Measuring Size, Shape and Position of Pits and Grooves

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Outline

- Why make Physical Measurements of Pits and Grooves?
- Pit Geometry and Jitter (DVD-ROM)
- Groove Geometry (CD-R)
- Track centering in complex headers (M-O)
- Wobble groove amplitude (DVD+RW, CD-R)

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DVD = NanoTechnology

- Feature Size:
  400 nm L x 320 nm W x 120 nm H
- Track Pitch: 740 nm
  Mean +/- 10
  Range 710-770
- Jitter: 8% = 11 nm
- Nanometer Manufacturing needs Nanometer Inspection Tools

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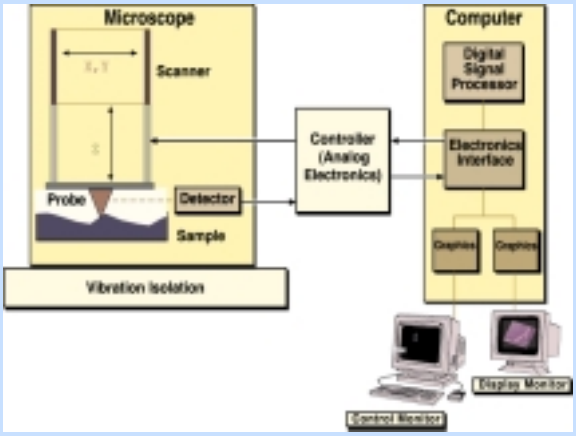
Scanning Probe Microscope



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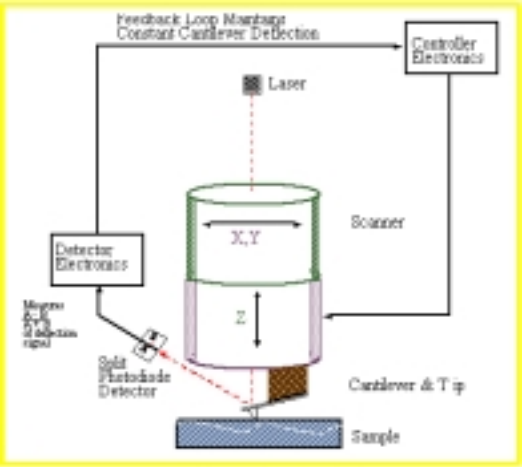
Atomic Force Microscope



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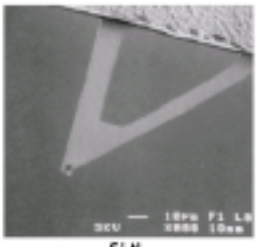
Probes



Si_3N_4

single-crystal Si

- Batch fabricated using lithography and etching techniques
- Pyramid tips are extremely sharp: end radii 5-40 nm
- Cantilevers 50-500µm long
- Cantilever spring constants ~0.1 - 50 N/m
- Resonant frequencies 10 kHz - 1 MHz

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DiscTrack Plus makes AFM more Powerful

- AFM = Atomic Force Microscope
- AFM gives 3-Dimensional Images of individual pits
- AFM is used at many Disc companies
- Root Cause Analysis
- Correlation of Dimensions

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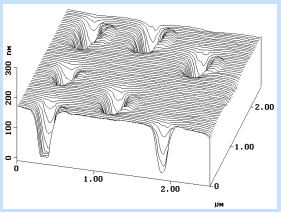
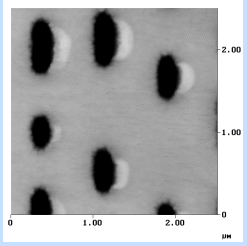
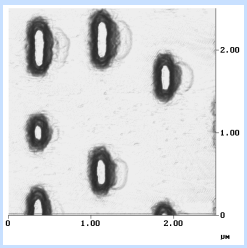
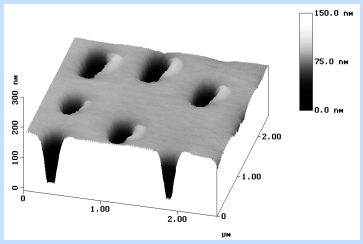
Plowing Marks ("clouds")









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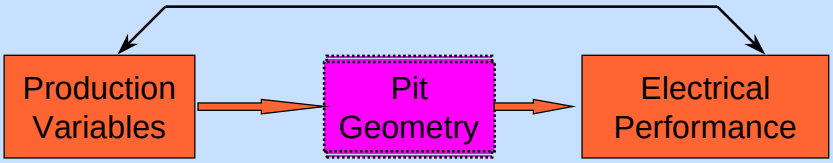
Process Optimization

- Indirect Control Using Disc Analyzer



Pit Geometry is a hidden variable

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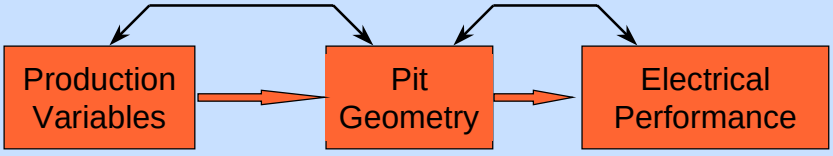
Process Optimization

- DiscTrack Plus provides missing link



Causes and Effects of Pit Geometry can now be Examined

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Data Analysis

- Old Method
  - Built-in Tools
- New Method
  - Add-on Tools: DiscTrack Plus™
  - Patented

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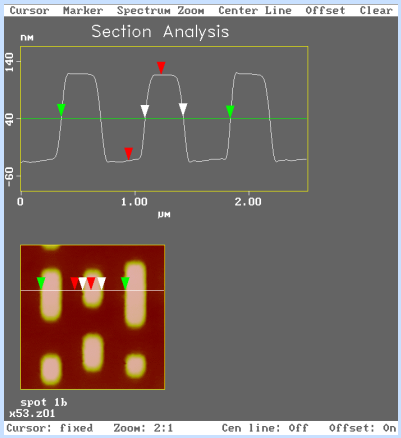
Old Method



- Height 149 nm
- Width 335 nm
- Pitch 1481/2 = 740 nm

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Method Characteristics: Old New

- Quick, easy for single measurements
- Imprecise (1 pixel)
- Inaccurate (up to 5% error)
- Slow, tedious for many measurements

- Find Features Automatically
- Sub-Pixel Precision
- Detect, correct measurement errors (to 0.3% accuracy)
- Measure 100s of Features Easily

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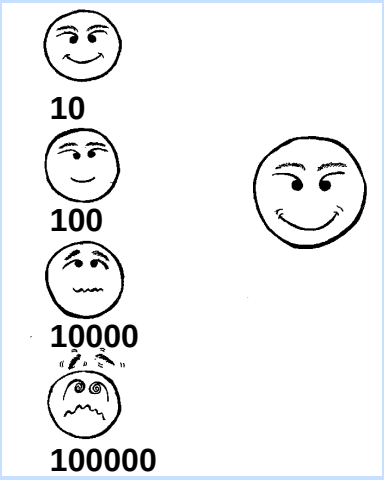
Mental State vs. Measurement Number

Manual Automatic



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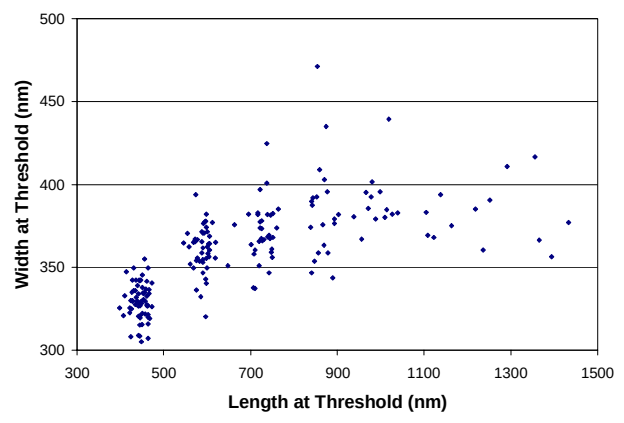
Automated measurement without calibration correction



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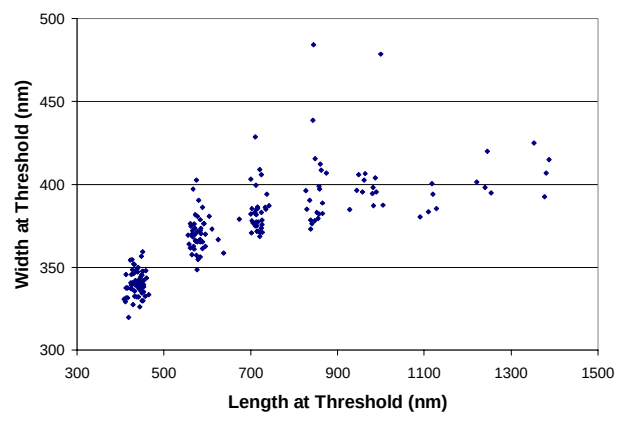
Automated measurement with calibration correction



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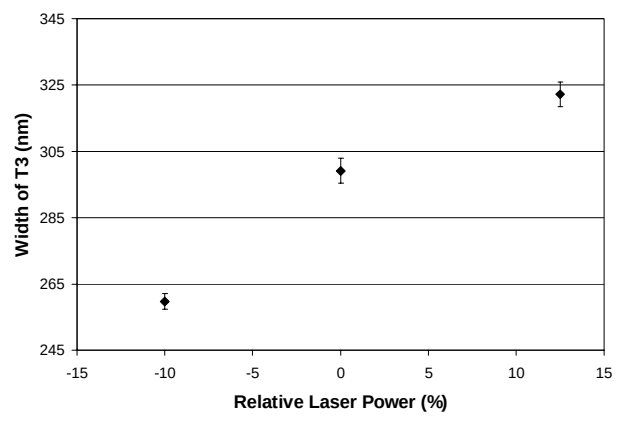
Mean values of T3 width (Automated measurements)



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Feature Geometry

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

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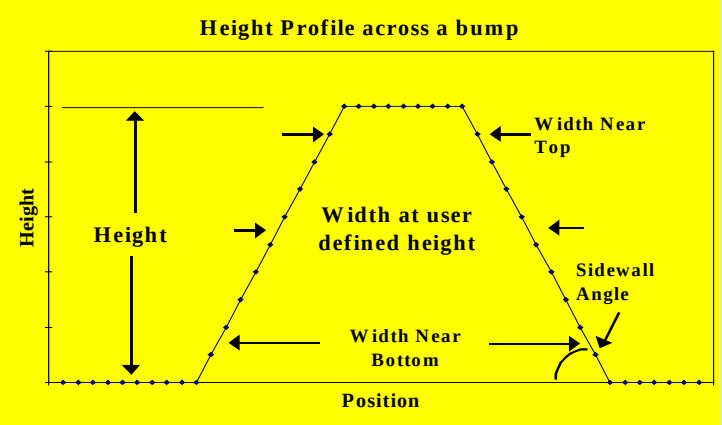
Feature Geometry



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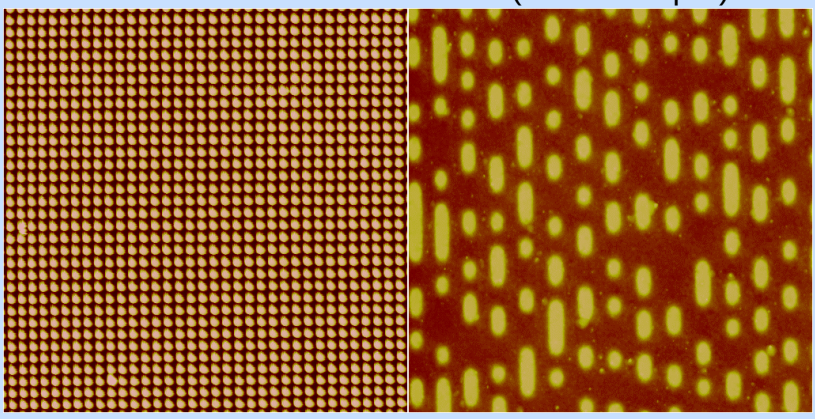
Data Capture: 10 um Scans for DVD

Calibrator Test (DVD Stamper)



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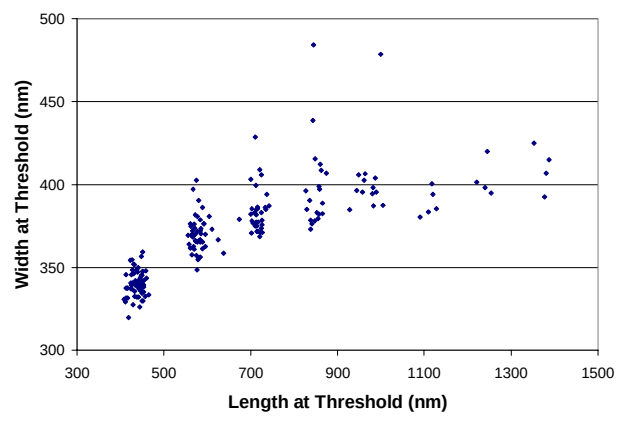
Pit Geometry of DVD



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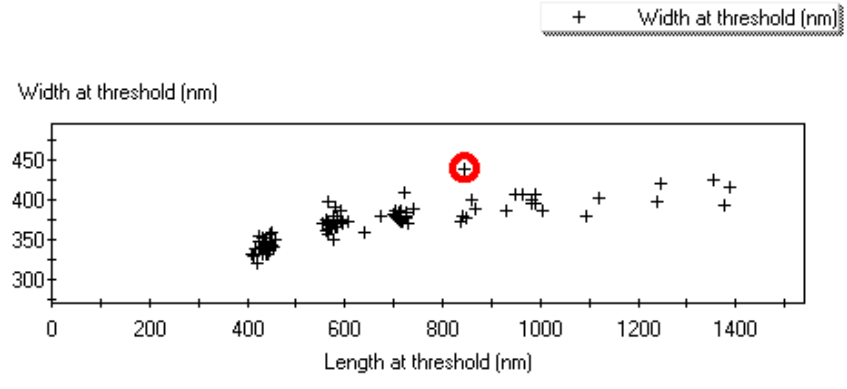
Feature Width: Defect Identification



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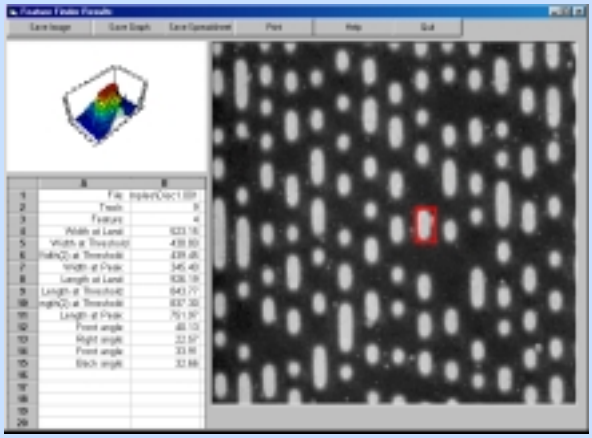
Feature detail



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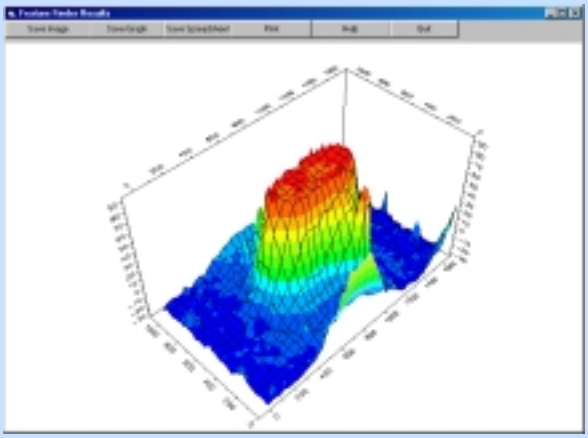
Expansion of Feature detail



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Length Analysis gives "AFM Jitter" and more

Length Analysis		
	Bumps	Lands
Jitter	6.82%	6.00%
Channel bit length (nm)	134.38	133.68
Offset (nm)	31.88	-36.76

Good Stampers have Jitter about 3 - 3.5%

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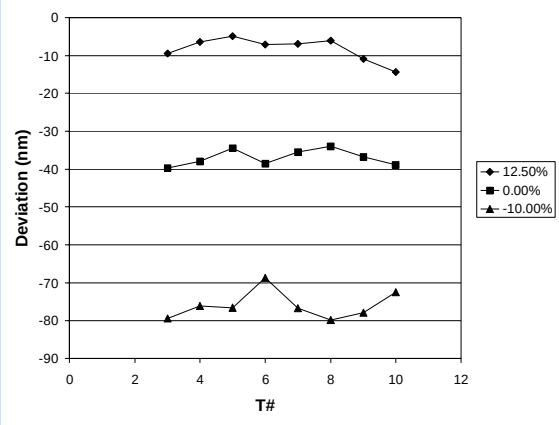
Length deviation vs T number (Power series stamper)



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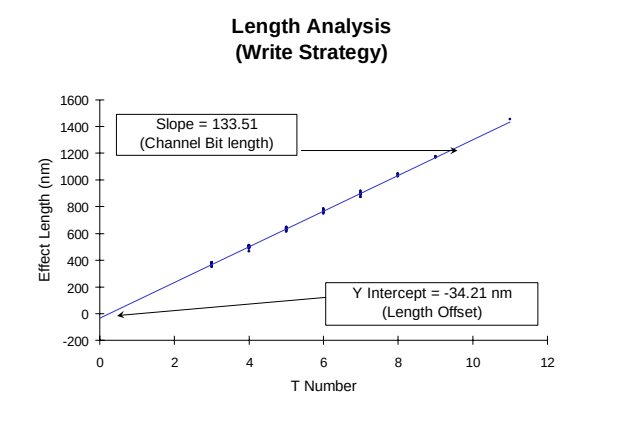
Write Strategy / Length Offset Length vs. T Number



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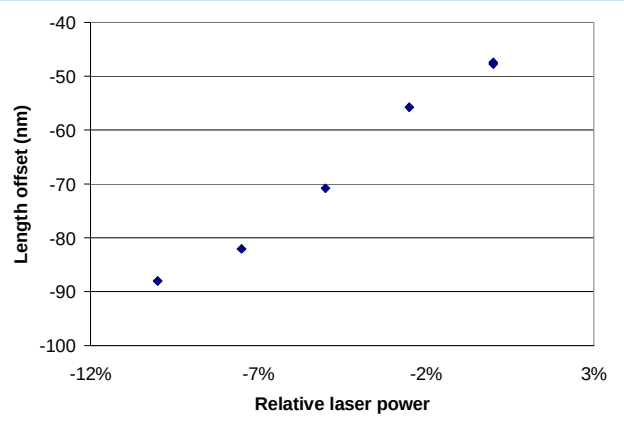
Length offset vs relative laser power



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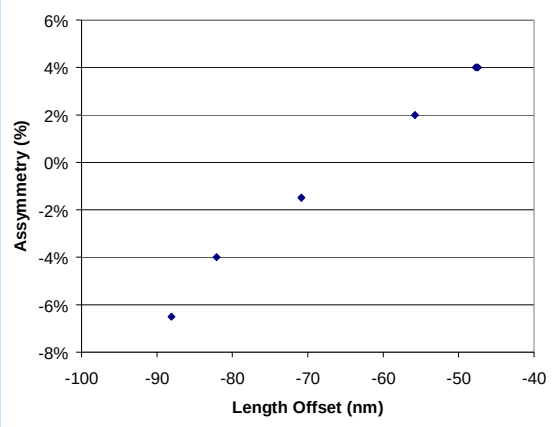
Asymmetry vs Length Offset



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Comparison of DiscTrack Plus with Stamper Player

		Effect (Bump)			Land		
	Relative Laser Power	12.5%	0.0%	-10.0%	12.5%	0.0%	-10.0%
AFM - DiscTrack Plus	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			
	Width Variation (Total SD within group)	9.61	7.29	7.30			
Stamper Player	Jitter (%)	10.10%	7.10%	15.20%			
	Asymmetry	17.90%	6.10%	-5.90%			

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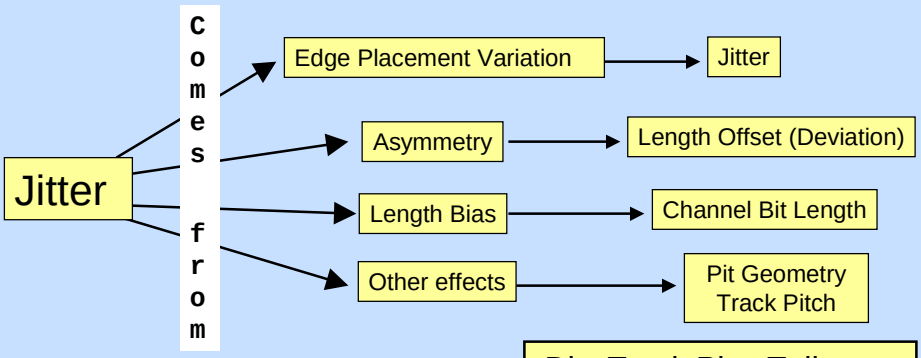
How do you fix a jitter problem?



Disc Analyzers give you a number

DiscTrack Plus Tells you what causes it

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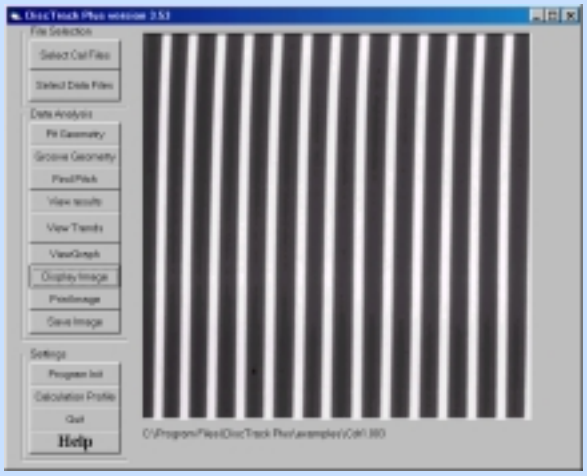
Image of CD-R Stamper



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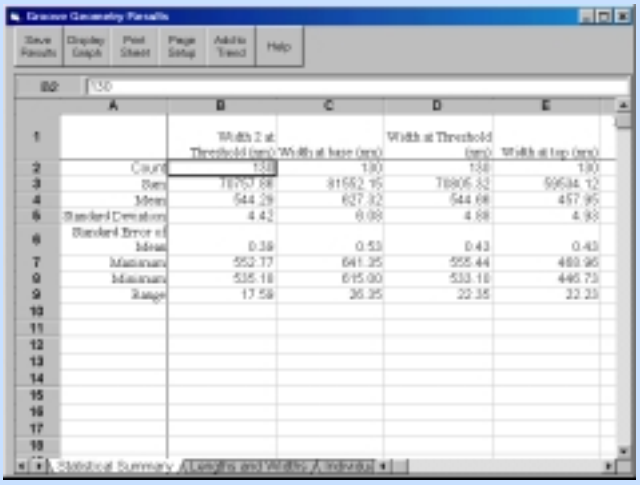
Summary of Measurements



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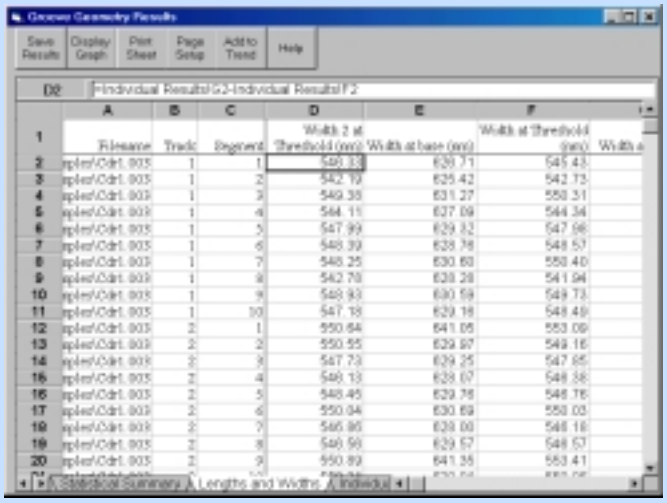
Individual Width Measurements



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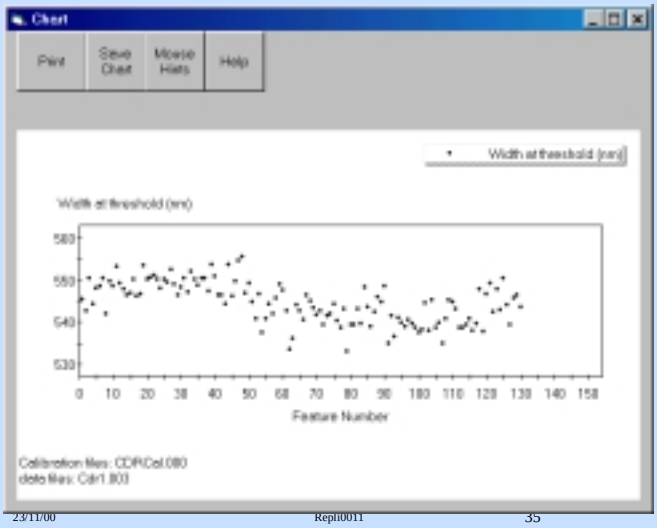
Width of stamper ridges



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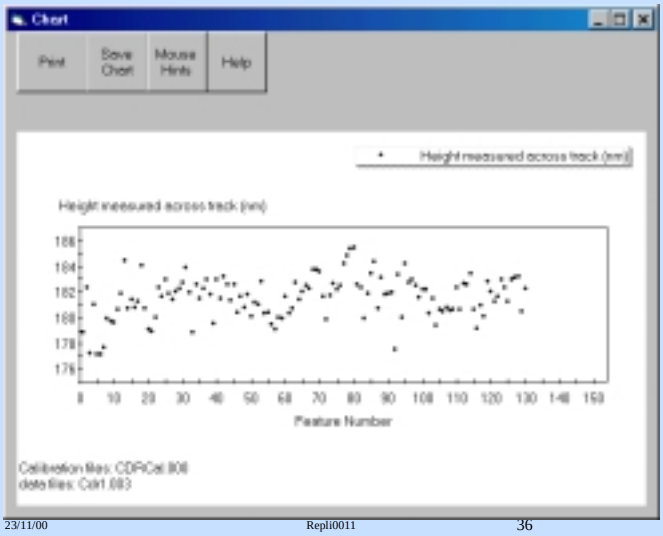
Height of Stamper Ridges



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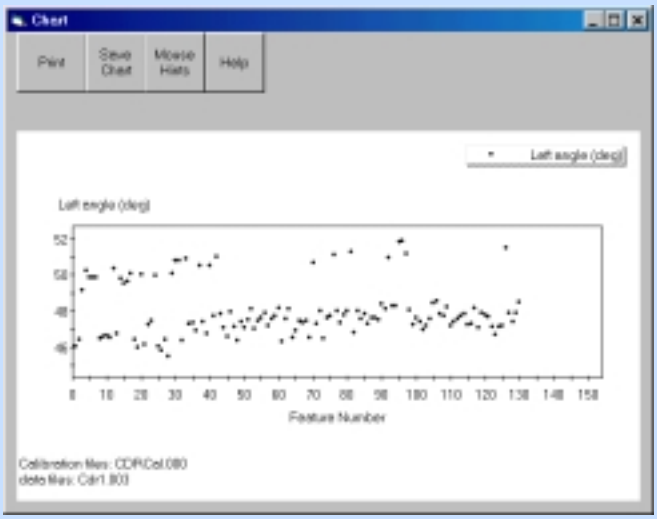
OD angle in stamper ridges



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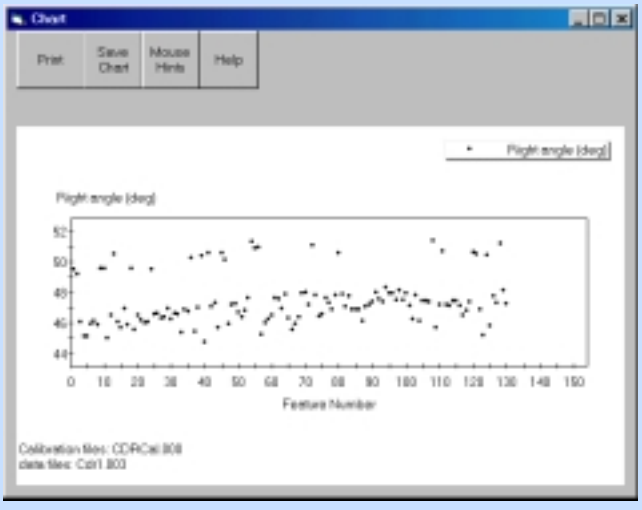
ID angle in stamper ridges



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Geometry of pre-formed groove in CD-R

Mean values	Brand A	Brand B
Groove Depth (nm)	135.61	172.18
Width at Half-Ht. (nm)	442.82	569.49
Left Side Angle (deg.) (Outer Diameter Direction)	26.37	26.91
Right Side Angle (deg) (Inner Diameter Direction)	21.85	24.5

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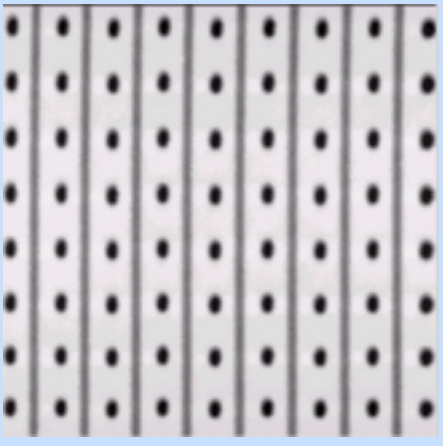
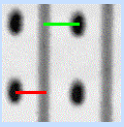
Complex Header Structure: Magneto Optical Disc

- Are the Pits Centered between the Grooves?





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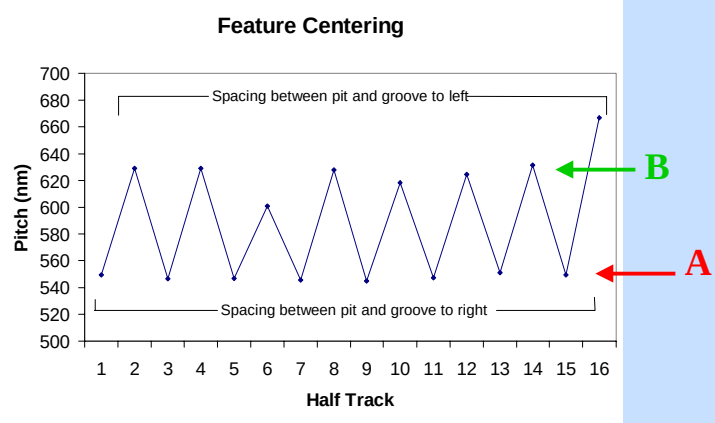
Track Pitch measurement of Magneto Optical disc



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Pitch results for Groups A and B (left and right half tracks)

- Groups A and B had different Pitch, so Pits not centered between grooves
- Group A pitch had 5x less variation than Group B pitch, so Group A corresponds to 2 beams locked together. Group B pitch variation reflects stage motion in LBR.

Half Tracks	Mean (nm)	StDev	Max	Min	Range
Left B	622.98	10.61	631.37	601.02	30.35
Right A	547.45	2.14	551.01	544.83	6.18

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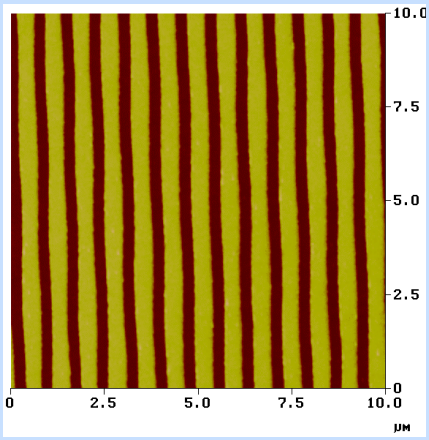
DVD+RW Groove Wobble



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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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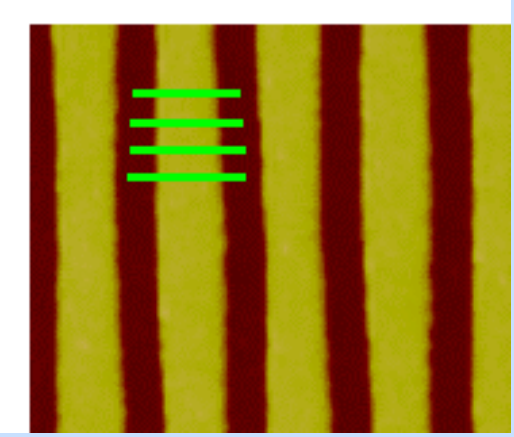
Pitch Measurements



Measure 50 pitch values along each pair of tracks.

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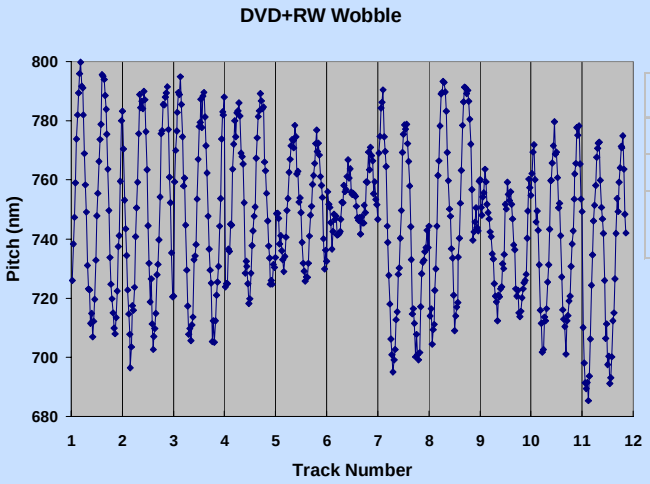
Wobble Measurements



Pitch (nm)	
Mean	746.35
Range	114.37
Wobble Amplitude	28.59

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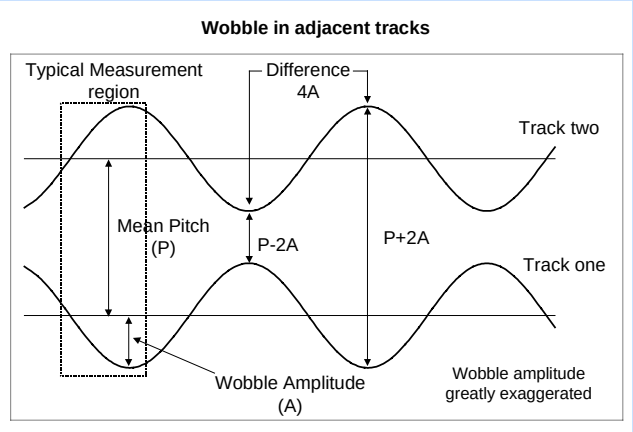
Compute Wobble from Track Pitch



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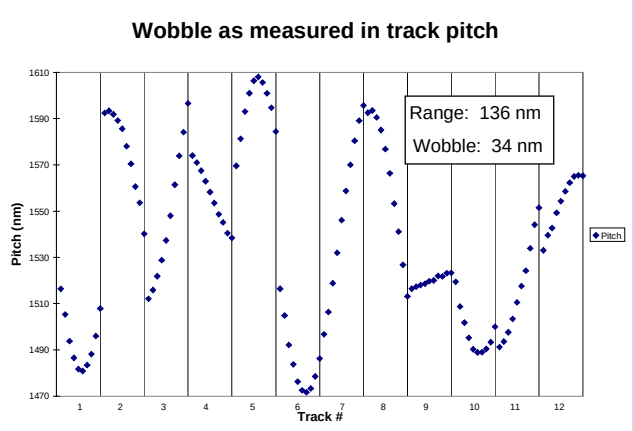
Wobble Measurement Sample Results



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Summary

- AFM plus Automatic Tools
- Improved Calibration & Precision
- High Count --> Statistical Analysis
  - Track Pitch
  - Pit Geometry
  - Width Variation
  - Defects
  - Wobble

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Advanced Surface Microscopy

- We don't make the AFM, we make the AFM better.
- DiscTrack Plus™ Media Measurement System
- www.asmicro.com
- donc@asmicro.com

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Where is ASM?

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What does ASM do?

- Analytical Service Lab specializing in SPM (Scanning Probe Microscopy)
- Precision measurement systems and other software enhancements for SPM's
- Buy and sell used NanoScopes
- Consulting and training in SPM

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