

AFM vs THoT Resolution

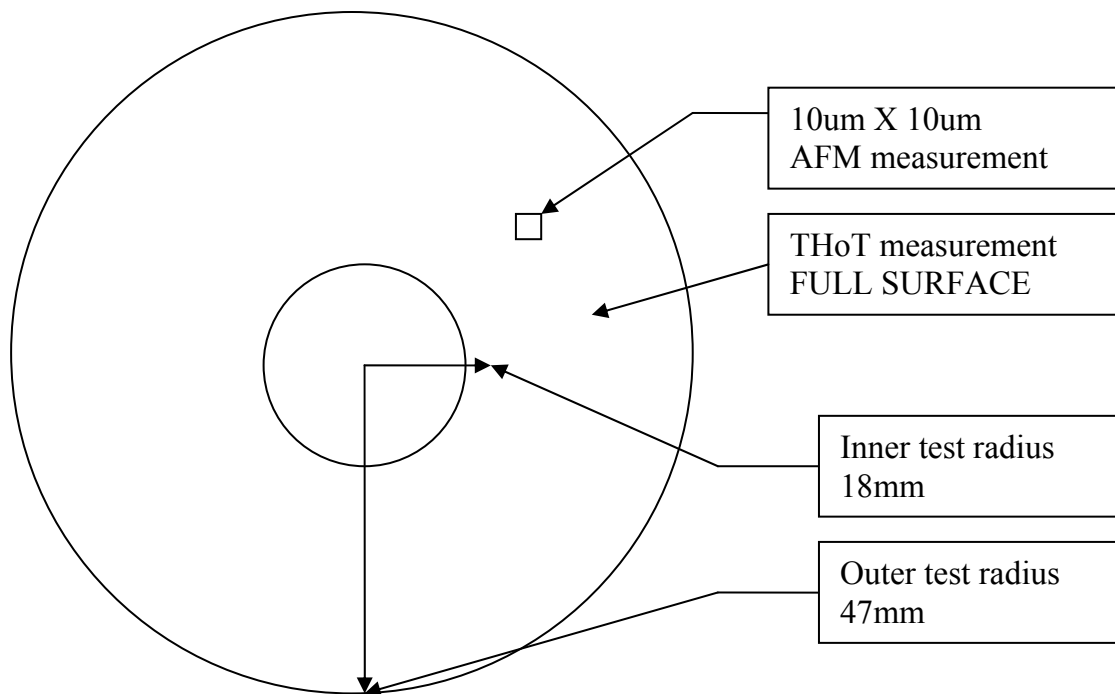
The Atomic Force Microscope is designed to be an analytical tool capable of imaging very small features so that the feature structure and composition can be analyzed.

The THoT Photonic Force Microscope is designed to scan large areas and detect the presence of very small features.

The THoT tool will never replace the AFM for critical defect analysis and the AFM will never be capable of full disk surface examination.

In the following example, we compare an AFM to the THoT Model 42010 Optical Defect Scanner for surface coverage, test time, data storage requirements and resolution.

Given a disk with a 25mm inner diameter and 95mm outer diameter:



Total area calculation:

- $A = r^2\pi$, $\pi = 3.14159$, $1\text{mm} = 1,000\mu\text{m}$
- $A1 = r1^2 \pi = (18,000^2) \pi = 1,017,876,020$ square microns
- $A2 = r2^2 \pi = (47,000^2) \pi = 6,939,778,172$ square microns
- Total area = $A2 - A1 = 6,939,778,172 - 1,017,876,020 = 5,921,902,152$ square microns.

Total measurement calculation:

AFM:

- $5,921,902,152 \text{ sq. microns} / (10 \times 10\mu\text{m}) = 59,219,022 \text{ AFM measurements.}$
- $\text{A single AFM measurement} = 256 \times 256 \text{ readings} = 65,536 \text{ measurement points per } 10 \times 10\mu\text{m square.}$
- $65,536 \text{ measurement points} \times 59,219,022 \text{ AFM measurements} = \text{Total measurement points} = 3,880,977,825,792$
- $\text{Double precision 12 bit measurements} = 4 \times \text{Total} = 15,523,911,303,168 \text{ bytes of data.}$
- $\text{AFM} = 15.5\text{TB per surface}$

THoT:

- $0.2\mu\text{m track, } 1024 \text{ sectors}$
- $47\text{mm} - 18\text{mm} = 29\text{mm} = 29,000\mu\text{m}$
- $29,000\mu\text{m} / 0.2\mu\text{m} = 145,000 \text{ tracks}$
- $145,000 \text{ tracks} \times 1,024 \text{ sectors} = 148,480,000 \text{ measurements}$
- $\text{Double precision 12 bit measurements} = 4 \times 148,480,000 = 593,920,000$
- $\text{THoT} = 0.0006\text{TB per surface}$

Total measurement time calculation:

AFM:

- $2 \text{ minute for each AFM measurement} \times 59,219,002 \text{ AFM measurements} = 118,438,004 \text{ minutes (225 years, 49 weeks, 5 days, 14 hours, 44 minutes)}$

THoT:

- $\text{THoT Nano-Scan test time} = 145,000 \text{ tracks} / 6,000 \text{ rpm} = 24 \text{ minutes, } 10 \text{ seconds}$
- $\text{THoT Optical Glide / Optical Certification scan time} = 14,500 \text{ tracks} / 6,000 \text{ rpm} = 2 \text{ minutes, } 25 \text{ seconds}$
- $\text{THoT AOI scan} = 2,900 \text{ tracks} / 6,000 \text{ rpm} = 29 \text{ seconds}$

Vertical Resolution:

- $\text{Vertical resolution is critical for drive performance. It is the height of the defect that will impact the head or the depth of the defect that will have the greatest effect on data integrity.}$

AFM:

- Measurement-to-measurement without moving sample or probe (also known as “tool noise”) = ± 0.01 Angstroms.
- Measurement-to-measurement without moving sample (known as “measurement repeatability”) = ± 0.02 Angstroms.
- Measurement-to-measurement removing and replacing sample (known as “tool repeatability”) = ± 0.10 Angstroms
- Tool-to-tool sample measurement repeatability = ± 1.00 Angstroms.

THoT:

- Measurement-to-measurement without moving sample or probe (also known as “tool noise”) = ± 0.01 Angstroms.
- Measurement-to-measurement without moving sample (known as “measurement repeatability”) = ± 0.01 Angstroms.
- Measurement-to-measurement removing and replacing sample (known as “tool repeatability”) = ± 0.02 Angstroms.
- Tool-to-tool sample measurement repeatability = ± 0.05 Angstroms.

Obviously the spatial resolution is much lower, 600MB verses 15.5TB, but the speed is much quicker, 24 minutes verses many years. Vertical resolution is better due to the fact that the THoT tool uses HeNe light (632.8nm wavelength) with a phase discrimination of one part in ten to the minus six (0.006328 Angstroms) rather than a cantilever mechanical stylus.

Measurement considerations.

- The AFM is a drag stylus type of measurement with readings being made every 390 Angstroms [(10um X 10,000A/um)/256 measurements].
- The LDV is a Gaussian laser beam recording the Rq and +/- Rp at a track spacing of 2000A in the Nano-Scan mode, 2um in the Optical Glide / Optical Certification mode or 10 microns in the AOI mode.
- The AFM makes measurements every 390Angstroms, forming a square pattern of measurement points.
- The LDV makes 1024 sector readings every revolution recording the Rq and +/-Rp (highest and lowest values) of each sector.

Will the THoT system replace the AFM?

- If you are trying to scan a full surface to determine the location, quantity and severity of defects in a short period of time, yes!
- If you are attempting to determine the shape of the defect and need to analyze the defect type, an AFM or SEM should be used.
- The THoT tool is not intended to replace the AFM but rather to supplement it and allow the AFM to be used for defect analysis work rather than process control.
- The THoT tool is designed to be a full surface process control tool to examine surface morphology, contamination and sub-micron nano-defects quickly and accurately.

Advantages of the THoT tool:

1. Full surface scanning capability.
2. Ability to differentiate pits from asperities.
3. Fast scan capability between 30 seconds and 25 minutes depending on scan mode.
4. Ability to determine coincidence of pit and asperity and identify embedded particles.
5. Excellent tool to identify the location of particles, defects and nano-defects so that they can be located under an AFM or SEM for further evaluation.
6. Ease of use, does not require extensive training.
7. Tool does not require special vibration isolation.
8. Tool-to-tool repeatability is excellent.