NANOVEA
A Better Measure

www.nanovea.com
info@nanovea.com
euro@nanovea.com
mexinfo@nanovea.com

3D SURFACE ANALYSIS

OF A

PENNY

Prepared by

Jonathan Thomas and Pierre Leroux

www.nanovea.com
info@nanovea.com
euro@nanovea.com
mexinfo@nanovea.com

Introduction

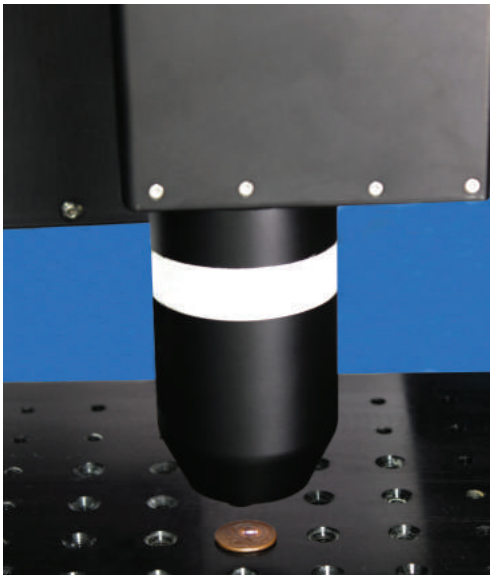
Currency is highly valued in modern society because it is traded for goods and services. Coin and paper bill currency circulates around the hands of many people. Constant transfer of physical currency creates surface deformation. Nanovea's 3D Profilometer scans the topography of coins minted in different years to investigate surface differences.

Importance of Non-contact Profilometry for Coins

Coin features are easily recognizable to the general public since they are common objects. A penny is ideal for introducing the strength of Nanovea's Advanced Surface Analysis Software: Mountains 3D. Surface data collected with our 3D Profilometer allows for high level analyses on complex geometry with surface subtraction and 2D contour extraction. Surface subtraction with a controlled mask, stamp, or mold compares the quality of manufacturing processes while contour extraction identifies tolerances with dimensional analysis. Nanovea's 3D Profilometer and Mountains 3D software investigates the submicron topography of seemingly simple objects, like pennies.

MEASUREMENT OBJECTIVE

The full upper surface of five pennies were scanned using Nanovea's High-Speed Line Sensor. The inner and outer radius of each penny was measured using Mountains Advanced Analysis Software. An extraction from each penny surface at an area of interest with direct surface subtraction quantified surface deformation.



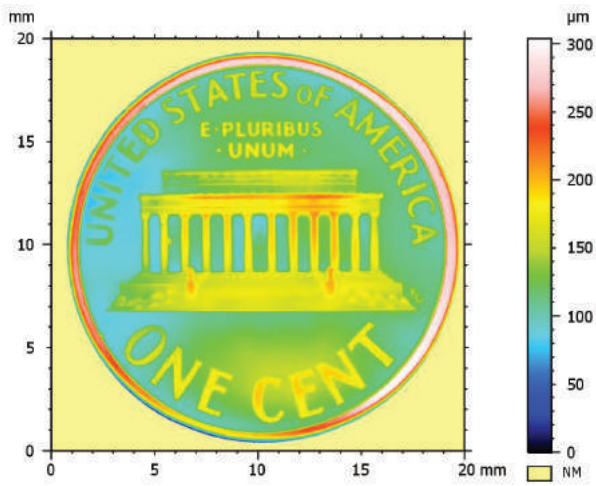
Measurement Setup	
Instrument	Nanovea HS200L
Optical Sensor	LS2 Lens (1mm Z-Range)
Scan Size (mm)	20mm x 20mm
Step Size (um)	10µm x 10µm
Scan Time (h:m:s)	00:00:24

A penny being anaylzed with the Nanovea 3D Profilometer.

RESULTS AND DISCUSSION

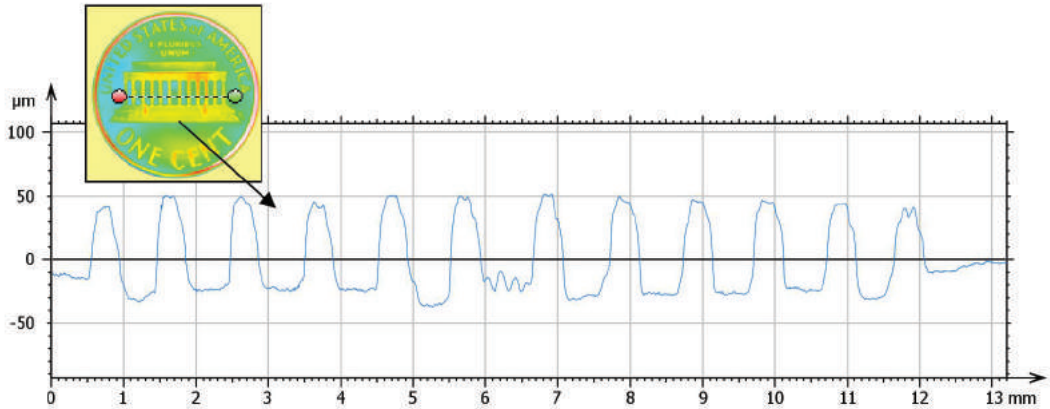
3D Surface

The Nanovea HS2000 profilometer took only 24 seconds to scan 4 million points in a 20mm x 20mm area with a 10um x 10um step size to acquire the surface of a penny. Below is a height map and 3D visualization of the scan. The 3D view shows the High-Speed sensor's ability to pick up small details unperceivable to the eye. Many small scratches are visible across the surface of the penny. Texture and roughness of the coin seen in the 3D view are investigated.



ISO 25178		
Height Parameters		
Sq	44.600	µm
Ssk	1.3685	µm
Sku	4.9175	µm
Sp	161.21	µm
Sv	142.63	µm
Sz	303.84	µm
Sa	33.492	µm

Figure 1: False Color View and Height Parameters for the 1995 Penny.



ISO 4287			
Amplitude parameters - Roughness profile			
Ra	12.47	µm	Gaussian filter,0.8mm
Rq	13.85	µm	Gaussian filter,0.8mm
Rz	44.37	µm	Gaussian filter,0.8mm
Rp	22.47	µm	Gaussian filter,0.8mm
Rv	21.90	µm	Gaussian filter,0.8mm
Rt	54.33	µm	Gaussian filter,0.8mm
Rc	41.64	µm	Gaussian filter,0.8mm, ISO 4287 w/o ammendment 2

Figure 2: 2D Profile Extraction and Height Parameters for the 1995 Penny.

Figure 3: 3D view for 1995 Penny; Amplified 10%.

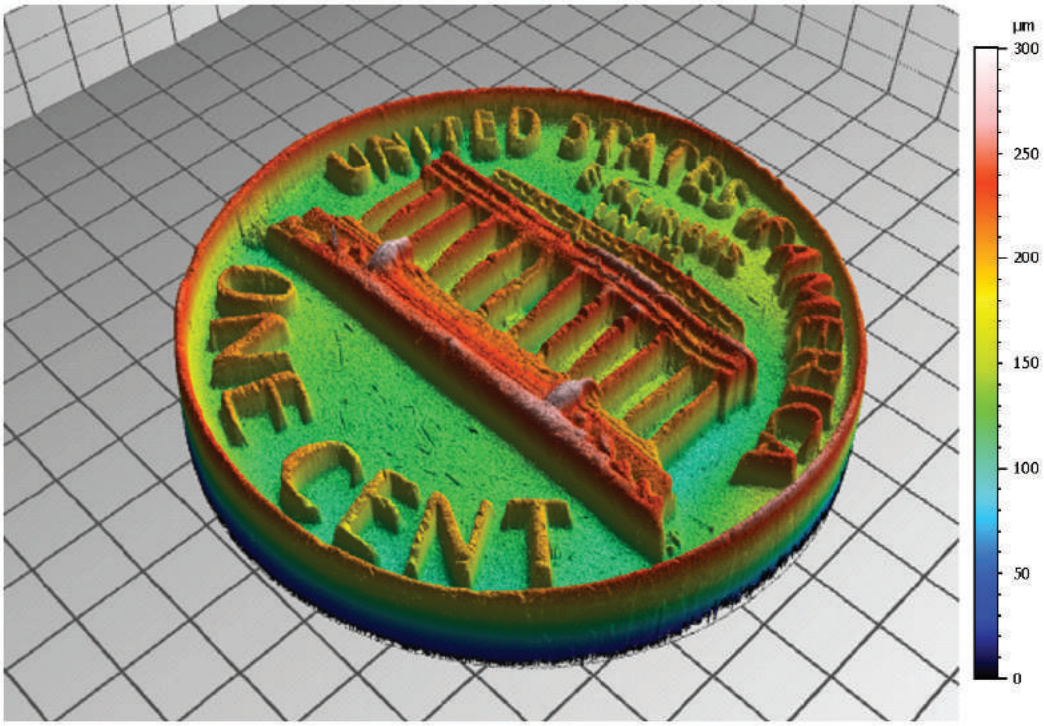


Figure 3: 3D view for 1969 Penny; amplified 10%, Isometric View.

Dimensional Analysis:

The contours of the penny were extracted and dimensional analysis obtained inner and outer diameters of the edge feature. The outer radius averaged 9.500 mm ± 0.024 while the inner radius averaged 8.960 mm ± 0.032. Additional dimensional analyses Mountains 3D can do on 2D and 3D data sources are distance measurements, step height, planarity, and angle calculations.

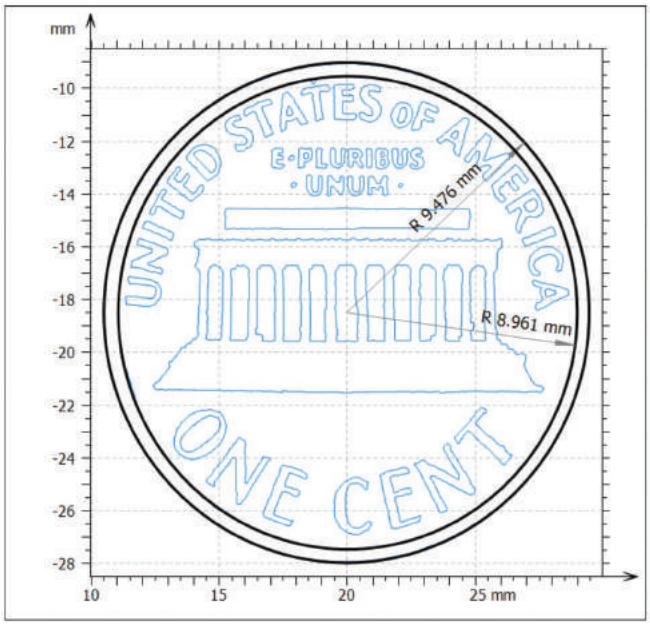


Figure 4: Contour analysis for 1969 Penny.

Year	Outer Radius (mm)	Inner Radius (mm)
1969	9.476	8.961
1977	9.484	8.948
1985	9.488	8.966
1995	9.540	8.913
2007	9.514	9.011
Average	9.500	8.960
Standard Deviation	0.024	0.032

Surface Subtraction:

Figure 5 shows the area of interest for the surface subtraction analysis. The 2007 penny was used as the reference surface for the four older pennies. Surface subtraction from the 2007 penny surface shows differences between pennies with holes/peaks. Total surface volume difference is obtained from adding volumes of the holes/peaks. The RMS error refers to how closely penny surfaces agree with each other.

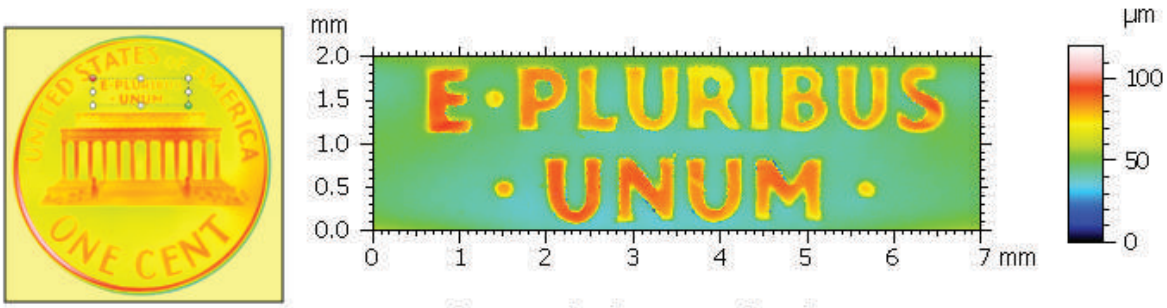
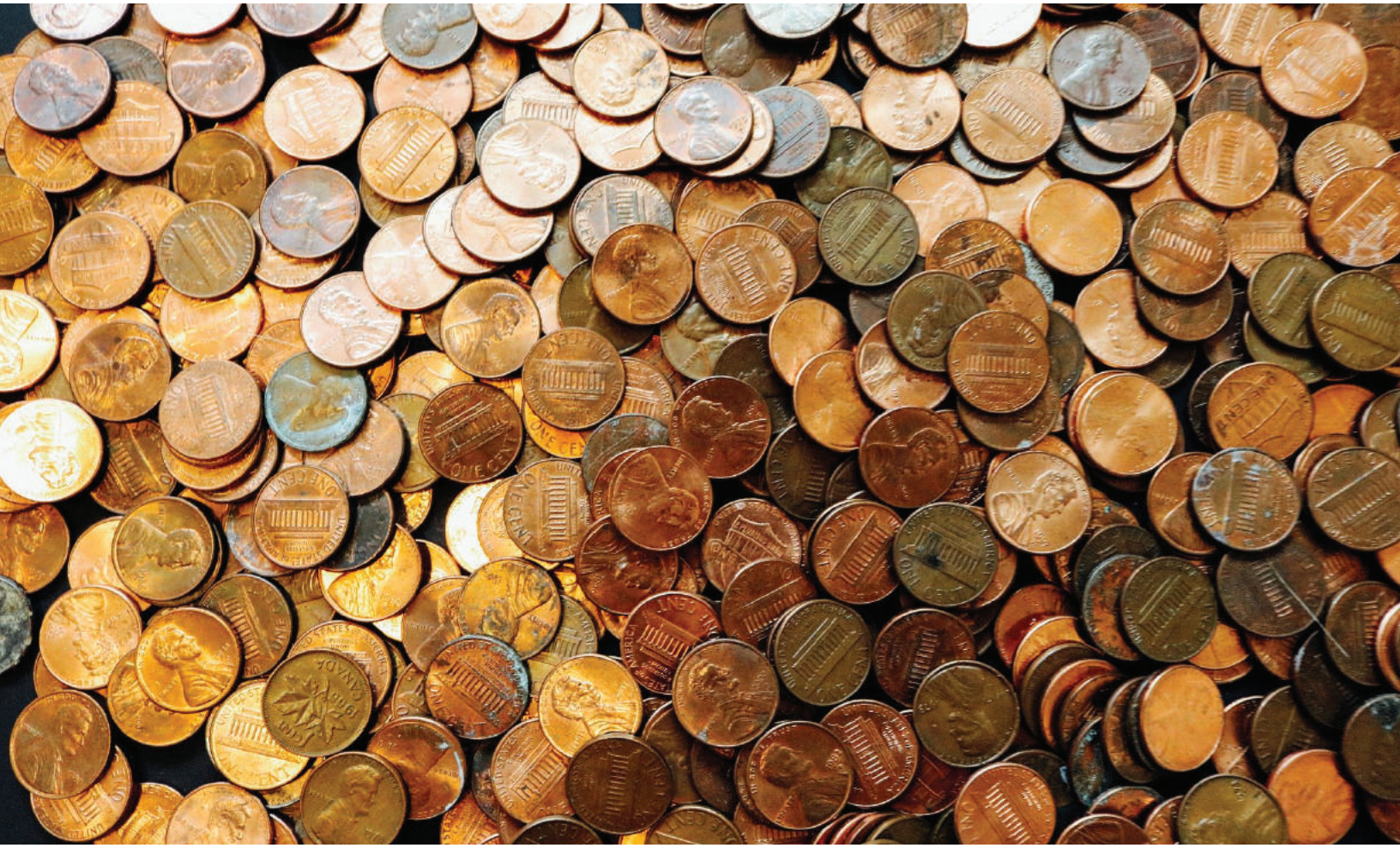


Figure 5: Extracted area and reference surface for 2007 penny

Penny Year	Volume of a "Hole/Peak" Analysis	Surface Volume Difference (um³)	RMS Value
1969		25862453	5.405
1977		39173134	8.182
1985		47427247	7.598
1995		18194986	4.756

www.nanovea.com
info@nanovea.com
euro@nanovea.com
mexinfo@nanovea.com



Conclusion

Nanovea's High-Speed HS2000L scanned five pennies minted in different years. Mountains 3D software compared surfaces of each coin using contour extraction, dimensional analysis, and surface subtraction. The analysis clearly defines the inner and outer radius between the pennies while directly comparing surface feature differences. With Nanovea's 3D profilometer's ability to measure any surfaces with nanometer-level resolution, combined with Mountains 3D analysis capabilities, the possible Research and Quality Control applications are endless.

This Report has been created using one of

NANOVEA

OPTICAL PROFILERS

Designed with Chromatic Light technology, which measures physical wavelength, the instruments provide the highest accuracy on any roughness, any form, any material. Transparent or opaque.

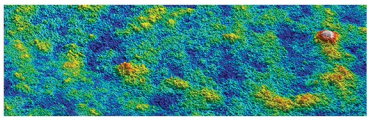
For pricing information, please contact ***sales@nanovea.com***

HS2000

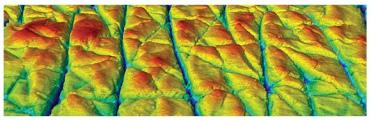
CHROMATIC LIGHT

Analyze Any Surface
No Image Stitching
No Refocusing
High Speed

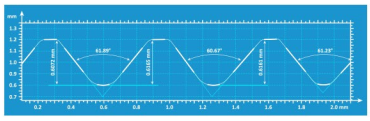
2D & 3D SURFACE MEASUREMENT



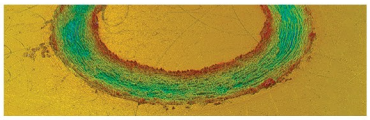
ROUGHNESS & FINISH



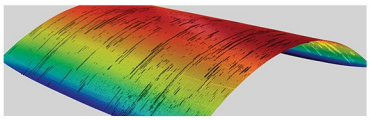
TEXTURE



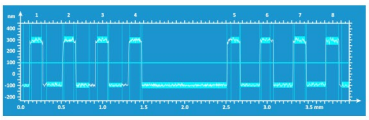
GEOMETRY & SHAPE



VOLUME & AREA



FLATNESS & WARPAGE



STEP HEIGHT & THICKNESS

PORTABLE ◆ COMPACT ◆ ZERO NOISE ◆ HIGH SPEED ◆ LARGE AREA