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The Measurement of Residual Film Stress in Deposited Thin Films Using the KLA-Tencor 2D/3D P7 Surface Profilometer

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QNF QUATTRONE NANOFABRICATION FACILITY	Measurement of residual stress in deposited films	Document No:
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	KLA Tencor P7	Author: Roman Mays

Goal:

To note the procedures regarding obtaining the residual stress in a films deposited on silicon substrates.

Materials:

3 inch patterned wafer (1.8 µm S1818, 100 µm lines and spaces)
4 inch wafer
Diamond scribe or wafer cleaver
Acetone

Equipment:

KLA Tencor 2D/3D Stress Profilometer (https://www.seas.upenn.edu/~nanosop/P7_2D3D_SOP.htm)

Protocol:

SOP Link for stress measurements: https://www.seas.upenn.edu/~nanosop/P7_Stress_SOP.htm

A. Pre-deposition wafer bow measurement:
   1. Begin a stress operation by choosing "stress" from the "tasks" list
   2. From this, choose "NORMAL_OPERATION_STRESS_4INCH", which has the following settings:
      a. Stress points: 15
      b. Substrate Selection: 1.805 Silicon 100
      c. Thickness: 525 µm
      d. Modulus: 1.805 x 10^{-4} Pa
      e. Scan Parameters:
         i. Scan length: 80000 µm
         ii. Scan speed: 2000 µm/s
         iii. Sampling rate: 200 Hz
         iv. Stylus force: 5 mg
      f. Polyfit order: 5^{th}
   3. Set up the pegs to allow for the placement of a 4 inch wafer (~100 mm holes)
   4. Place 4 inch wafer onto pegs, with major flat facing outward (Fig. 1)
   5. Hit "Man Load" to load the wafer for study
   6. Hit "Focus" to focus the stylus onto the substrate
   7. Run the scan
      a. It is a good idea to take a screen shot of the scan obtained from this
   8. Hit "Man Load" to bring the substrate and stage back out
   9. Re-insert the wafer, now with the minor flat facing outward (Fig. 2)
   10. Repeat steps 5-8

One may now do a deposition upon the 4 inch substrate and samples from the 3 inch patterned wafer (Used for film thickness measurement), as described In various deposited metal characteristics.

B. Post-Deposition film thickness measurement
   1. Using acetone, remove some of the deposited film from the 3-inch patterned wafer samples
   2. Place the three samples onto the stage
   3. Select “recipes and data” from “Tasks”
   4. Select “NORMAL_OPERATION” from the recipe list
   5. Hit “View/Modify” to view the scan parameters, which should be the following settings:
      a. X scan size: 167 µm
      b. Scan speed: 50 µm/s
      c. Sampling rate: 200 Hz
      d. Multi-Scan Average: 1
      e. Scan Direction →
      f. Applied force: 2 mg
   6. Hit “Man Load” to load the samples
   7. Hit focus to focus the stylus unto the sample
   8. Drag the scan length across such that it covers three lines of film
   9. Take the scan
   10. Using the level and measure bars, obtain the step height of the silicon base to the deposited film
   11. Repeat steps 7-10 for 3 different places on each sample for 9 total points
   12. Use the 9 film size values to find an average and error for the film size

C. Post-Deposition Wafer bow measurement and stress calculation
   1. With the same wafer used in *Pre-Deposition wafer bow measurement*, repeat steps A. 1-11, making sure the data here is named differently from the pre-stress data
   2. Once both the pre- and post- deposition wafer bow measurements are logged, hit “Stress data” on the side bar
   3. Select the pre-stress major flat data and hit “Set pre”
   4. Select the post-stress major flat data and hit “Set post”
   5. Hit “calculate”
   6. When prompted for film thickness, enter the film thickness that was obtained from *Post-deposition film thickness measurement* (Section B) note: Film thickness asked for here is in µm
   7. Results are displayed; see section 4 https://www.seas.upenn.edu/~nanosop/P7_Stress_SOP.htm
   8. Repeat steps 3-7 for the minor flat data

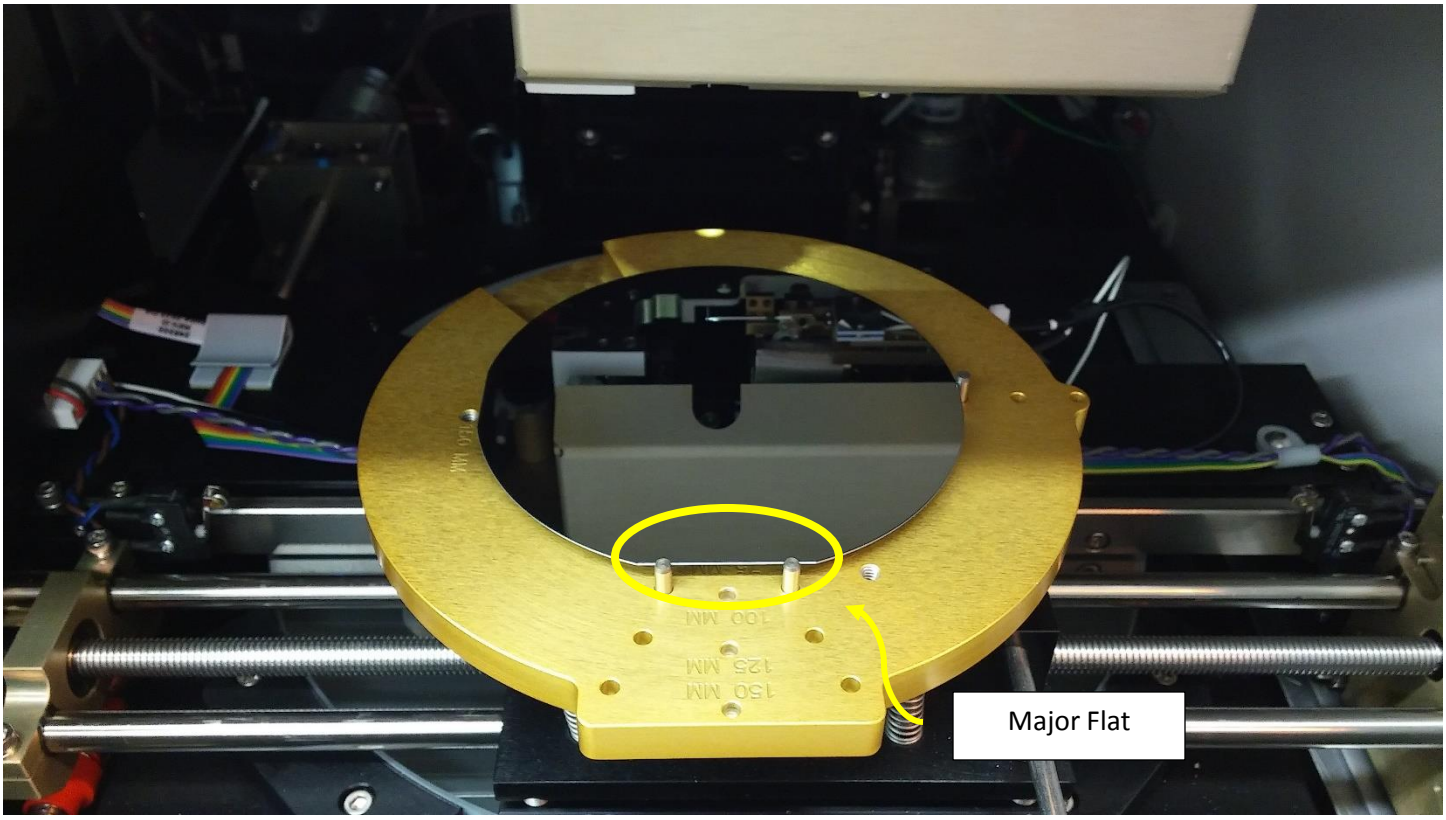

Fig.1. A Silicon wafer in the KLA Profilometer for stress measurements for the Major Flat down orientation. Note that the major flat of the wafer is facing downward in this picture (towards the outside of the machine).

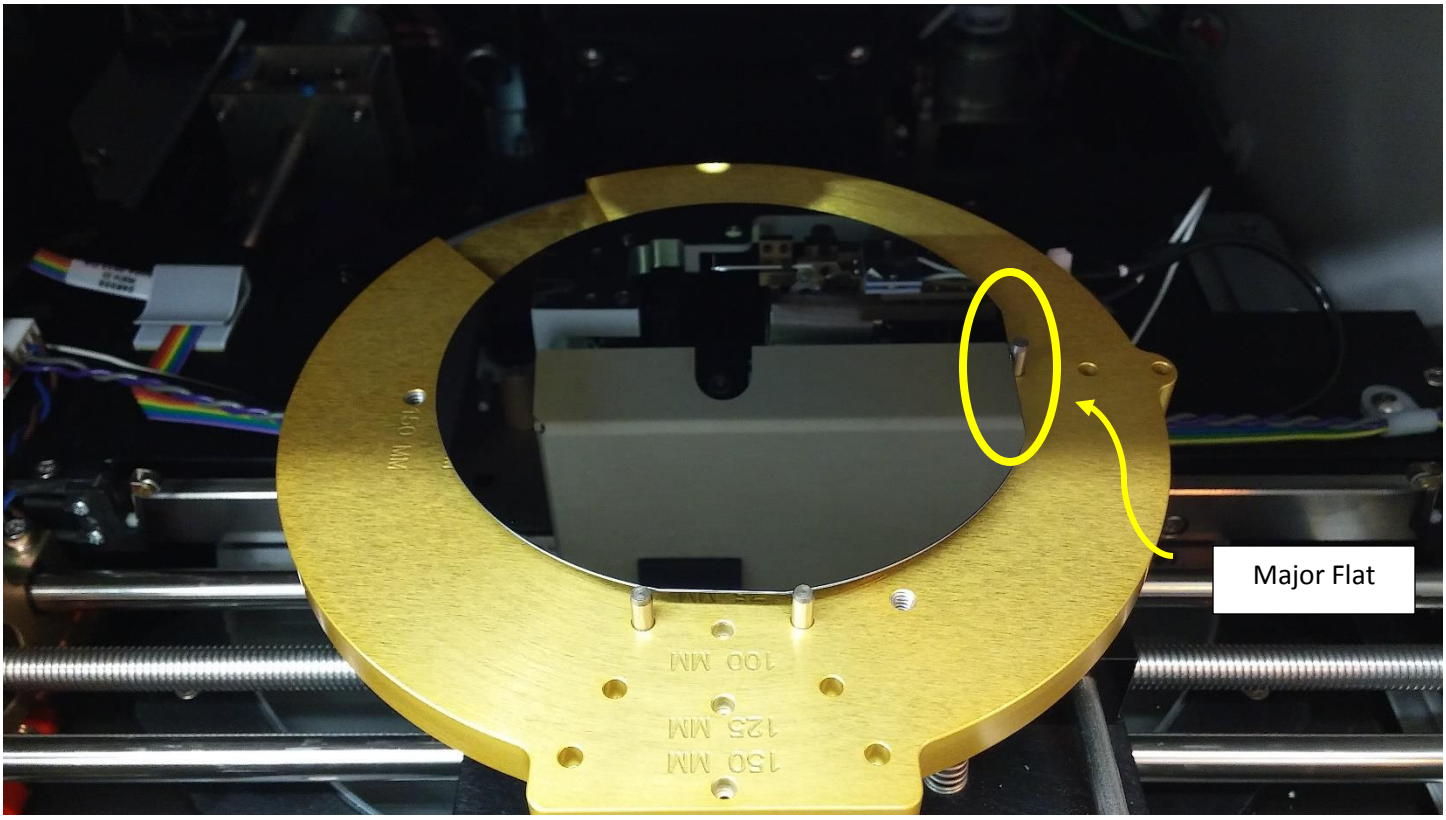

Fig.2. A Silicon wafer in the KLA Profilometer for stress measurements for the Major Flat right orientation. Note that the major flat of the wafer is facing towards the right in this picture.