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NEW FREQUENCY DOMAIN FIBER OPTIC INTERFEROMETRY FOR ADVANCED WAFER, MICRO- AND NANOSTRUCTURE METROLOGY

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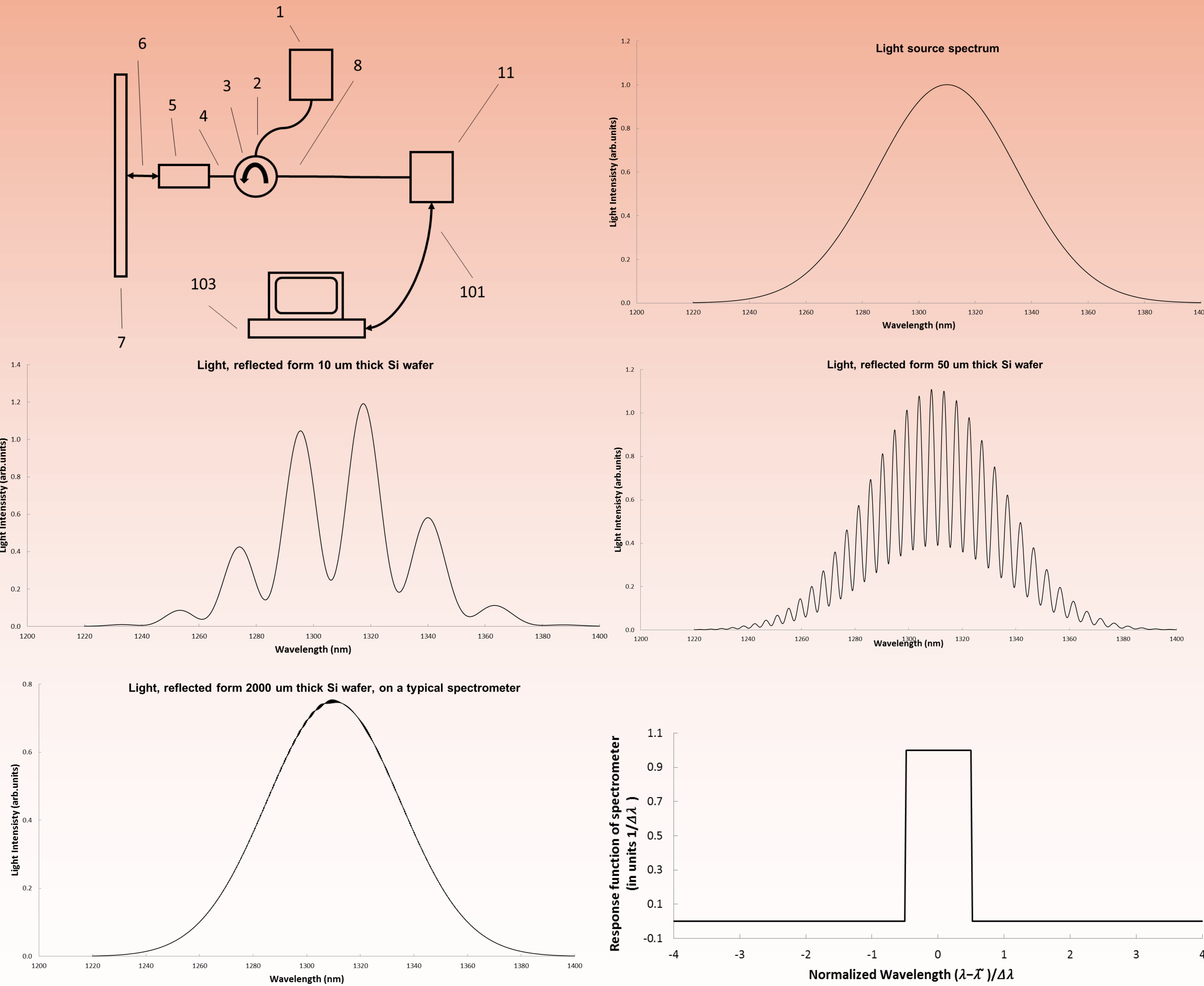
Motivation and Prior Art

Typical Fabry Perot thickness

Tools are limited to very thin films

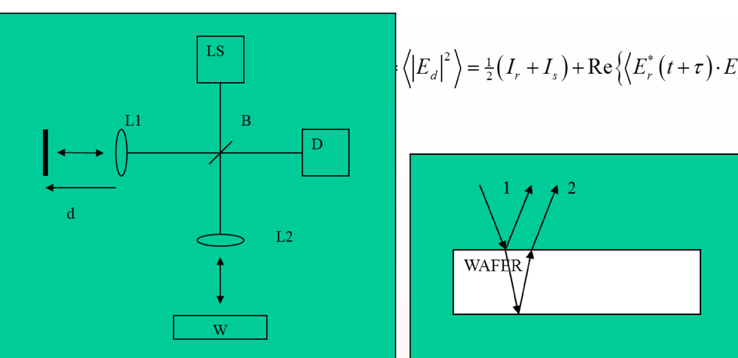
Thick Layer Measurements require High Resolution Systems



FSM 413 Echoprobe Technology

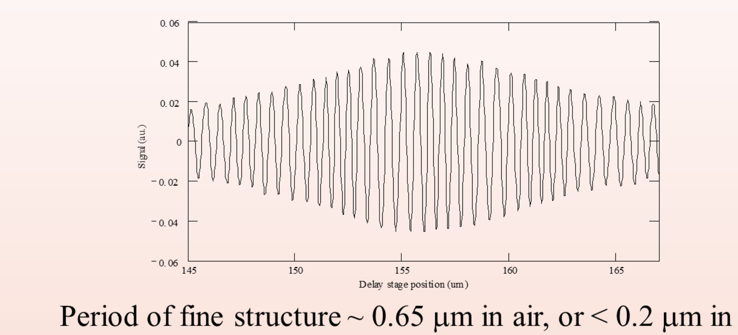
EchoProbe Technology: Principle of Operation

Fiber optic Fourier Transform Spectrometer



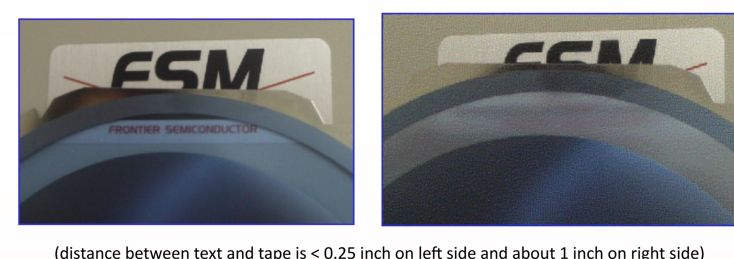
$$\langle |E_d|^2\rangle = \tfrac{1}{2}(I_r+I_s)+\mathrm{Re}\{\langle E_r^*(t+\tau)\cdot E_s(t)\rangle\}$$

When reference and signal arms are equal we observe interference fringes.



Period of fine structure ~ 0.65 μm in air, or < 0.2 μm in Si

Limitations



(distance between text and tape is < 0.25 inch on left side and about 1 inch on right side)

Inhomogeneous tapes heavily scatter light and complicate measurements.

Source of limitation: mechanical scanner affecting speed and accuracy.

Main Applications

Wafer Thickness in back-grinding back-etching process: Si or III/V wafers with or without tape, bumped wafers, bonded wafer and many other materials.

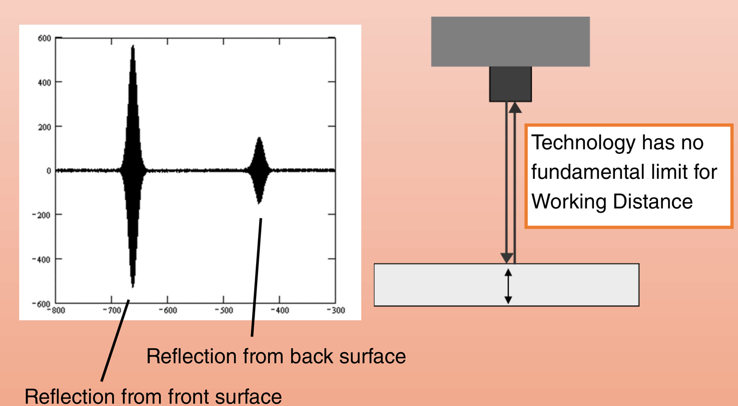
Bump height

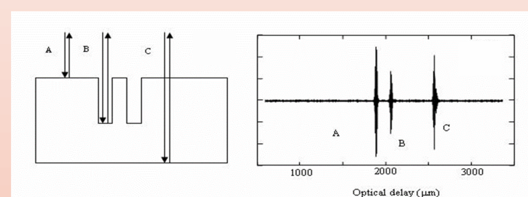
Trim depth

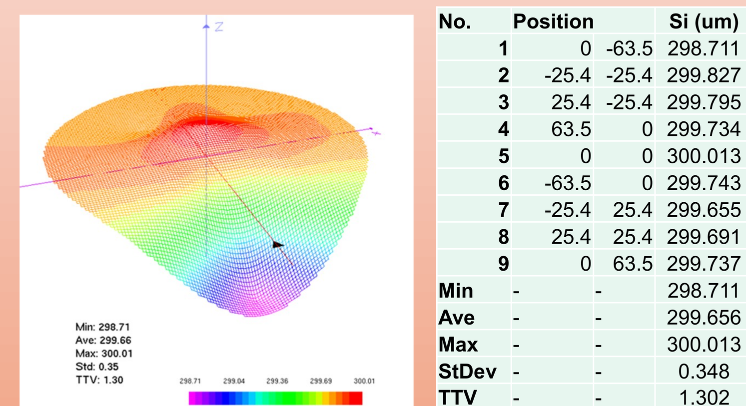
TSV depth in MEMS and 3DIC structures

Trench depth

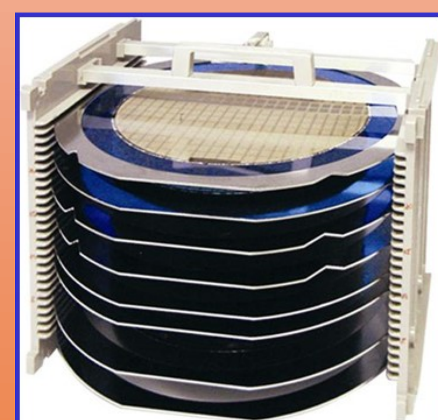
Measurements on Single Layer Blanket Silicon Wafer







No.	Position		Si (um)
1	0	-63.5	298.711
2	-25.4	-25.4	299.827
3	25.4	-25.4	299.795
4	63.5	0	299.734
5	0	0	300.013
6	-63.5	0	299.743
7	-25.4	25.4	299.655
8	25.4	25.4	299.691
9	0	63.5	299.737
Min	-	-	298.711
Ave	-	-	299.656
Max	-	-	300.013
StDev	-	-	0.348
TTV	-	-	1.302



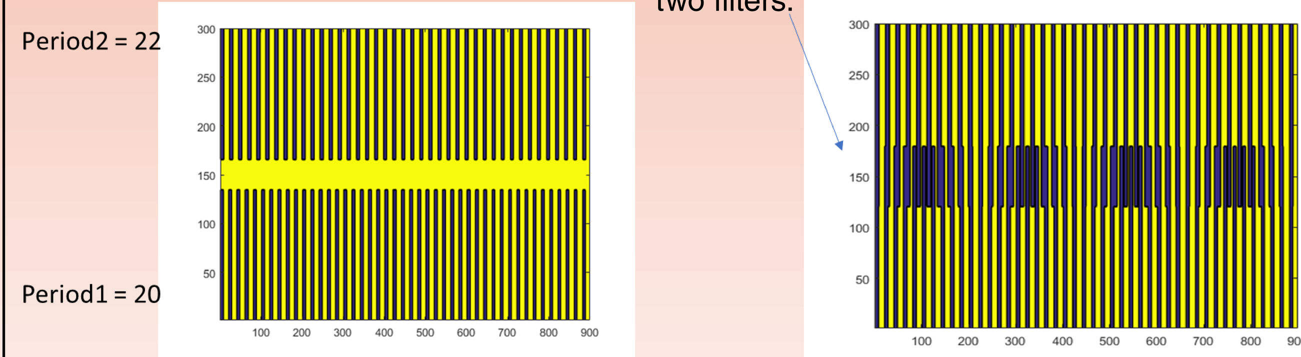
Elimination of scanner limitations utilizing Moire Effect: Principle of FSM 8108 VITE

Real Space Moire Effect:

Two small spacing patterns having similar but slightly different spacing (and frequency) ore overlapped.

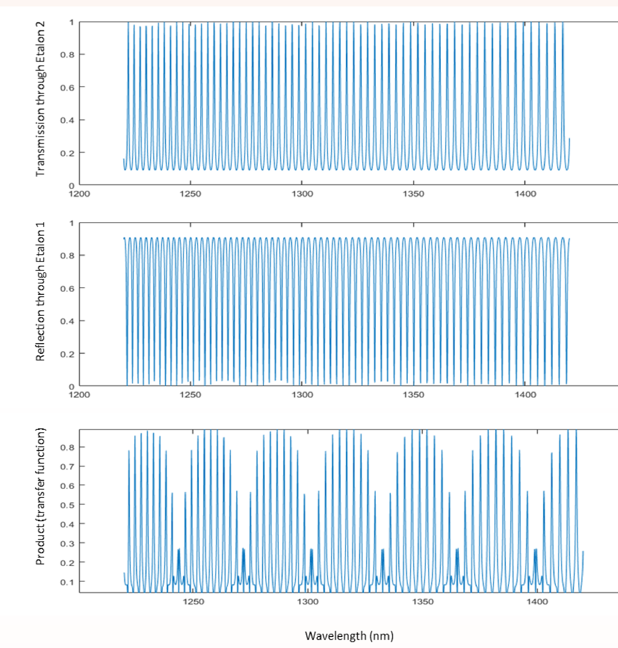
When the two patterns are overlapped they produce a new pattern. The resulting pattern has a large spacing component (slowly varying component).

Slowly varying oscillations corresponding to the "beat" Frequency resulting from product of transmission of two filters.

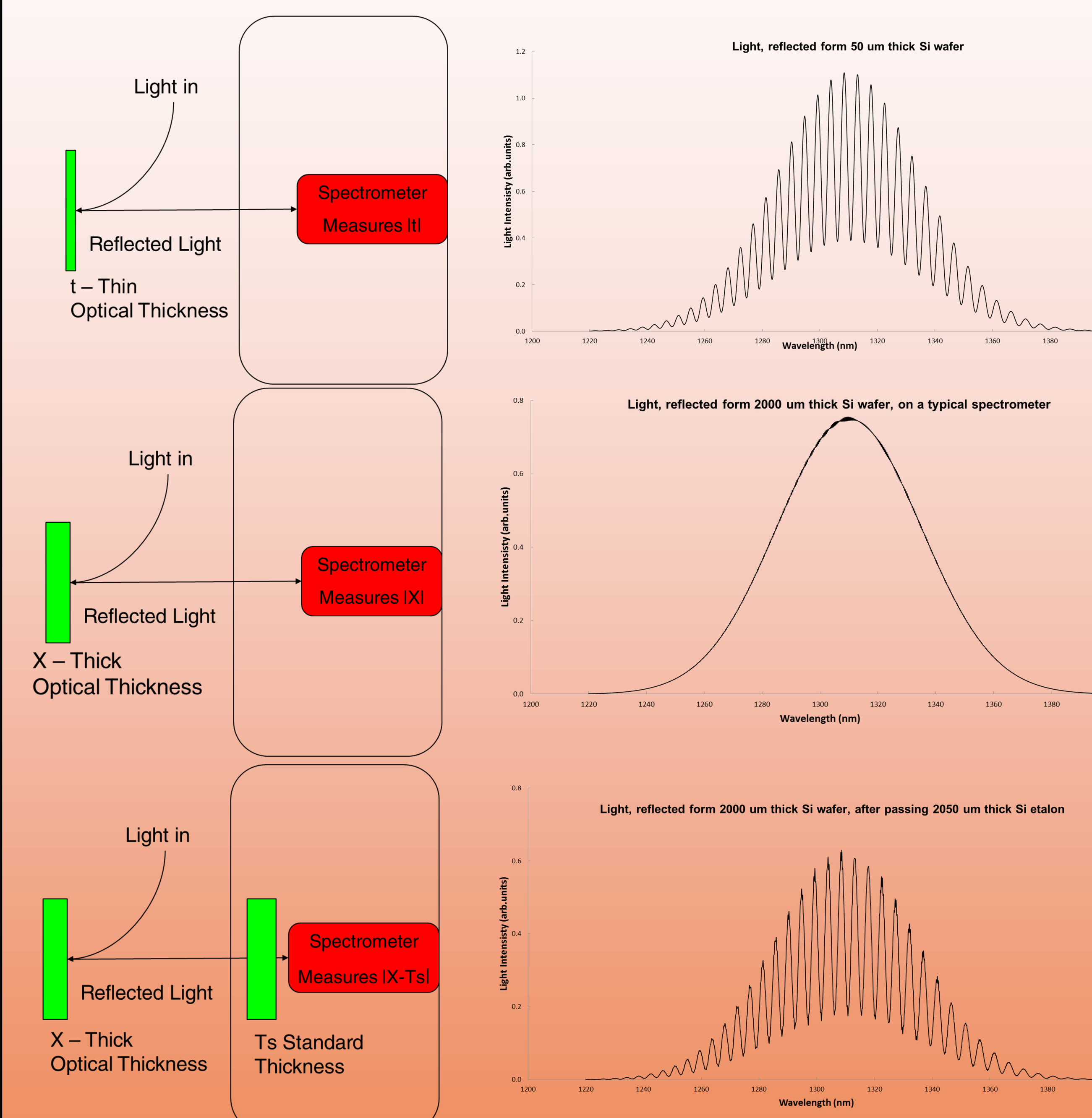


FSM Effect - Frequency Space Moire Effect

- Two thick etalons having slightly different thickness have fast oscillating transmission and reflection spectra with slightly different spacing of resonances as a function of wavelength.
- When the two such etalon filters are placed one after another the resulting transfer function has slowly varying components corresponding to the difference between optical thickness of each filter.
- Frequency Space Moire Effect - FSM Effect since it appears in wavelength (or frequency spectra) rather than in the real space.
- The observation and measurement of this slowly varying component does not require high resolution spectrometer.

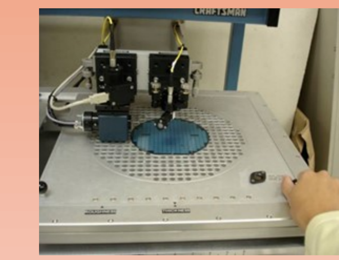


Measurement on thick samples with small (low resolution) spectrometer



FSM Effect allows us to monitor Fabry Perot fringes on 2000 um slabs of Si with the same ease as measuring 50 um thin films

FSM Family of Thickness Measurement Tools



Manual Systems

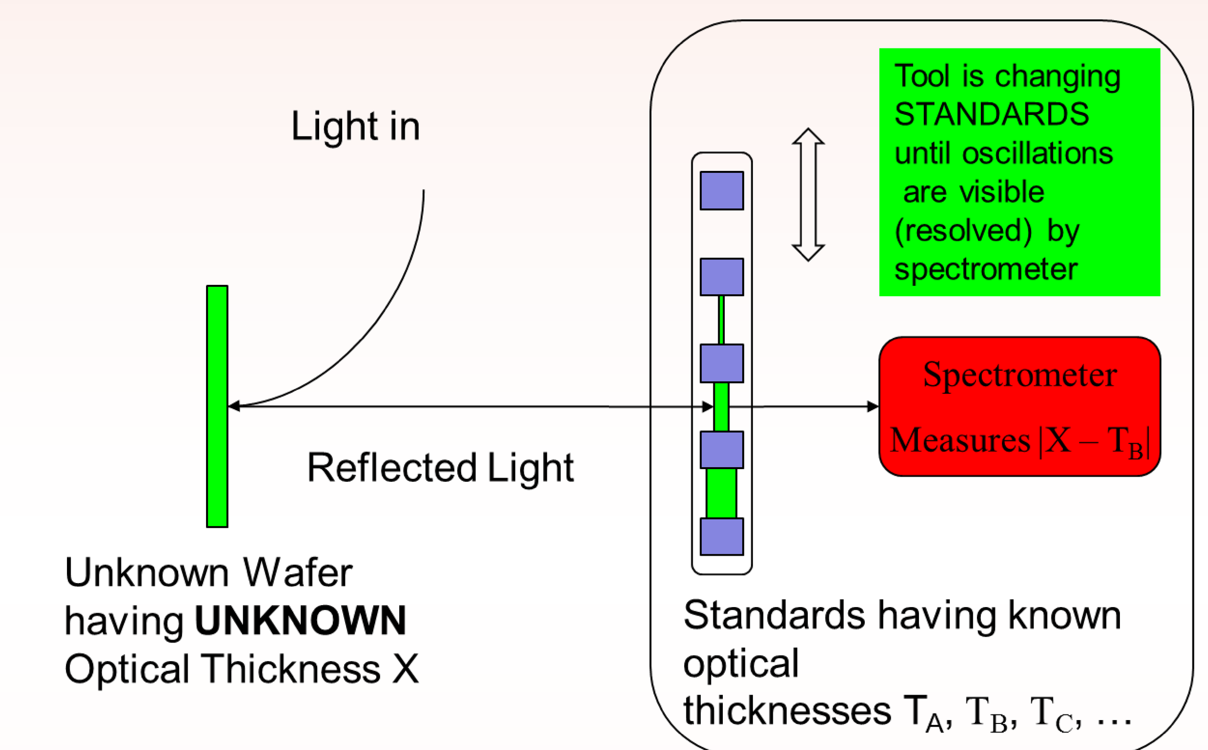
Semi Automated

Fully Automated

100+ Systems

Installed Worldwide

How does it work in FSM 8108 VITE



FSM 8108 VITE Application and Performance

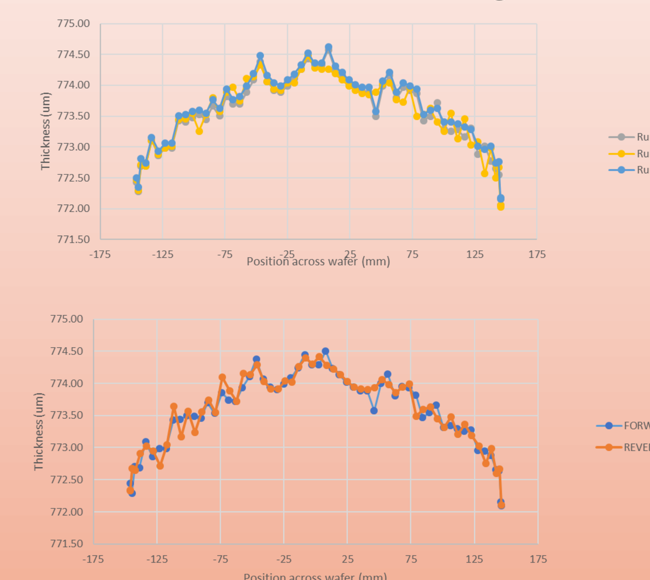
- Everything which interferometer technology FSM 413 can do **BUT**
- FASTER: about 10x faster
- MORE ACCURATELY
- REPEATABILITY: >3x better repeatability

Dynamic repeatability: Measurements on moving wafer

Scan time: 6.5 sec scan across 300mm Silicon wafer

This implies throughput >50 wafers per hour (WPH) for typical recipe

Repeatability: +/- 0.072 um for typical 300 mm wafer



CONCLUSIONS

- New FSM Effect based FSM 8108 VITE technology improvements
  - Speed x10
  - Accuracy and reproducibility x3
  - New high speed applications possible
  - No polarization sensitivity

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