

AVALIAÇÃO 3D SEM CONTATO DE SUPERFÍCIES EM PENETRADORES DE DUREZA

Medição ótica da topografia da superfície do penetrador de diamante

Medição Dimensional

Dimensional Surface measuring technology

Optical Systems

Tactile Systems

AFM*

SEM*

Confocal

Interferometry

Focus
Variation

Vision
Systems

3D

2D

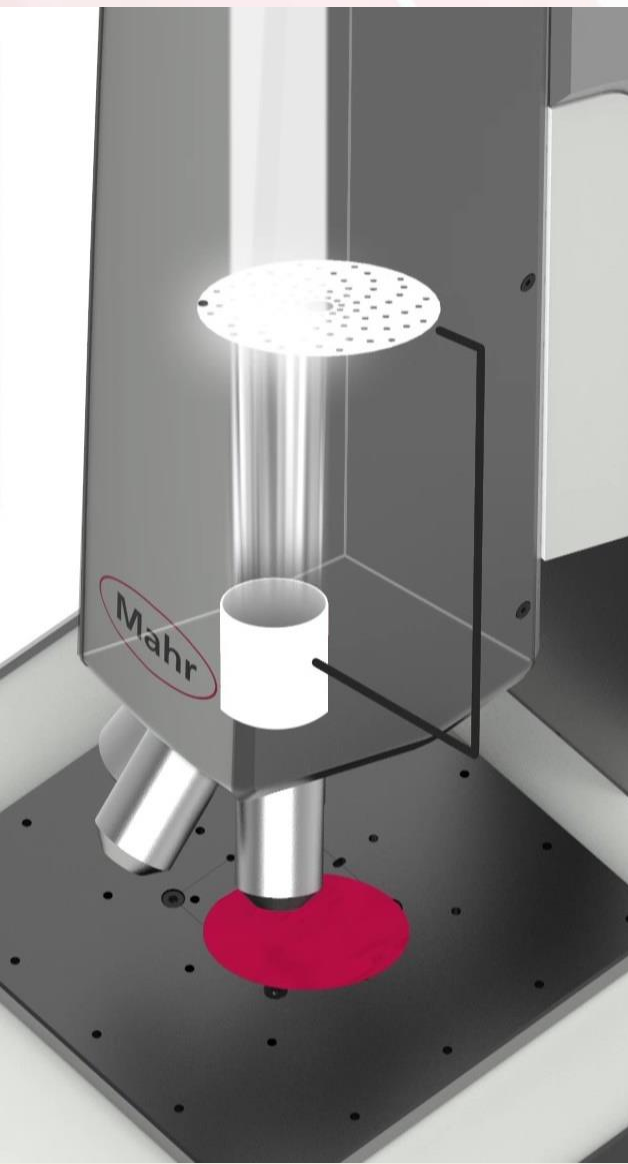
AFM = Atomic Force Microscope
SEM = Scanning Electron Microscope



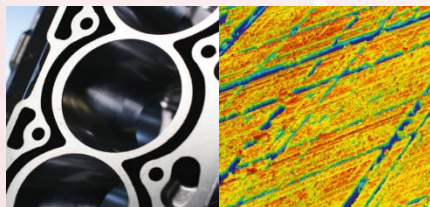
MarSurf CM

- Ensaio não destrutivo e independente de material
- Nenhuma preparação de amostra necessária
- A mais alta qualidade de dados com todas as ampliações
- Maior velocidade de medição
- Grande portfólio de produtos (padrão, soluções portáteis, soluções automatizadas)
- A mais alta transparência (Fair Data Sheet, especificação única)
- Know-how, serviços de consultoria
- Fornecedor de tecnologia de medição tátil e óptica

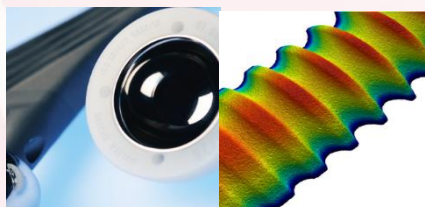
Mais informações sobre a Fair Data Sheet podem ser encontradas no site da Initiative [Fair Data Sheet](#).



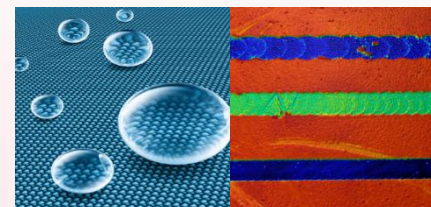
Aplicações – Segmentos Industriais



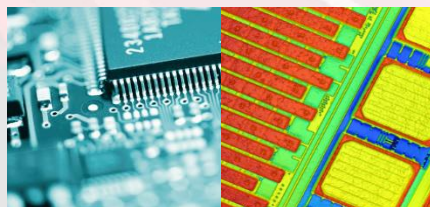
Automotive



Medical



Material Science



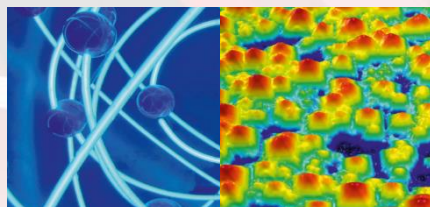
Semiconductor



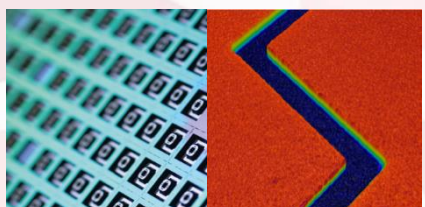
Security & Printing



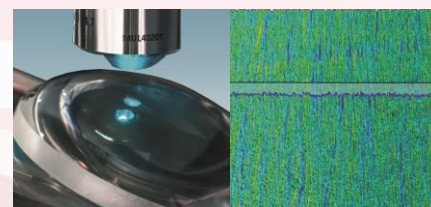
Tools



Energy



Microsystems

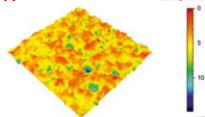


Optical

Aplicações – Tarefas de Medição

2D-/3D Roughness according DIN EN ISO

| | Context | Mean | Std dev |
|---|---------------------------------------|-------|---------|
| ISO 4287 | | | |
| Amplitude parameters - Roughness profile | | | |
| Ra | μm Gaussian filter: 0.8 mm | 1.594 | 0.002 |
| Rq | μm Gaussian filter: 0.8 mm | 1.928 | 0.003 |
| Rz | μm Gaussian filter: 0.8 mm | 7.844 | 0.032 |
| Rt | μm Gaussian filter: 0.8 mm | 9.454 | 0.213 |



Structured sheet metal

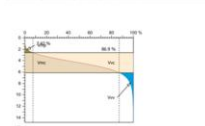


Roughness standard



| ISO 25178 | | |
|-------------------|------|---------------------------------------|
| Height Parameters | | |
| Sa | 1.17 | μm Arithmetic mean height |
| Sq | 1.56 | μm Root mean square height |
| Sp | 4.53 | μm Maximum peak height |
| Sv | 10.3 | μm Maximum pit height |
| Sz | 14.8 | μm Maximum height |

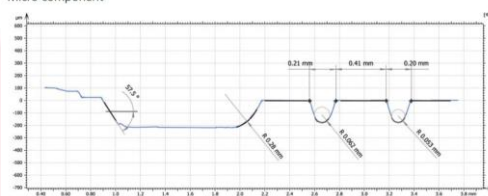
| Feature Parameters | | | |
|--------------------|------|---------------|------------------|
| S10z | 10.2 | μm | Pin point height |



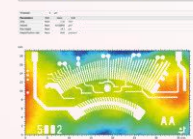
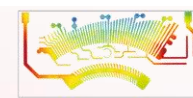
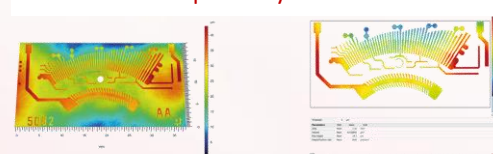
Form, Contur



Micro component

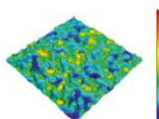


Flatness and coplanarity

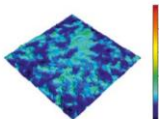
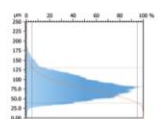
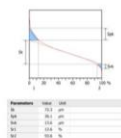


| ISO 13785 | |
|---------------------|----------|
| Hardware Parameters | |
| Height | 42.9 mm |
| Width | 24.8 mm |
| Depth | 20 mm |
| Weight | 6.07 gms |

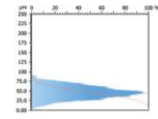
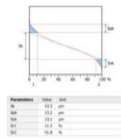
Tribology, bearing and functional surfaces



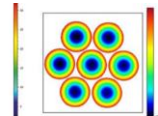
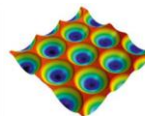
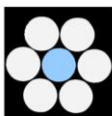
Sanding belt new



Sanding belt used



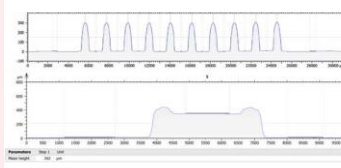
Volume



Micro cells

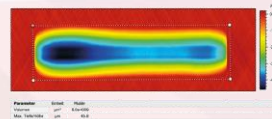
| | | |
|------------|-------|-----------------|
| Parameters | Value | Unit |
| Grain # | 4 | |
| Area | 0.046 | mm ² |

Layer thickness

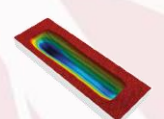


Paste on ceramic substrate

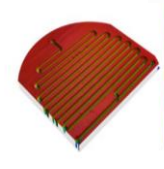
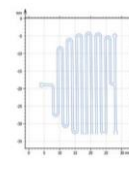
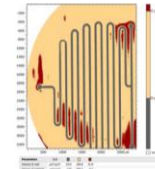
Wear



Wear at metal sheet



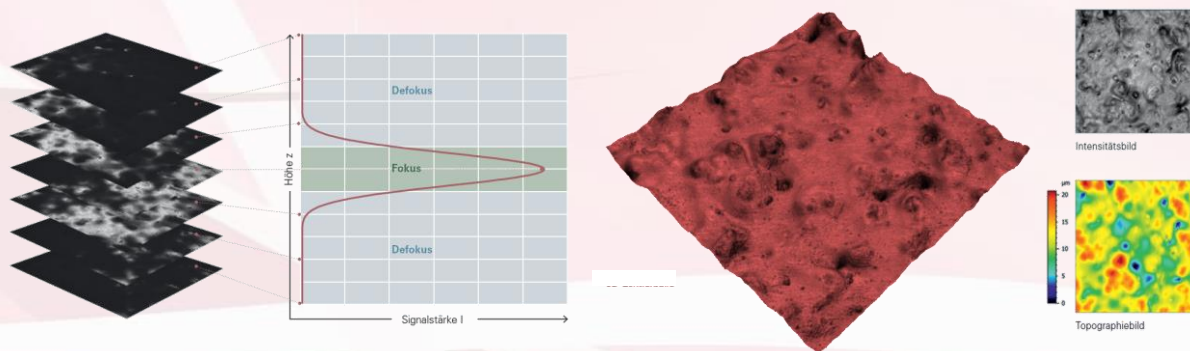
Form



Channels in a microfluidic chip

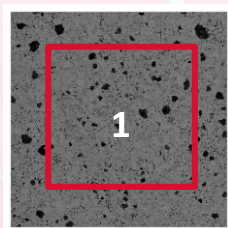
Princípio de funcionamento “3D”

- Semelhante à tomografia computadorizada, a superfície é capturada opticamente camada por camada.
- O computador mescla as imagens da camada individual em uma imagem de altura 3D da amostra com precisão **nanométrica**.

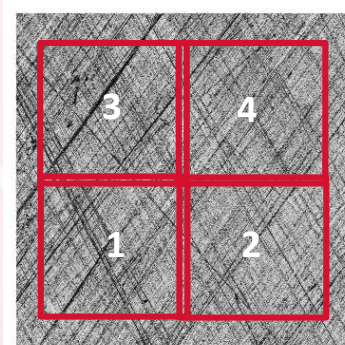


...para mais detalhes

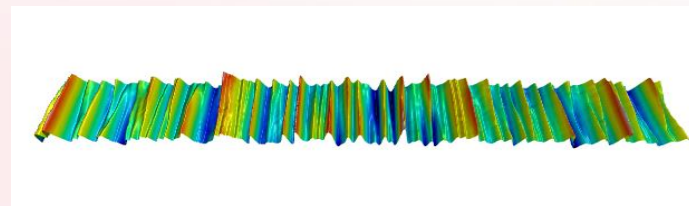
Data acquisition – Stitching function



Single Image
2-5 seconds



2 x 2 Stitching
~25 seconds



7 x 1 Stitching
~40 seconds



Initiative **Fair Data Sheet**

Objectives

| | | 3200S | 1600S | 800L | 800S | 800XS | 320L | 320S | 320XS ¹ | 160L | 160S | 160XS ¹ |
|---|--|-------|-------|------|------|-------|--------|--------|--------------------|--------|--------|--------------------|
| Objective magnification | | 5x | 10x | 20x | 20x | 20x | 50x | 50x | 50x | 100x | 100x | 100x |
| Measuring area x,y (µm) | | 3200 | 1600 | 800 | 800 | 800 | 320 | 320 | 320 | 160 | 160 | 160 |
| Measuring area x × y (mm ²) | | 10.24 | 2.56 | 0.64 | 0.64 | 0.64 | 0.1024 | 0.1024 | 0.1024 | 0.0256 | 0.0256 | 0.0256 |
| Extended measuring area | | 3200 | 1600 | 800 | 800 | 800 | 320 | 320 | 320 | 160 | 160 | 160 |

Métodos de Medição de Dureza

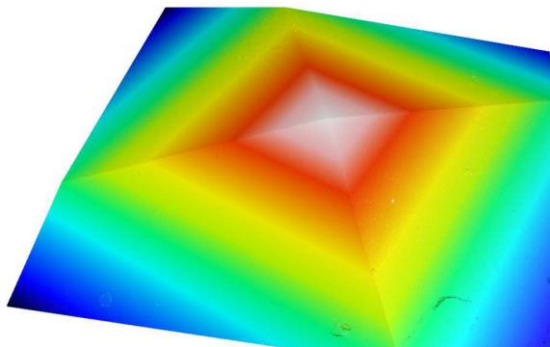
Existem três métodos mundialmente usados de medição de dureza:

Vickers → usa um penetrador em formato de pirâmide.

Rockwell → usa um penetrador de diamante cônico ou uma esfera de aço

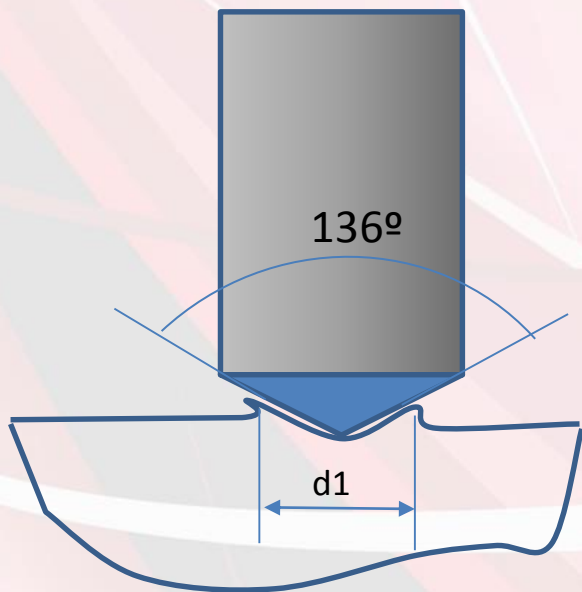
Brinell → usa um penetrador esférico

O valor da dureza é calculada pelo tamanho da indentação produzida pela carga. Quanto menor a marca deixada, mais duro o metal.



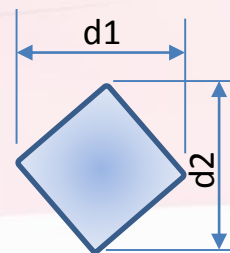
Detalhes do ensaio Vickers

Indentação Vickers



Medição da impressão das diagonais

$$\frac{d = d1 + d2}{2}$$

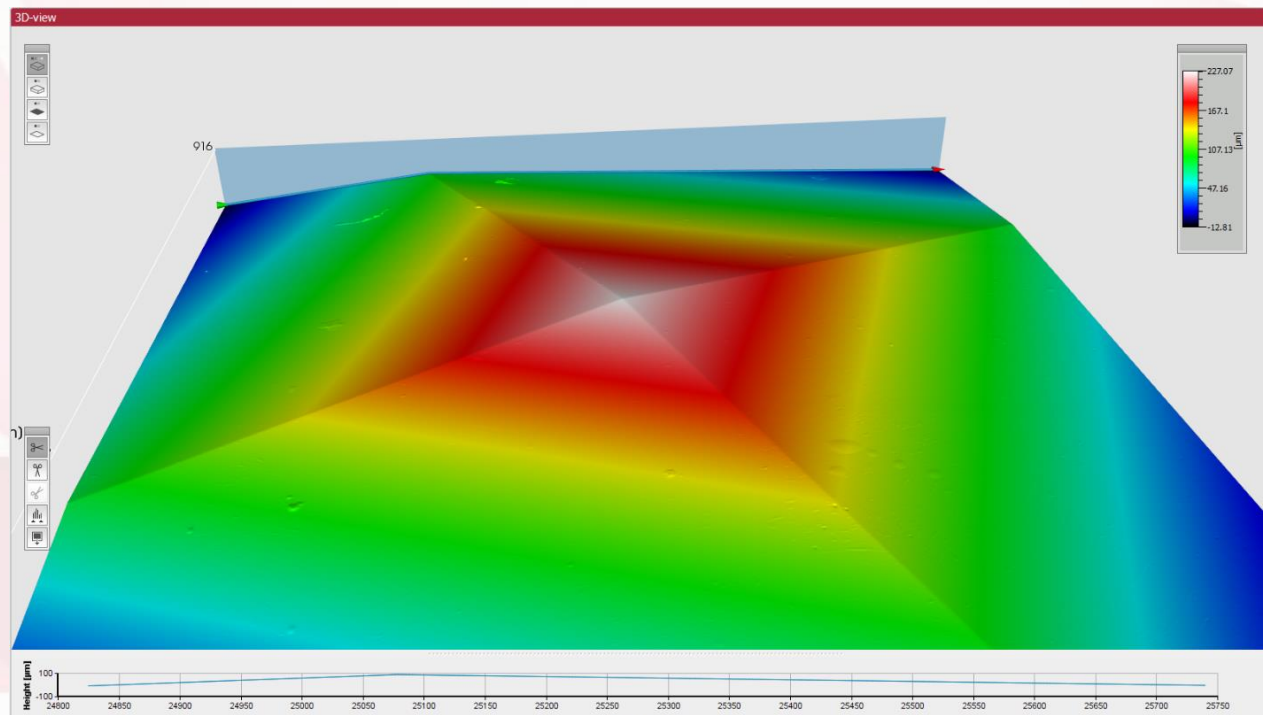
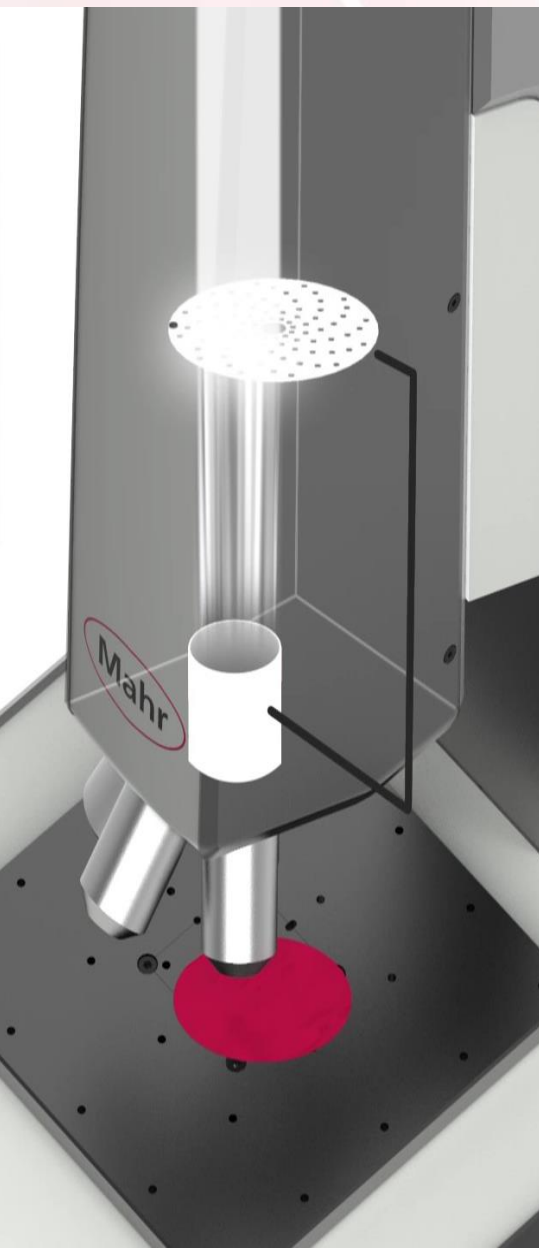


A dureza Vickers se baseia na resistência que o material oferece à penetração de uma pirâmide de diamante de base quadrada e ângulo entre faces de 136°, submetida a determinada carga. O valor de dureza Vickers (HV) é o quociente da carga aplicada pela área de impressão deixada no corpo ensaiado.

Detalhes do ensaio Vickers

Faixas típicas da superfície de contato de um indentador Vickers sob várias forças de teste

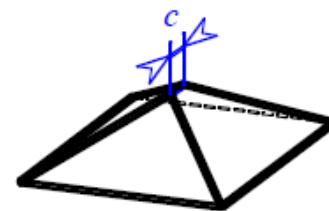
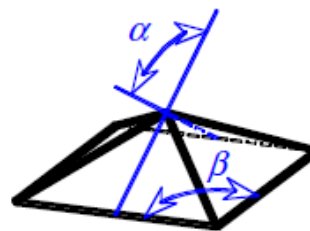
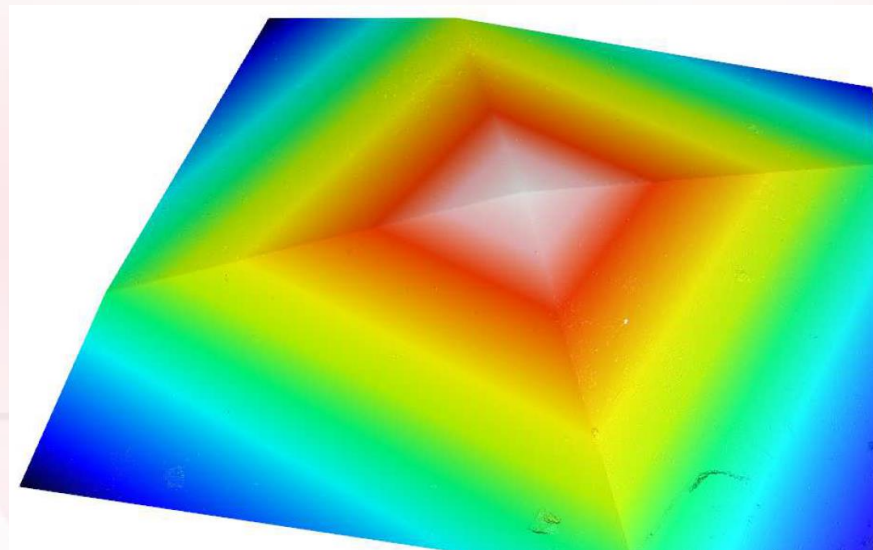
| Tipo de teste | Força* de teste | Profundidade da Indentação** | Largura da Diagonal** (um) |
|---|---------------------------------|------------------------------|----------------------------|
| Dureza | 49.03 - 980.7 | 14.50 - 137.5 | 101.5 - 962.8 |
| Dureza com baixa força | 1.961 - 29.42 | 2.900 - 23.82 | 20.30 - 166.8 |
| Microdureza | 0.9807-0.0987 | 2.857*** - 4.350 | 20.00*** - 30.45 |
| Nano-indentação | Não especificado na ISO 14577-1 | | |
| *Recomendação na norma ISO 6507-1 | | | |
| ** Dureza adotada como 200 a 900 HV | | | |
| ** Limite inferior da largura da diagonal na ISO 6507-1 | | | |



Geometria do Penetrador Vickers

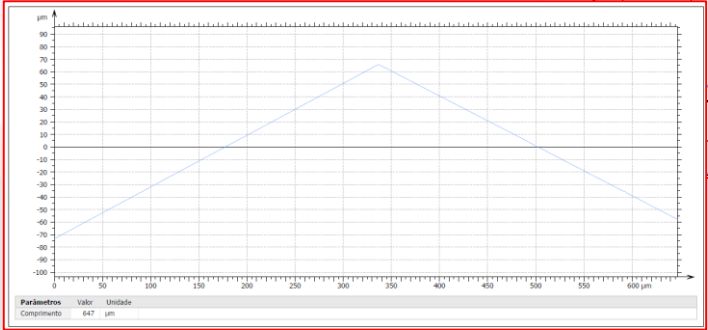
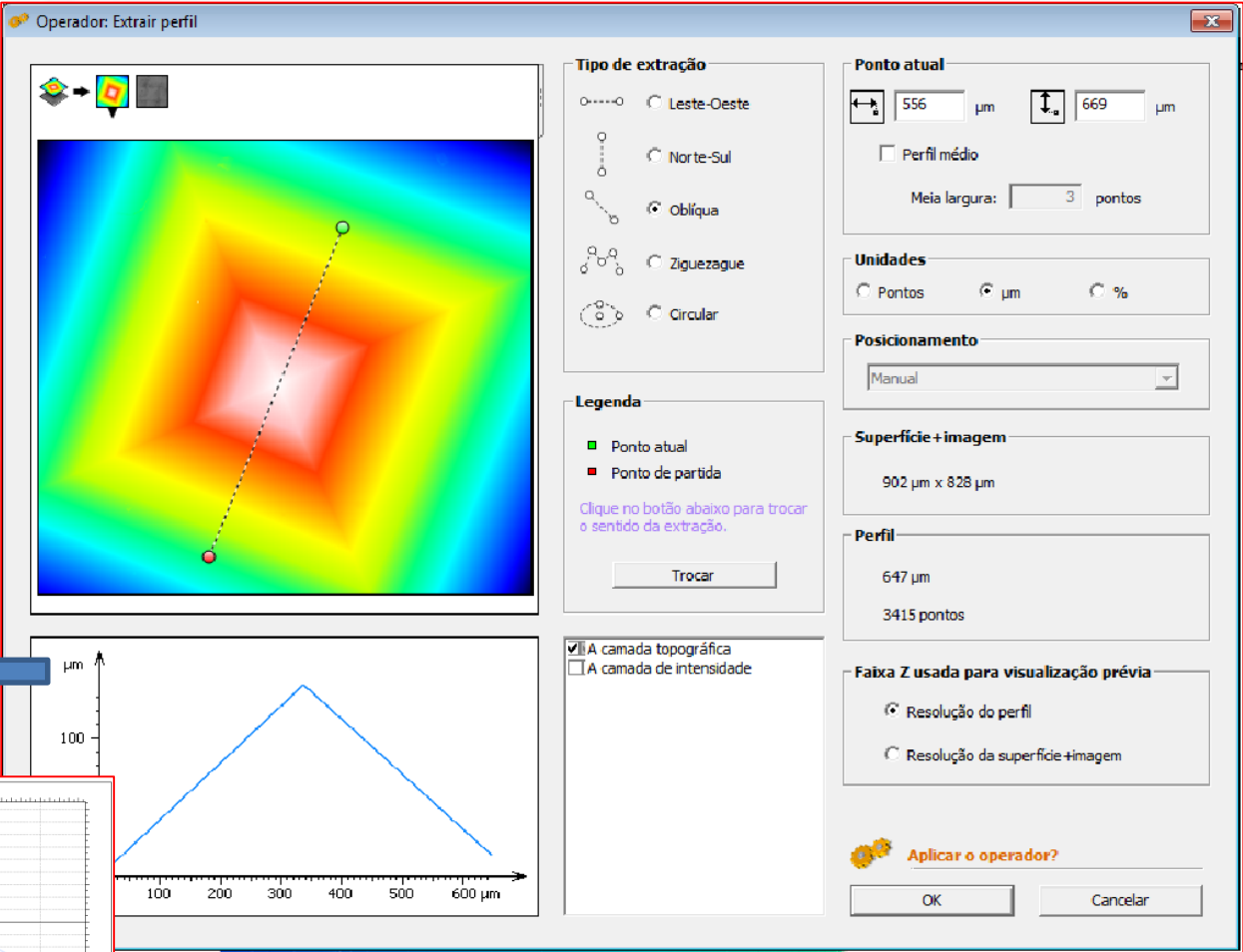
A geometria da pirâmide Vickers é definida com o ângulo entre as faces opostas de 136 graus. Para garantir a precisão de sua geometria, a ISO 6507-3 exige a verificação dos itens a seguir:

- a) O ângulo entre as faces opostas (α) deve ser $136 \pm 0,1^\circ$,
- b) A linha de junção entre as faces opostas deve ser menor que 0,001 mm, 0,0005 mm e 0,00025 mm para a faixa de força de teste de $F \geq 49,03$ N, $1,961$ N $\leq F < 49,03$ N e $0,09807$ N $\leq F < 1,961$ N respectivamente.
- c) O ângulo do canto da base quadrada da pirâmide (β) deve ser $90 \pm 0,2^\circ$.



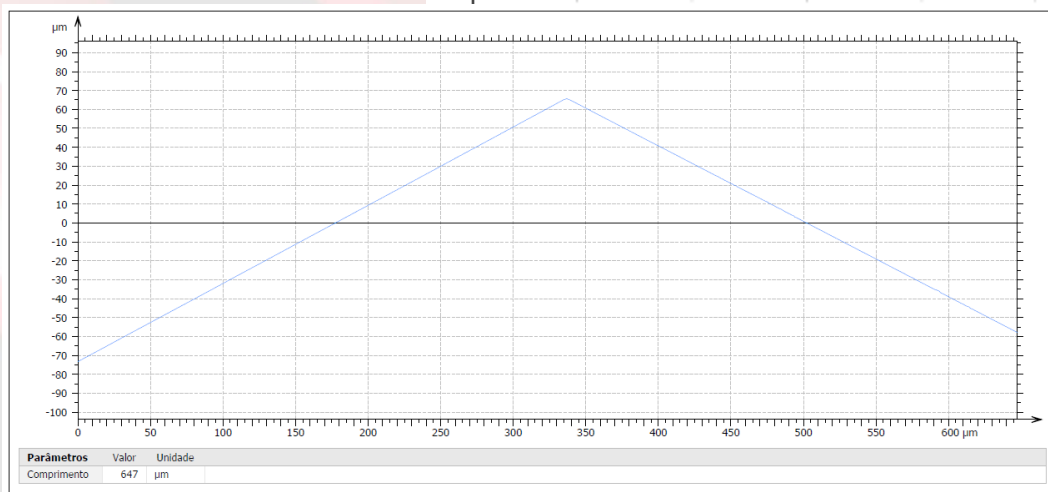
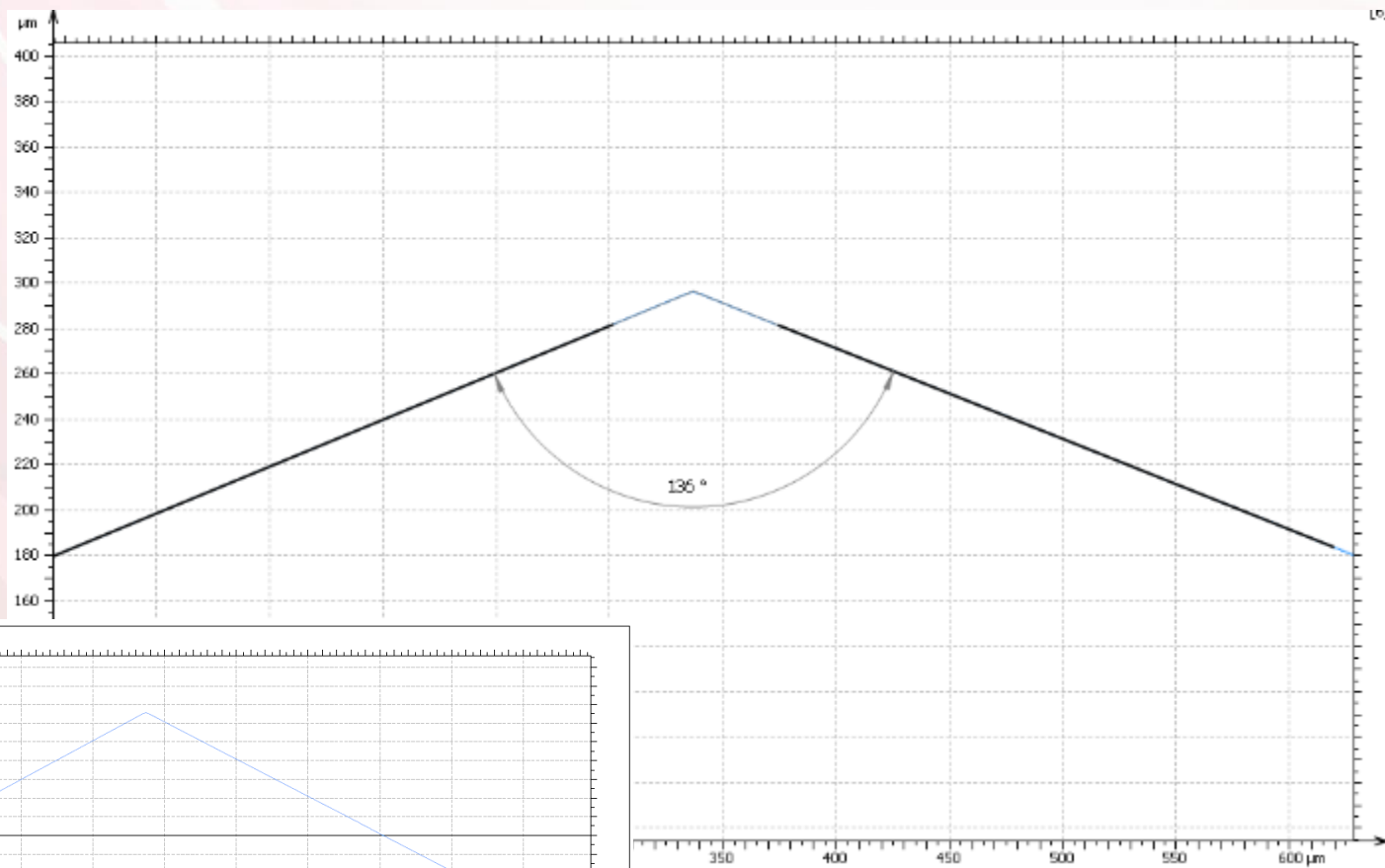
Fonte: Takagi et al, 2006

Ângulo entre as faces de 136º



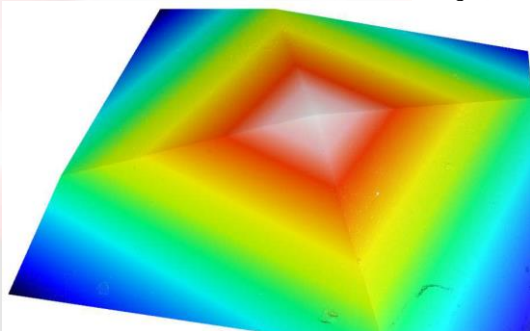
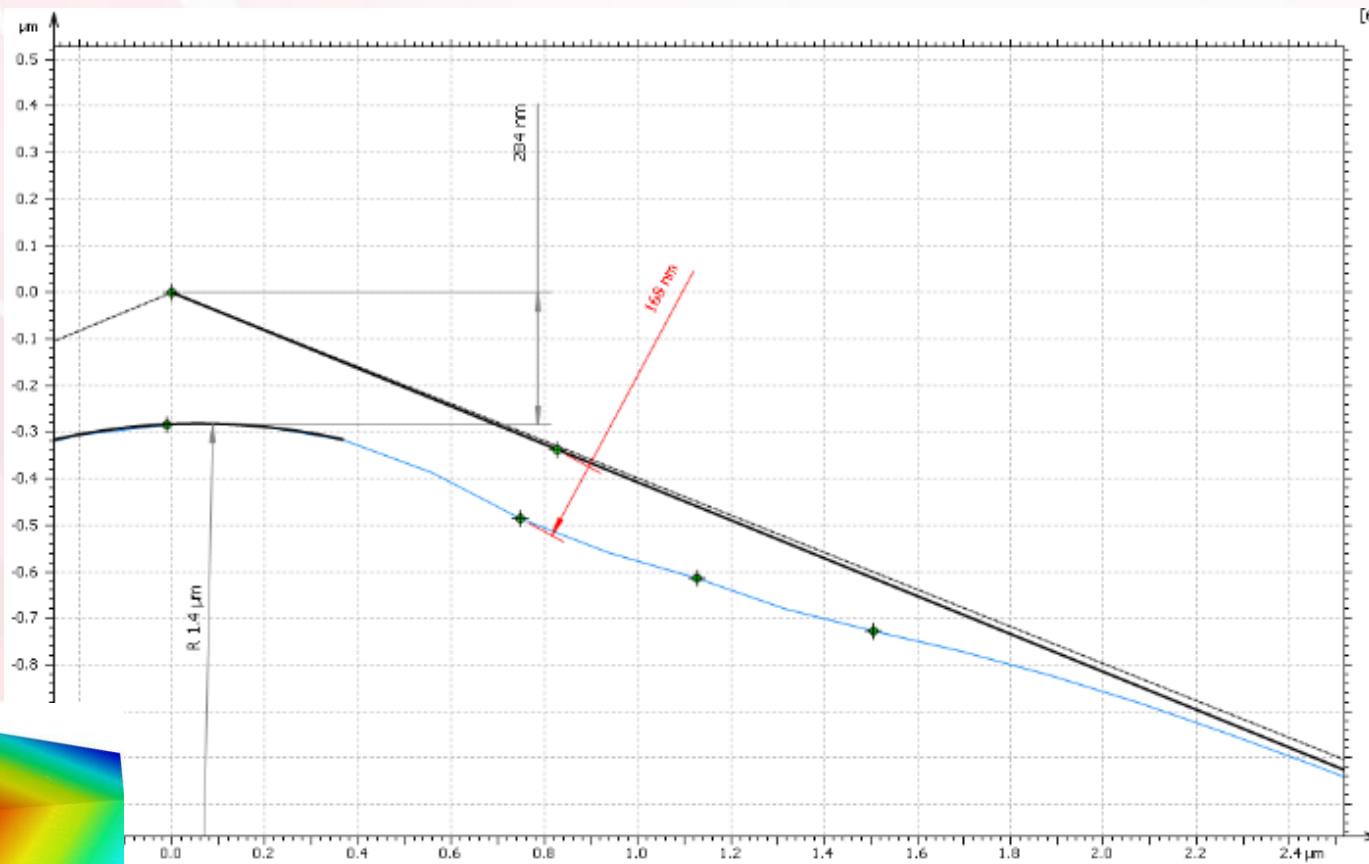
Ângulo entre as faces de 136°

136°

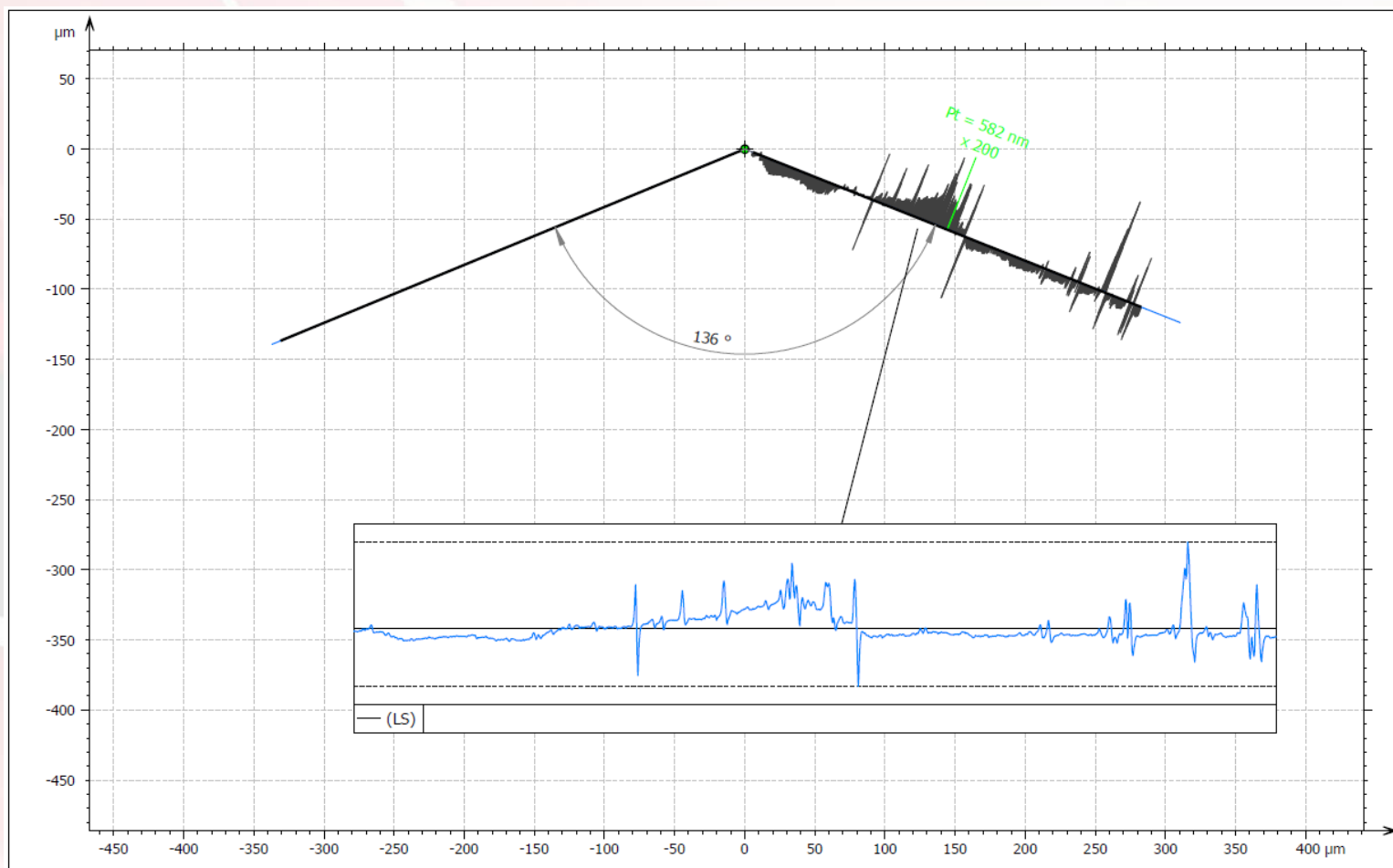


Ângulo entre as faces de 136°

Lente com
ampliação de
50x:



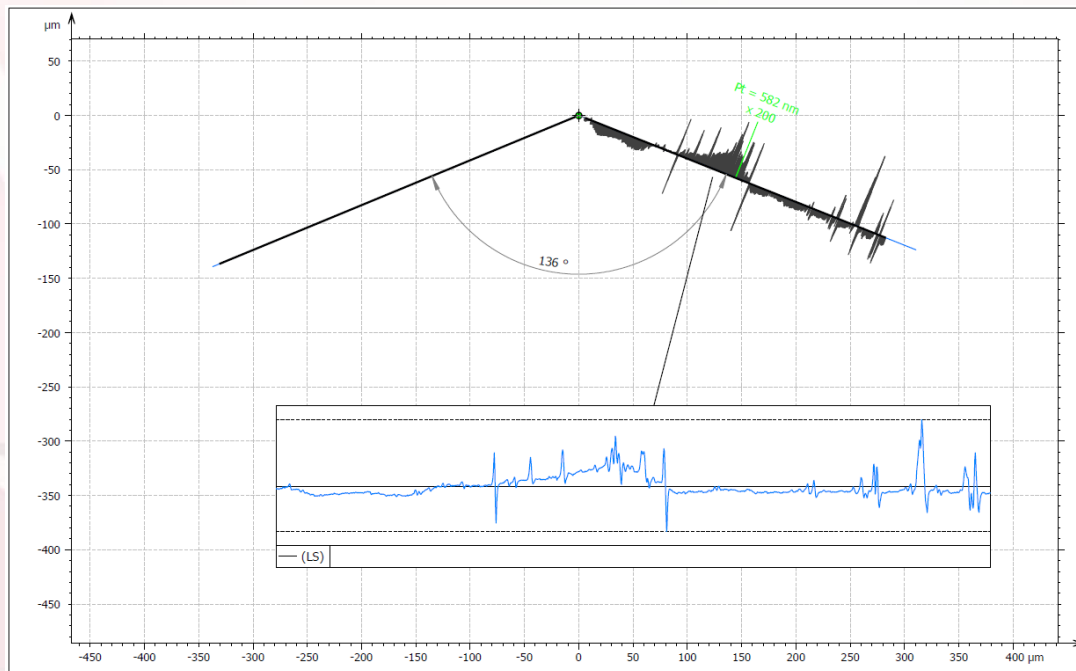
Retitude das faces



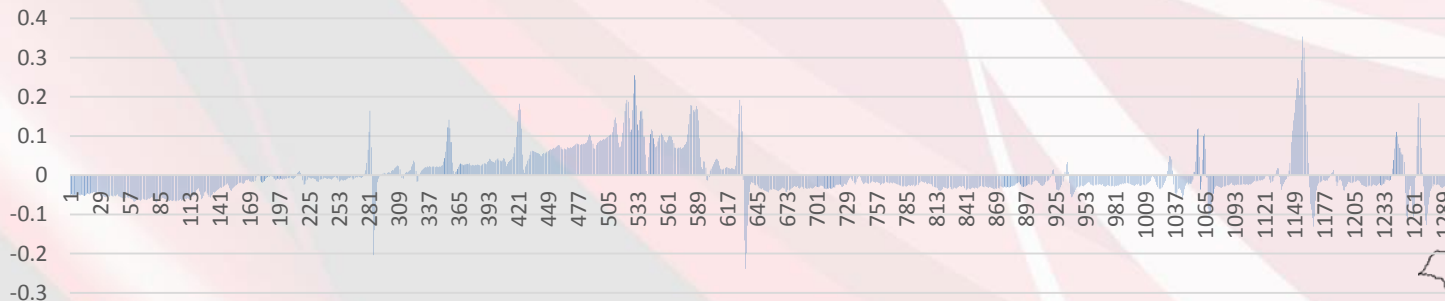
Exportar os dados (.txt)

retitude.txt - Bloco de notas

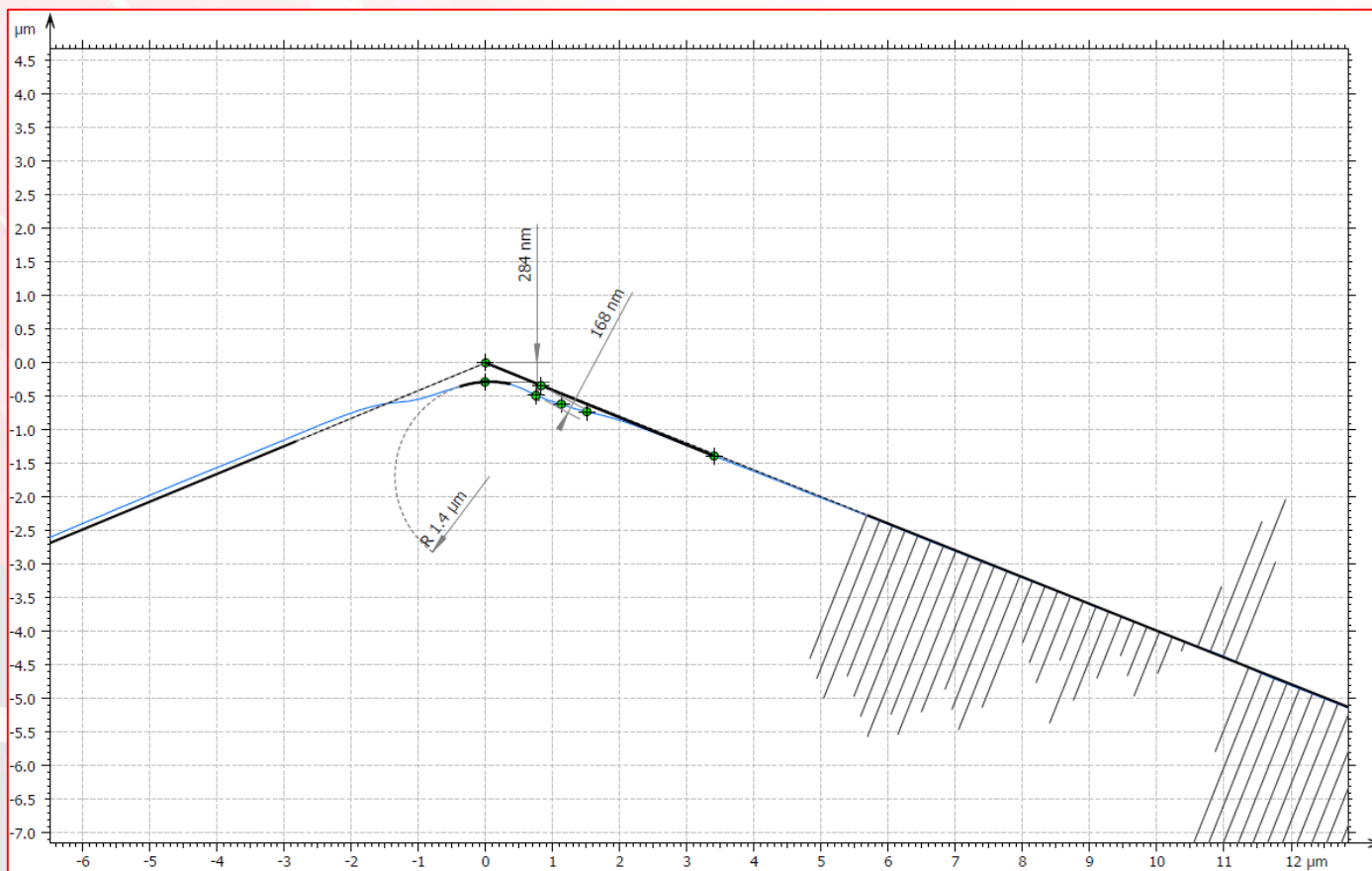
| X (μm) | Y (μm) | Desvio (μm) |
|-------------|--------------|----------------|
| 37.07334764 | -14.83782392 | -0.05127880469 |
| 37.26292983 | -14.91103022 | -0.04906095607 |
| 37.45251201 | -14.98789684 | -0.0502431001 |
| 37.64209419 | -15.06476345 | -0.05142524412 |
| 37.83167637 | -15.13796975 | -0.0492073955 |
| 38.02125855 | -15.21483637 | -0.05038953952 |
| 38.21084073 | -15.29170298 | -0.05157168355 |
| 38.40042292 | -15.36490928 | -0.04935383493 |
| 38.5900051 | -15.4417759 | -0.05053597895 |
| 38.77958728 | -15.51864251 | -0.05171812297 |
| 38.96916946 | -15.59184881 | -0.04950027435 |
| 39.15875164 | -15.66871543 | -0.05068241838 |
| 39.34833382 | -15.74558204 | -0.05186645624 |
| 39.537916 | -15.82244866 | -0.05304670642 |
| 39.72749819 | -15.89565496 | -0.05082885781 |
| 39.91708037 | -15.96886126 | -0.04861100919 |
| 40.10666255 | -16.04206756 | -0.04639316057 |
| 40.29624473 | -16.11893417 | -0.04757530459 |
| 40.48582691 | -16.19580079 | -0.04875744861 |
| 40.67540909 | -16.26900709 | -0.04653959999 |
| 40.86499128 | -16.34221339 | -0.04432175138 |
| 41.05457346 | -16.41908 | -0.0455038954 |
| 41.24415564 | -16.4922863 | -0.04328604678 |
| 41.43373782 | -16.56915292 | -0.0444681908 |
| 41.62332 | -16.64601953 | -0.04565033483 |
| 41.81290218 | -16.72288615 | -0.04683247885 |
| 42.00248437 | -16.79609245 | -0.04461463023 |
| 42.19206655 | -16.87295906 | -0.04579677425 |
| 42.38164873 | -16.95714631 | -0.05377890356 |
| 42.57123091 | -17.03767324 | -0.05836104023 |
| 42.76081309 | -17.11453986 | -0.05954318425 |
| 42.95039527 | -17.18408584 | -0.05392534299 |
| 43.13997746 | -17.26095246 | -0.05510748701 |
| 43.32955964 | -17.33781907 | -0.05628963104 |



Desvio (nm)

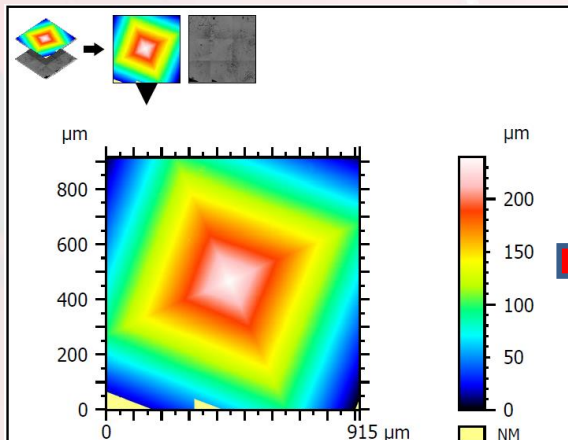


Exportar os dados (.txt)



Avaliação da Rugosidade 3D e 2D

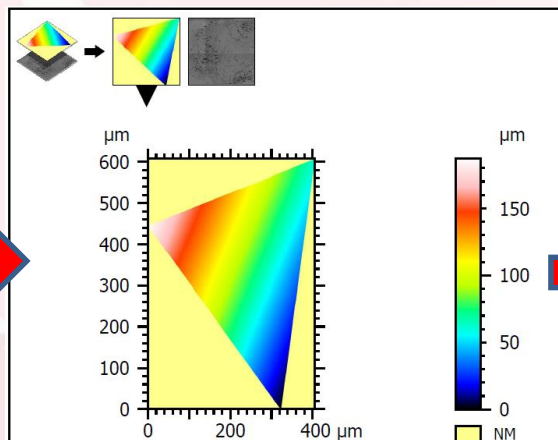
Dados iniciais



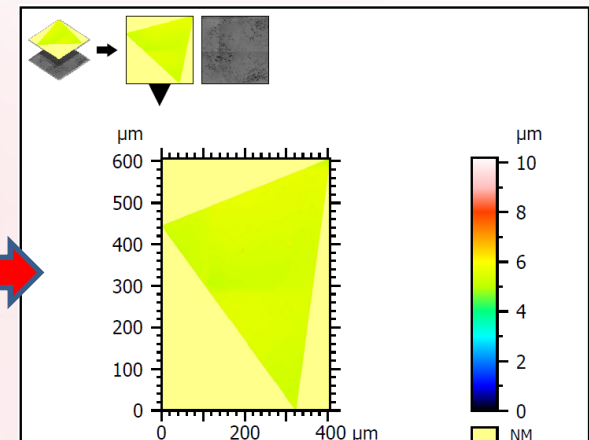
Informações

Camada Camada topográfica

Seleção de área



Nivelamento dos pontos



Informações

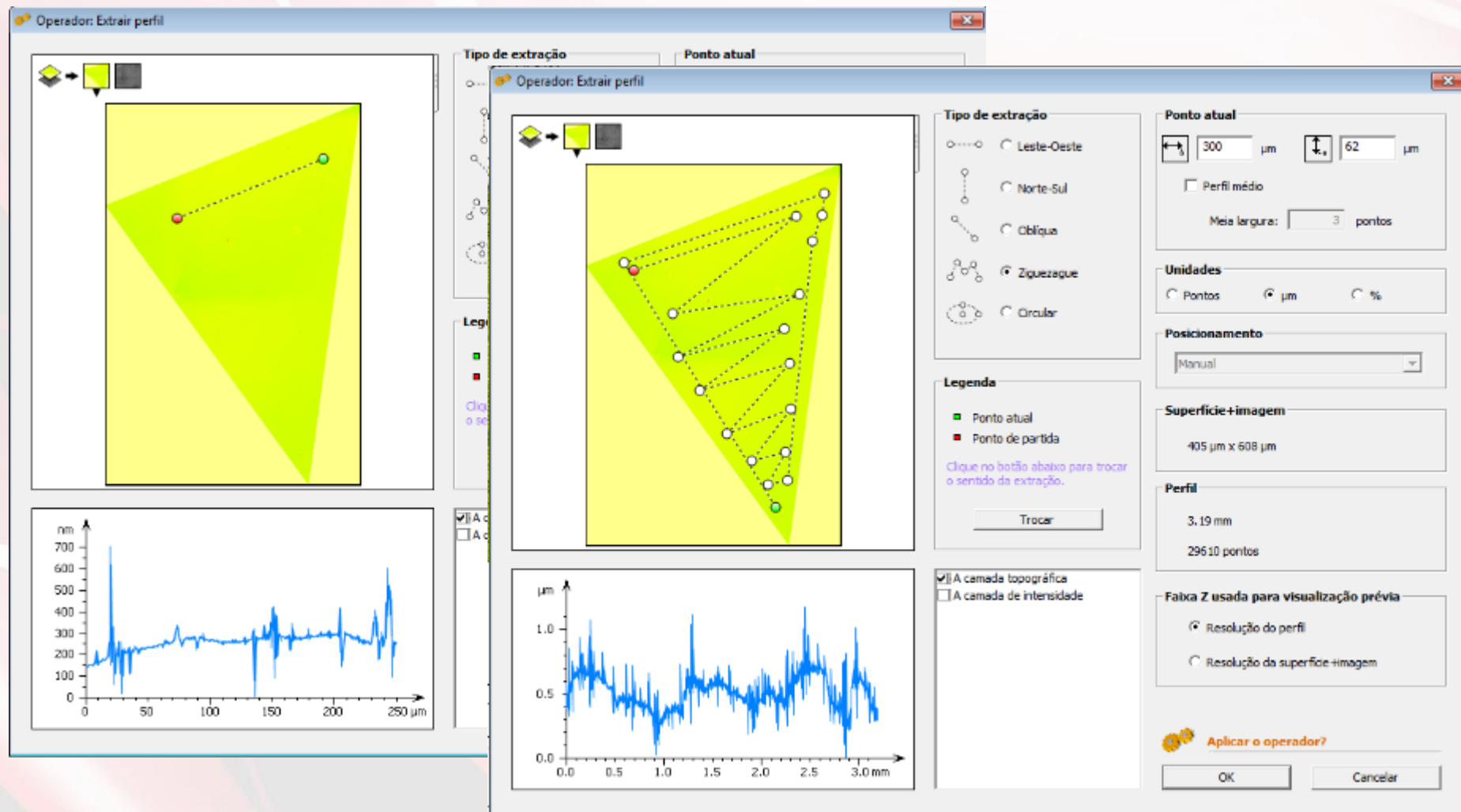
Camada Camada topográfica

ISO 25178

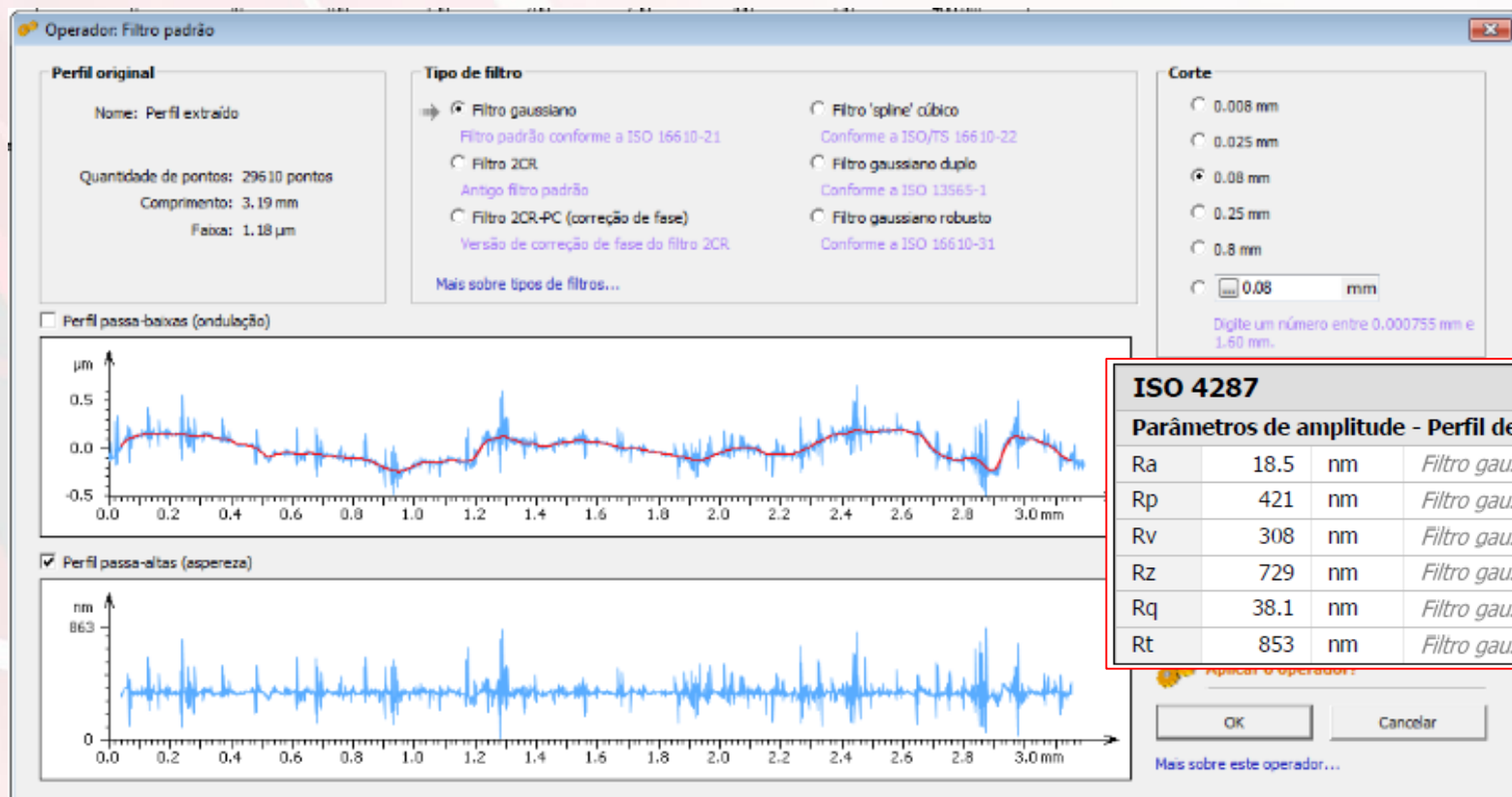
Parâmetros de altura

| | | |
|-----|-------|----|
| Sq | 0.125 | µm |
| Ssk | 0.172 | |
| Sku | 15.9 | |
| Sp | 4.76 | µm |
| Sv | 5.42 | µm |
| Sz | 10.2 | µm |
| Sa | 0.101 | µm |

Avaliação da Rugosidade 3D e 2D



Avaliação da Rugosidade 3D e 2D



CM Explorer – Máq. Med. Óptica 3D

Accuracy^{1,2}

| | | Standard | Uncertainty, standard deviation |
|--|----------------------------|---------------|---------------------------------|
| Measurement uncertainty by the example of step height measurement ^{2,3,4,5,6} | with objective lens 800 XS | Step = 75 µm | U = 0.320 µm, σ = 0.050 µm |
| | | Step = 10 µm | U = 0.060 µm, σ = 0.020 µm |
| | | Step = 1 µm | U = 0.030 µm, σ = 0.004 µm |
| Measurement uncertainty by the example of roughness measurement ^{2,3,4,5} | with objective lens 800 XS | Ra = 1.63 µm | U = 0.040 µm, σ = 0.004 µm |
| | | Ra = 0.58 µm | U = 0.024 µm, σ = 0.0066 µm |
| | | Ra = 0.23 µm | U = 0.010 µm, σ = 0.0050 µm |
| | with objective lens 320 S | Ra = 0.079 µm | U = 0.010 µm, σ = 0.0022 µm |
| | with objective lens 160 XS | Ra = 0.079 µm | U = 0.003 µm, σ = 0.0004 µm |

L: long working distance
S: normal working distance
XS: short working distance

- 1) VIM 2012
- 2) with image acquisition module 1200x1200 with fine positioning unit
- 3) U according to ISO/IEC GUIDE 98-3:2008(E), GUM:1995, K=1.96 (level of confidence 95%)
- 4) σ determined with 25 measurements
- 5) Measured in best possible conditions using PTB certified standards. Results only apply for the standards used.
- 6) Evaluation according to ISO 4287

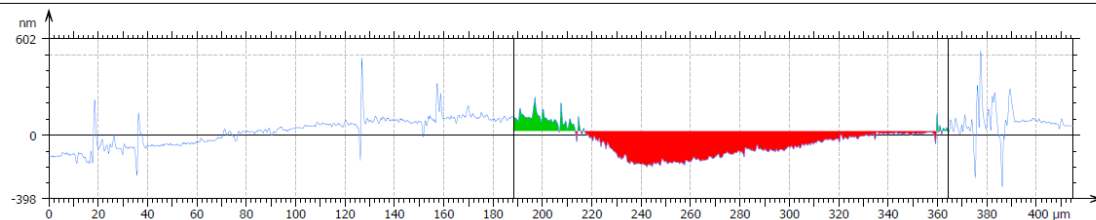
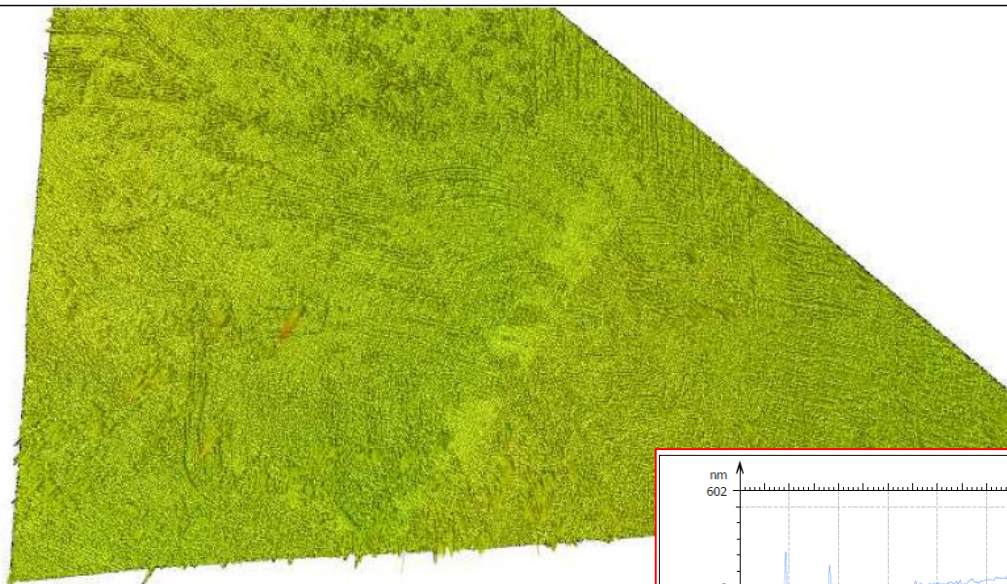
MarSurf



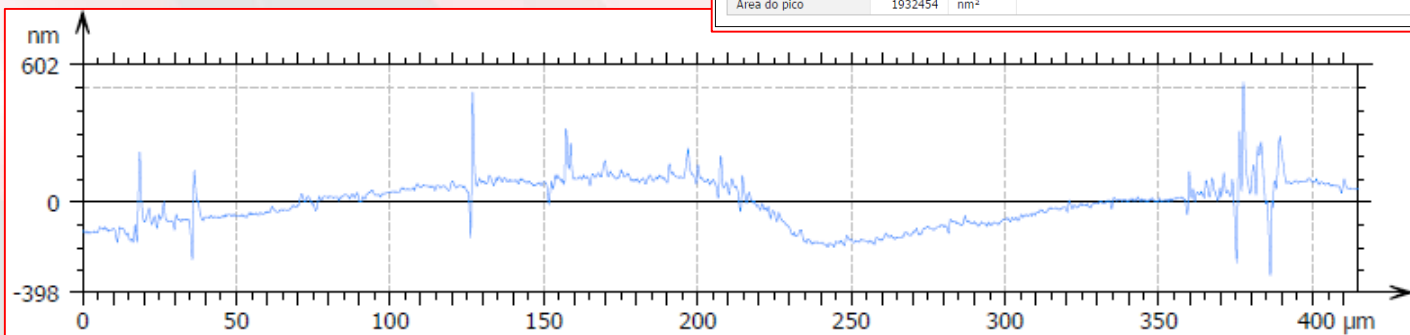
Para a aplicação apresentada, usamos:

CM Explorer com
Lente com ampliação de 50x
Resolução lente: 1200 x 1200 Mpx

CM Explorer – Máq. Med. Óptica 3D



| Parâmetros | Valor | Unidade |
|---------------------|----------|-----------------|
| Profundidade máxima | 231 | nm |
| Área do buraco | 15909641 | nm ² |
| Altura máxima | 205 | nm |
| Área do pico | 1932454 | nm ² |



Referências

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- Takagi, S., et al. "Verification of Vickers Indenter Geometry by Means of Three-Dimensional Coordinate Measurement." *Journal of Physics: Conference Series*, 2018, doi:10.1088/1742-6596/1065/6/062011.
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Agradecemos por sua participação!

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Ger. Produtos

Vinhedo – SP (Dez-2020)