

How to save Money using AFM Analysis of Pits and Grooves

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Summary

Media-Tech ASM interview transcript 0310.doc

This is a transcript of the video interview conducted at ASM's stand on Oct. 21, 2003.

Q: Don Chernoff, do you want to tell us a little bit about your company and your products?

A: We're working with the Atomic force microscope. This instrument makes 3-dimensional images of surfaces and it's used in many industries around the world. In the optical disc industry, people are using it to look directly at the physical structure of the pits and grooves that make up the disc and the data on the disc. We have worked with many companies around the world and have developed a new measurement software called the DiscTrack Plus Media Measurement System. This allows measuring very precisely and accurately the size, shape and position of the pits and grooves. It is a testing technique which complements traditional electrical testing using a disc analyzer. With an electrical test, you can see the output parameters, signal levels and so on, but you cannot see the actual structure of the pits or grooves. When you use a disc analyzer to adjust production variables, you are working partly blind. When you adjust the production variables, things like the laser power in the laser beam recorder or the pressure and temperature in the molding tool... When you adjust those, they directly affect the geometry produced on the disc. With the atomic force microscope and DiscTrack Plus, you can now see that directly. This gives you the possibility of having tighter process control. In over 20 companies around the world, our system is in use helping people save money and improve quality by detecting and correcting problems and by avoiding problems.

People tell us that the strong statistical data presentation gives them the confidence to actually make production changes based on the results.

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Summary, cont.

Q: Thank you. You were saying there are certain stages in the manufacturing process where this is particularly useful. You say the laser beam stage...

A: The AFM analysis of pits and grooves is particularly important in mastering and also in replication. The Atomic Force Microscope can look directly at the glass master or the stamper and allow you to correct problems or detect problems without having to actually mold the disc and put it into a disc analyzer. Our customers say that that saves them time and money because they can get the answers sooner in the process. I should also mention that the technique is important for DVD and is becoming even more important for higher-density formats such as Blu-Ray because the manufacturing tolerances are becoming tighter with each generation.

Q: So people are in increasing need of more and more sophisticated test equipment, as you say, as the manufacturing tolerances are getting tighter and tighter.

A: Yes, that's correct.

Q: Thank you. And one thing, Don, that we forget to let you do is say the name of your company.

A: Our company is called Advanced Surface Microscopy.

Q: Thank you very much.

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To see the video, go to <http://tvfilms.media-tech.net/media-tech/> and follow the links to "interviews" -- "Advanced Surface Microscopy".



Overview

- ◆ Introduction:
 - Saving Money
 - AFM
- ◆ What customers say is important
- ◆ Qualitative analysis
- ◆ Quantitative analysis
- ◆ Open discussion



Test Equipment saves Money

- ◆ By Improving Quality
- ◆ By Improving Yield
- ◆ Both at same time
- ◆ Correct Problems
- ◆ Avoid Problems



What is AFM?

- ◆ Atomic Force Microscope
- ◆ Makes 3-dimensional image of surface
- ◆ Masters, Stampers, Replica
- ◆ Shows pit and groove structure
- ◆ Measure size, shape, position of pits and grooves



Qualitative AFM applications

- ◆ Detect Plowing
- ◆ Investigate “Missing data” (at Mastering)
- ◆ Bad Packaging (120 discs in box of 100) – scratches
- ◆ Electroforming defects

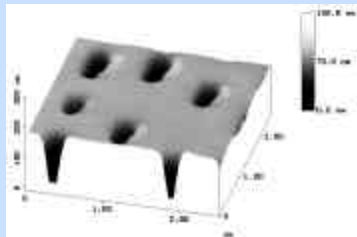
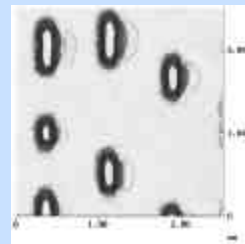
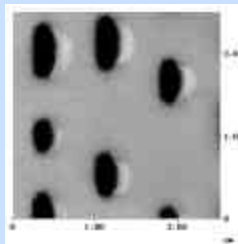
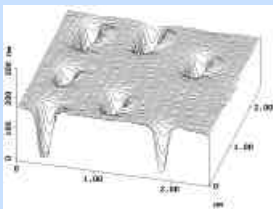
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Plowing Marks (“clouds”)



Different Displays of same Height Data

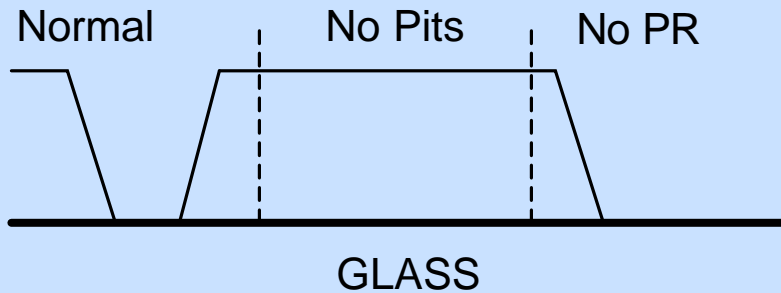
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Missing Data on Glass Master (AFM Height Profile)



Causes for Missing Data

- ◆ AFM distinguishes: PR coating failure (gap in photoresist as coated) from PR development failure (pits not exposed or developed)
- ◆ Causes:
 - Contamination
 - Bubbles, mist

Quantitative Analysis

- ◆ Track Pitch and Wobble
- ◆ Pit and Groove Geometry
- ◆ Length Analysis and Jitter
- ◆ Statistical Presentation of Results



What is wobble?

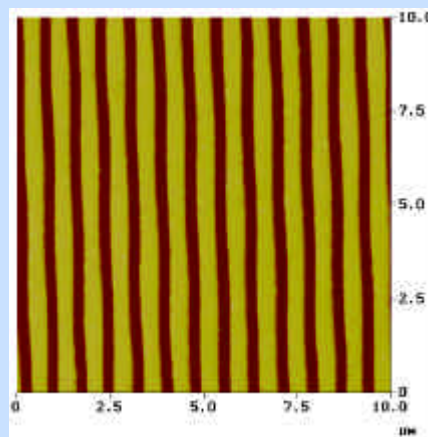
- ◆ Recordable/rewritable media (such as CD-R and DVD+-RW) have a continuous spiral groove. The path is not a smooth spiral, but instead wobbles from side to side. This provides signals for tracking, timing, and special data.



Wobble Measurement by Disc Analyzers – Problems

- ◆ Disc Analyzers measure the ratio of track-crossing signals.
- ◆ No direct calibration to a length standard
- ◆ Disc Analyzers are not available for new formats in the research lab.

AFM shows Groove Path



DVD+RW

AFM image courtesy Paul van Roosmalen, Philips

AFM Measurement of Wobble

- ◆ AFM images show groove path directly
- ◆ Measure Wobble using:
 - a) variation in spacing (track pitch) of adjacent grooves; or
 - b) variation in groove position
- ◆ Measurements are calibrated directly to a length standard.
- ◆ We show (a) here.

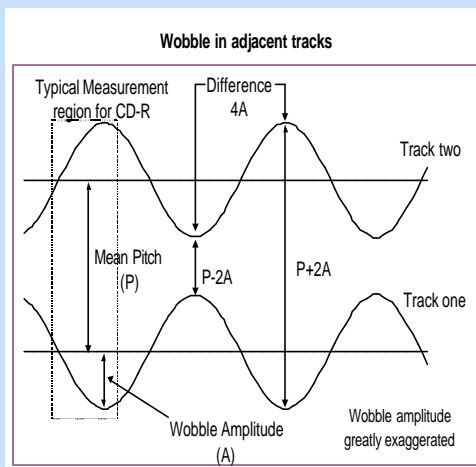
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Computing Wobble from Track Pitch



- ◆ 2 Tracks out of phase
- ◆ A = wobble amplitude
- ◆ Pitch Max. - Pitch Min. = $4 * A$

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Materials and Methods

- ◆ Atomic Force Microscope (AFM)
- ◆ Calibration Specimen:
 - 2D Grating (292 nm pitch) (for DVD+RW)
 - 2D Grating (700 nm pitch) (for CD-R)
- ◆ Test specimens: Glass Master, Stamper or Replica
- ◆ Data Analysis: DiscTrack Plus™

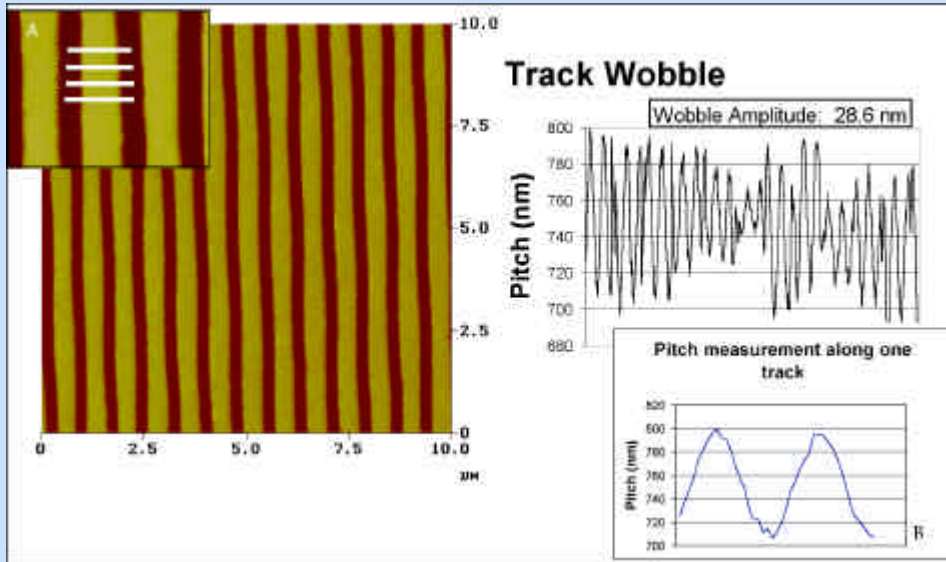


Case 1: Fast Wobble

- ◆ In DVD+RW, the wobble period is about 4 μm .
- ◆ This is smaller than the 10 μm AFM image size



DVD+RW Wobble



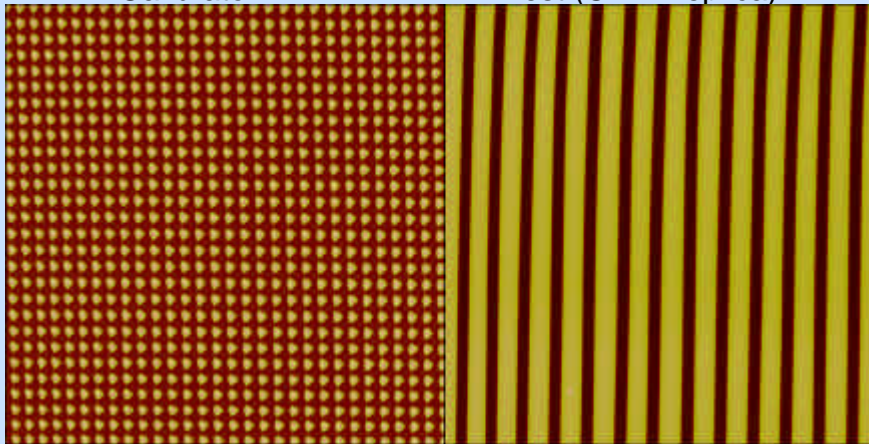
Case 2: Slow Wobble

- ◆ In CD-R, the wobble period is about 55 μm.
- ◆ This is larger than the 20 μm AFM image size
- ◆ We can still measure wobble because we sample many track pairs

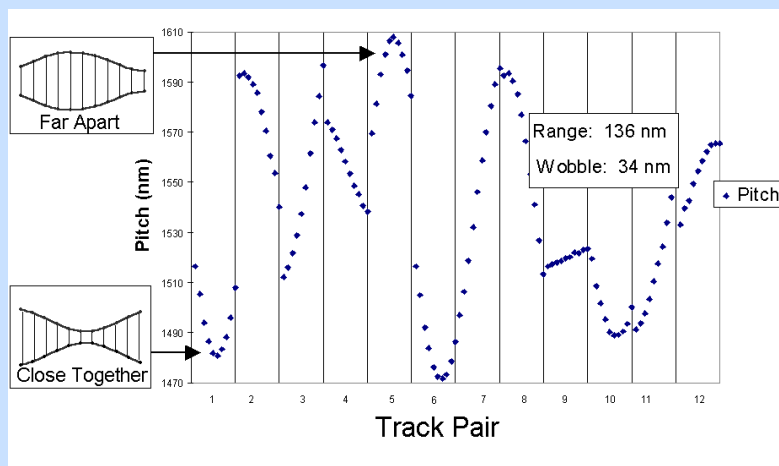
Data Capture - 20 um Scans

Calibrator

Test (CD-R replica)



Wobble Measurement CD-R



Summary: AFM Measurement of Groove Wobble Amplitude

- ◆ Direct Physical Measurement using many, high-precision track pitch measurements
- ◆ Can Measure stampers or masters before replication
- ◆ Independent check on electrical testers

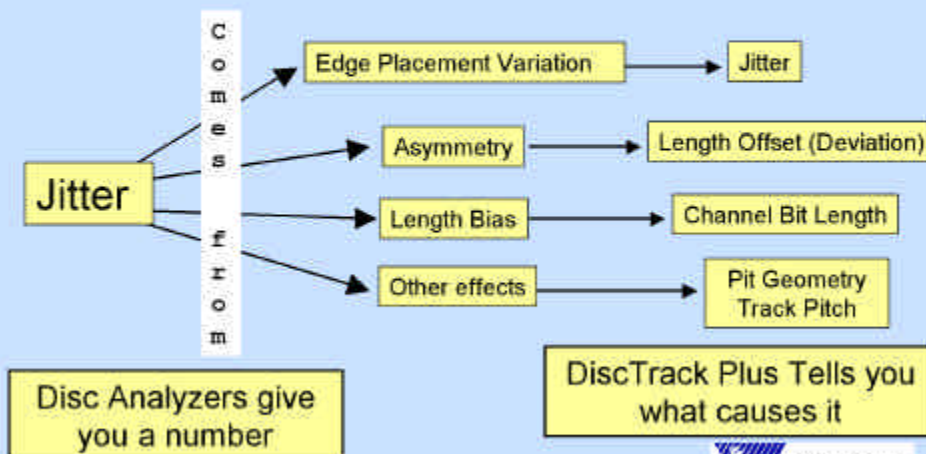
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How do you fix a jitter problem?



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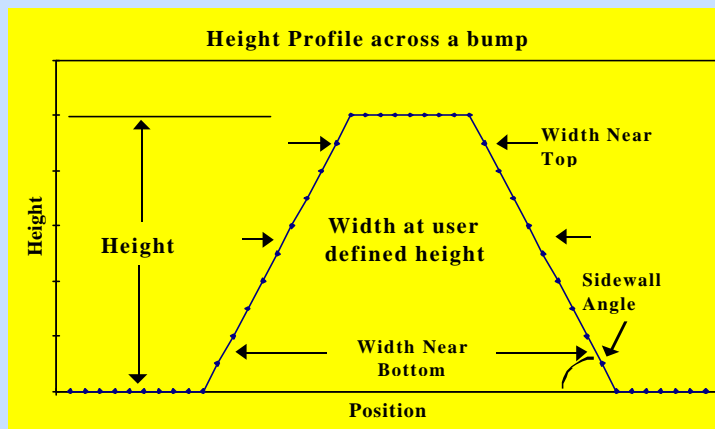


Feature Geometry

Automated, high-accuracy measurement of size, shape, and position of individual features

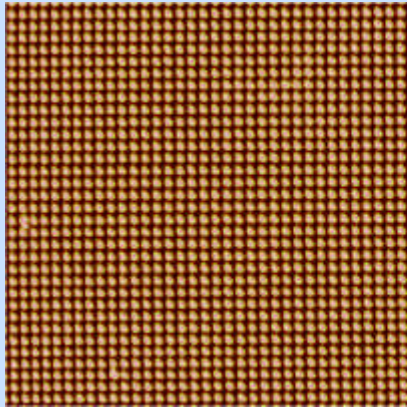


Feature Geometry

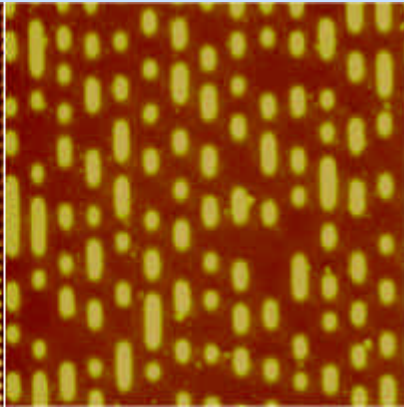


Data Capture - 10 um Scans

Calibrator



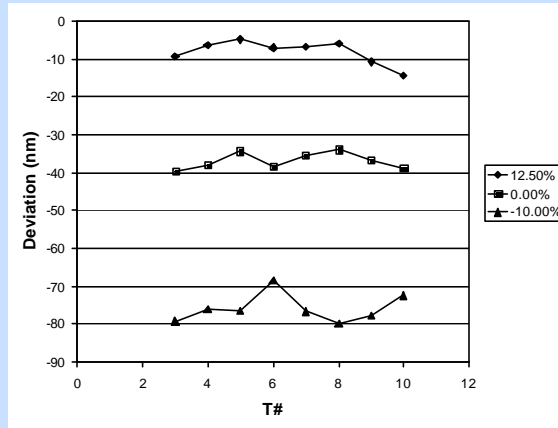
Test (DVD Stamper)



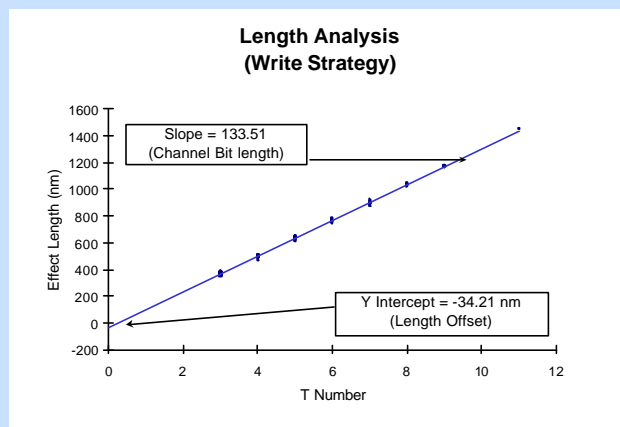
Live DTP Demo

- ◆ Pit Geometry
- ◆ Jitter
- ◆ Good vs. bad stamper
- ◆ Trend tables, charts

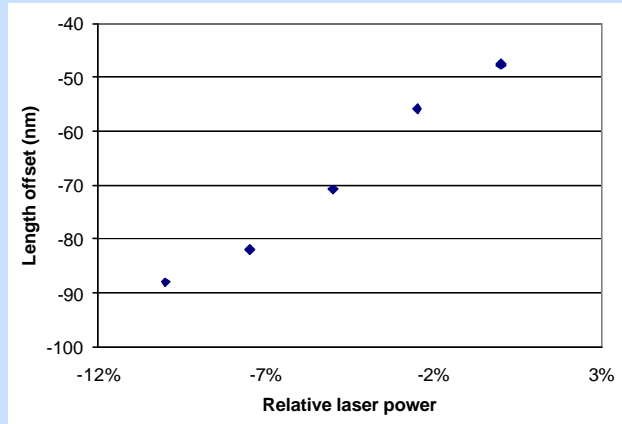
Length deviation vs T number (Power series stamper)



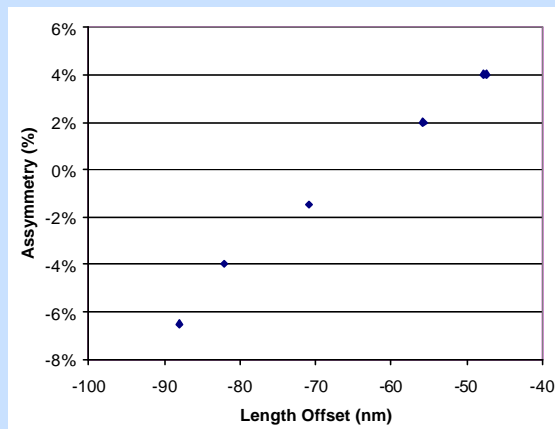
Write Strategy / Length Offset Length vs. T Number



Length offset vs relative laser power



Asymmetry vs Length Offset

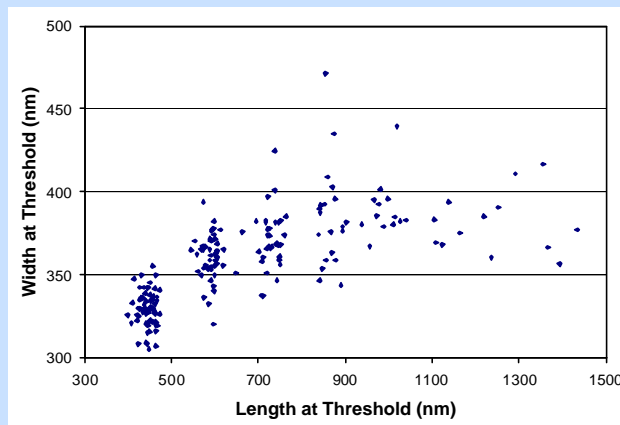


Comparison of DiscTrack Plus with Stamper Player

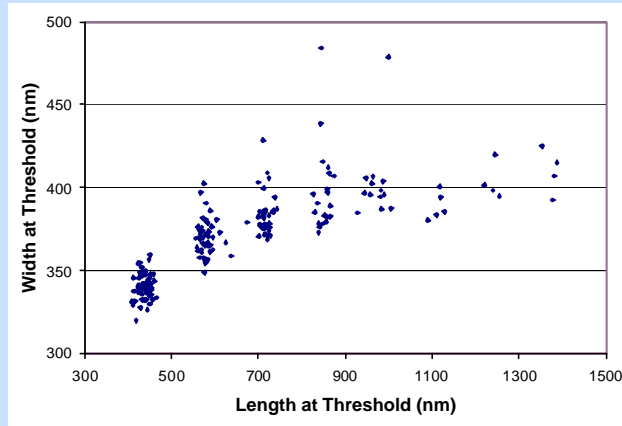
	Relative Laser Power	Effect (Bump)			Land		
AFM - DiscTrack Plus	Relative Laser Power	12.5%	0.0%	-10.0%	12.5%	0.0%	-10.0%
	Jitter (%)	3.20%	3.29%	3.34%	3.00%	3.35%	3.54%
	Channel Bit Length	132.94	133.05	132.63	132.66	133.26	135.05
	Offset	-7.09	-37.61	-74.91	1.90	34.20	65.32
	Mean Width at T3	322.27	299.13	259.80			
Stamper Player	Jitter (%)	10.10%	7.10%	15.20%			
	Asymmetry	17.90%	6.10%	-5.90%			



Automated measurement without calibration correction



Automated measurement with calibration correction



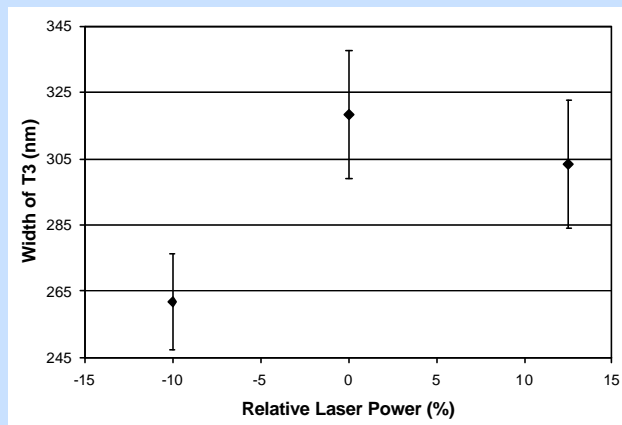
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Single measurements of T3 width (power series stamper)



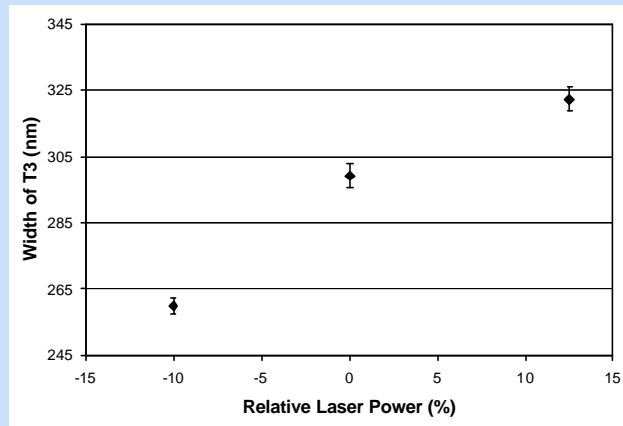
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Mean values of T3 width (Automated measurements)



Summary: AFM with DiscTrack Plus

- ◆ AFM: Direct Physical Measurements
- ◆ DTP: Calibration, Automation, Convenience, Reproducibility
- ◆ Statistical Data give fast, safe answers

Problems solved

- ◆ Pitch errors in LBR
- ◆ Bad optical alignment in LBR
- ◆ Molding variation ID vs OD (compare pit geometry)
- ◆ Get results earlier in the process – no need to make stamper or mold discs to look for defects in glass master.



Advanced Surface Microscopy

- ◆ DiscTrack Plus™ Measurement Systems
- ◆ Analytical and Measurement Services
- ◆ Used NanoScope AFMs
- ◆ Training and consulting
- ◆ www.asmicro.com
- ◆ See our Exhibit nearby!

