. 0.25 with Polarizer**
- **40X BD Plan Objective N.A. 0.65 with Polarizer**
- **100X BD Plan Objective N.A. 0.90 with Polarizer**







Aperture diaphragm (N.A.$_{diaphragm}$) (○ → ● ***) Stopped down to 70-80% of NA.*** *OBJECTIVE*

5.1.3 The Total Magnifying power of the microscope is the product of the magnifying power of these two lens systems. The Nikon Optiphot 66 Microscope uses a standard 10X eyepiece in combination with the four objectives (5X, 20X, 40X and 100X) has a total magnifying power for the compound bright-field viewing has a range of 40X to 1000X (see table below).

OBJECT LENS MAGNIFICATION	EYEPIECE MAGNIFICATION	TOTAL MAGNIFICATION
5X	**10X**	**50X**
20X	**10X**	**200X**
40X	**10X**	**400X**
100X	**10X**	**1000X**

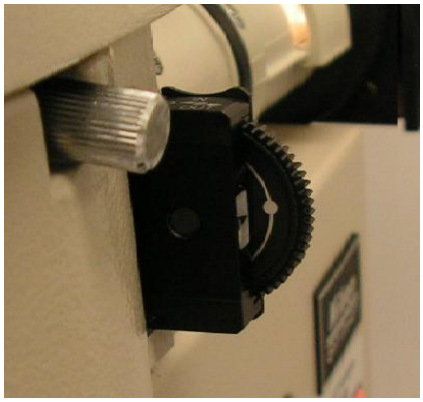
5.1.4 The neutral density filter or ND filter modifies the intensity of all wavelengths or colors of light equally. The ND filter is used to limit the amount of light from a bright light source reducing the depth of field and allowing the use of a wider aperture. The Nikon Optiphot 66 Microscope uses an ND32 filter type (see table below).

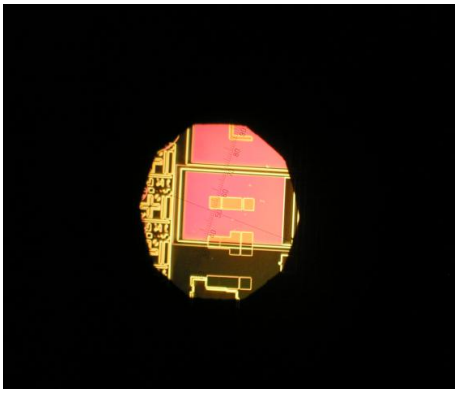
	lens area opening, as fraction of the complete lens	optical density	f-stop reduction	% transmittance
	1	0.0		100%
ND2	1/2	0.3	1	50%
ND4	1/4	0.6	2	25%
ND8	1/8	0.9	3	12.5%
ND16	1/16	1.2	4	6.25%
ND32	1/32	1.5	5	3.125%
ND64	1/64	1.8	6	1.563%
ND128	1/128	2.1	7	0.781%
ND256	1/256	2.4	8	0.391%
ND512	1/512	2.7	9	0.195%
ND1024	1/1024	3.0	10	0.098%
ND2048	1/2048	3.3	11	0.049%
ND4096	1/4096	3.6	12	0.024%

5.1.5 The Polarized reflected light microscopy is a technique that is suitable for examining surfaces containing structures or relief to change the image contrast. For example, the structural grains a number of metallic alloys and thin films can be readily examined using this method. To change the image contrasts rotate the polarizer wheel and pull in or out the tint plate as follows:

Rotating the polarizing wheel until ● coincidence with► the background will be dark offering images similar to brightfield phase contrast images.

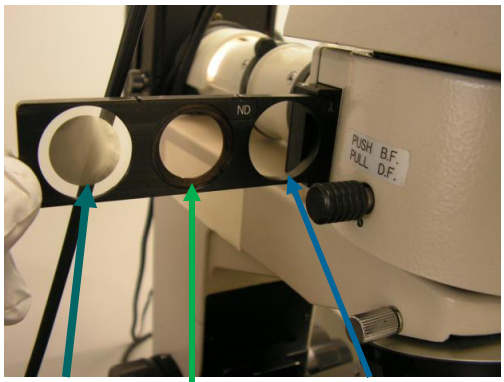
When the background is changes from black to grey by slight rotation of the polarizer wheel, a so-called sensitive color of grey will appear offering the best image contrast so images appears in relief.





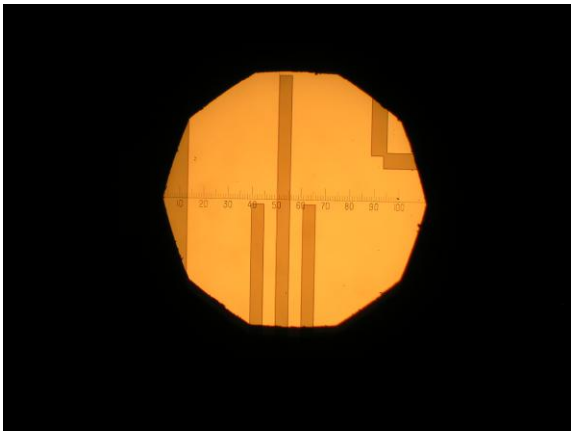
Rotate polarizing wheel: until ● coincidence with► to use polarizer filter

In the state of black background when the tint plate is put **IN** the optical path the background will show a sensitive color to **red-violet** offering the best color contrast. Furthermore with the tint plate **IN** the optical path to make the background sky-blue an interference image similar to dark contrast in the phase- contrast will appear. A surface uneven or in relief it would be possible to change the background to another color to obtain the desired contrast.

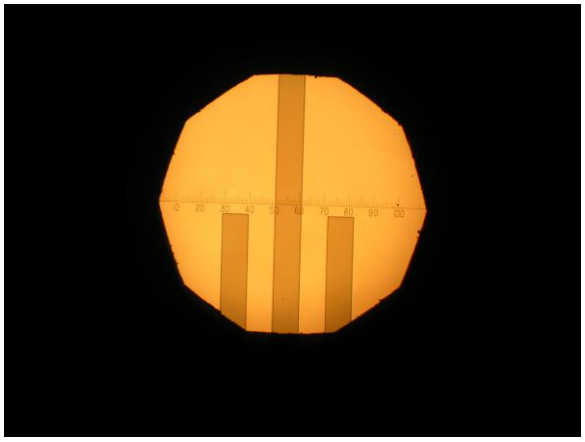


Tint Plate , ND filter, Hole (no filter)

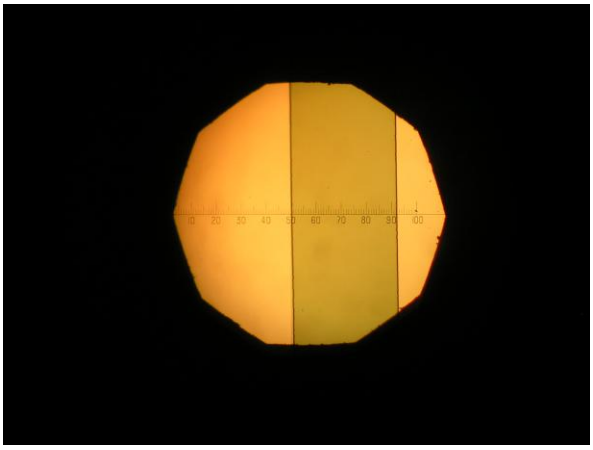
5.1.6 The device feature dimensions can be checked using the Diopter scaling as follows . At magnification above **40X** vibrations can have a significant effect on focusing.



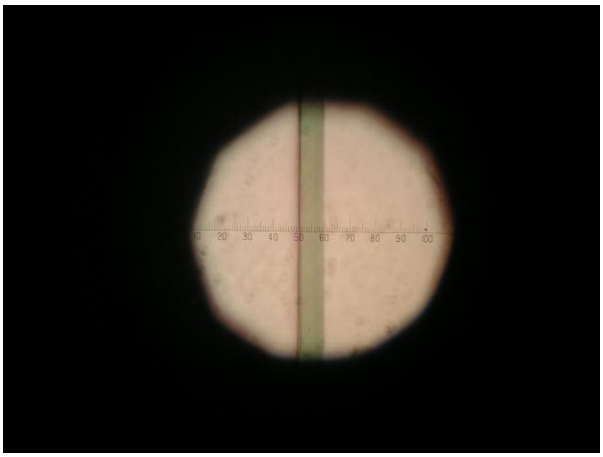
5X : 1 division = 20 µm



20X : 1 division = 10 µm



40X : 1 division = 2.3 µm



100X : 1 division = 1µm