Mesure de topographie de surfaces par interférométrie en lumière blanche

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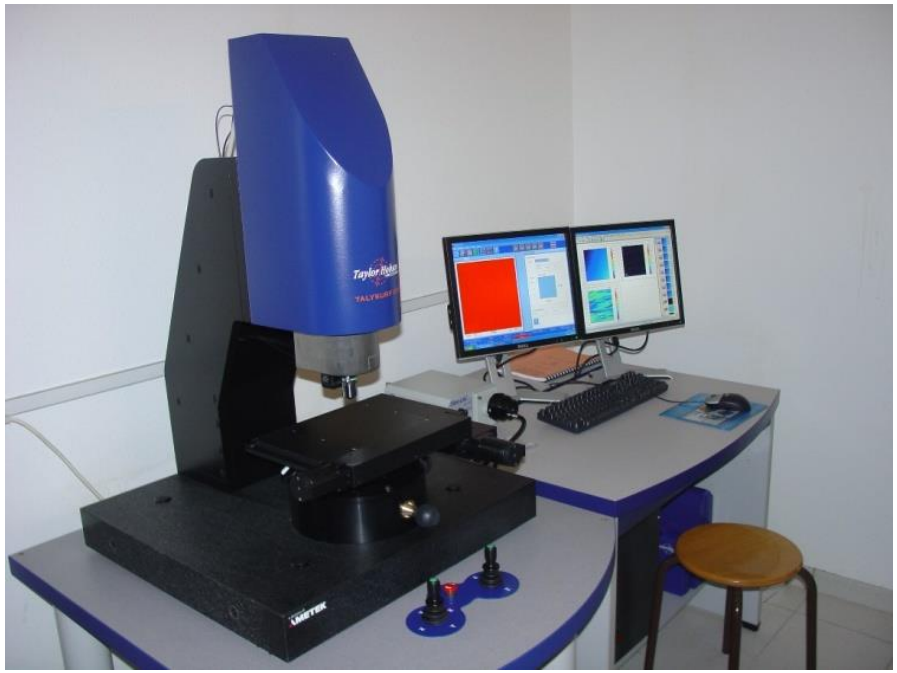
Introduction



2004: Détection d'un **besoin** pour la **mesure rapide** de **topographie 3D** de surface (tribologie, matériaux, physique, etc)

2005: - Prospection
- Financement XIICPER

2006: Achat d'un microscope interférométrique à lumière blanche (Taylor Hobson CCI 6000 > 165 k€)

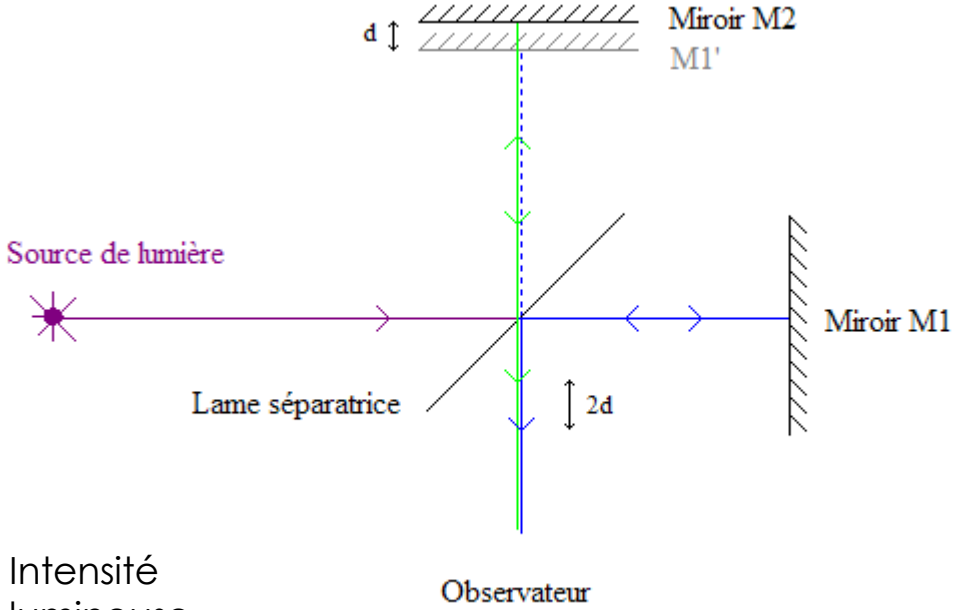
Présentation des possibilités du microscope

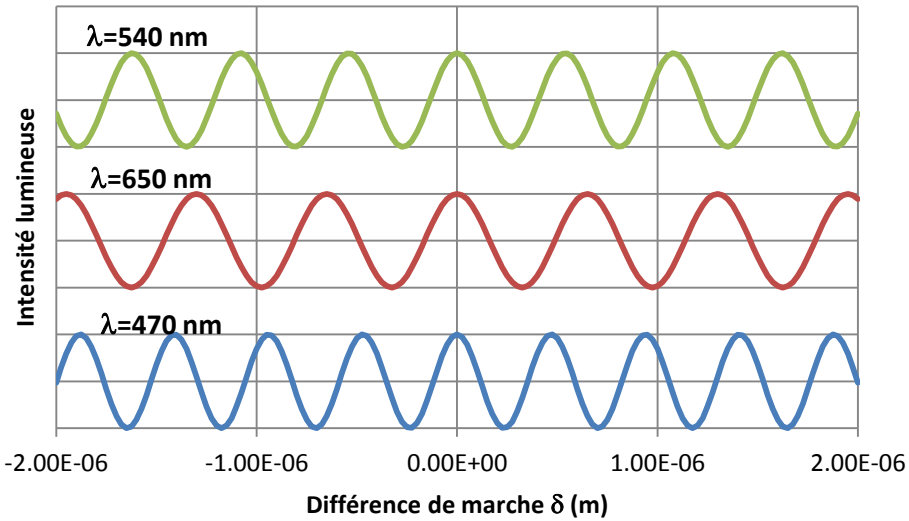
Plan

- Introduction
- Rappels d'interférométrie
- Mesure d'altitude
- Caractéristiques du microscope
- Exemples d'application
- Conclusion

Rappels d'interférométrie

- Lumière monochromatique





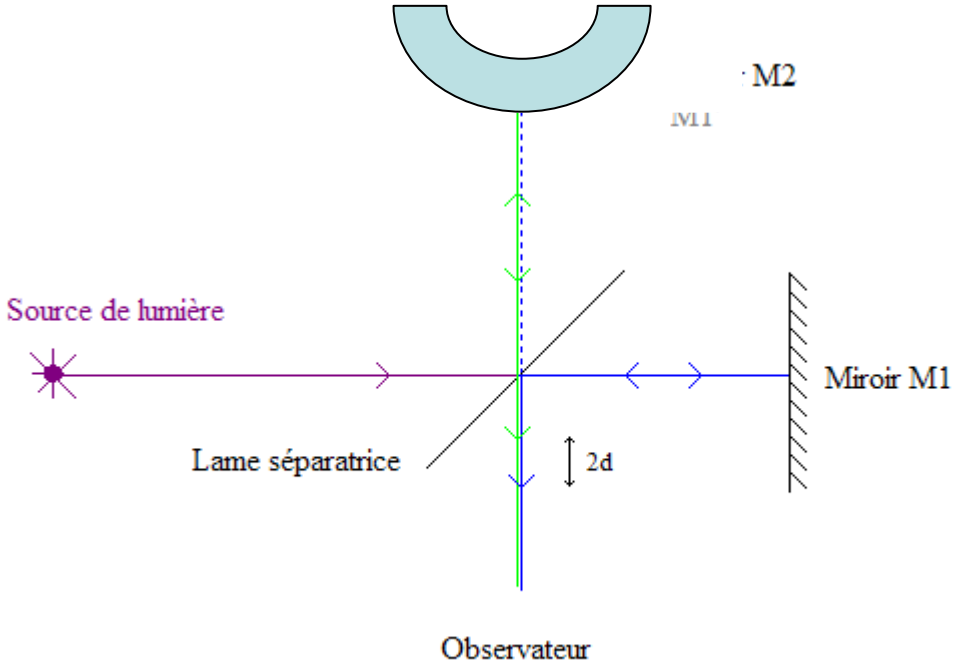
Intensité lumineuse observée

$$I(\delta = 2d) = 4I_0 cos^2\left(\pi n \frac{\delta}{\lambda}\right)$$

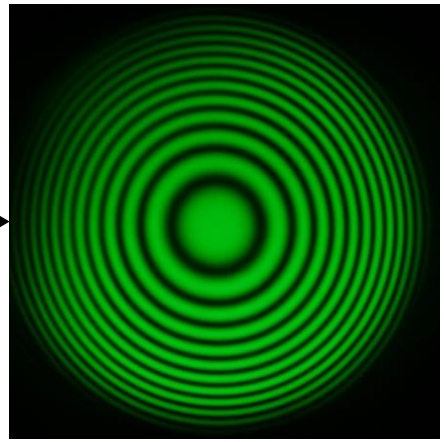
Différence de marche
Indice de réfraction du milieu (air, n=1)
Longueur d'onde de la source

Rappels d'interférométrie

- Lumière monochromatique

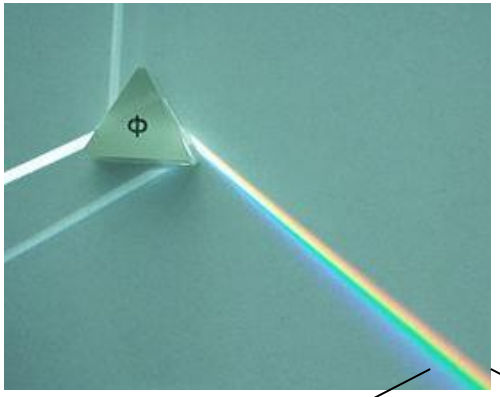


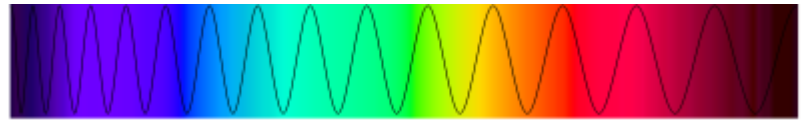
$$I(\delta = 2d) = 4I_0 cos^2\left(\pi n \frac{\delta}{\lambda}\right)$$

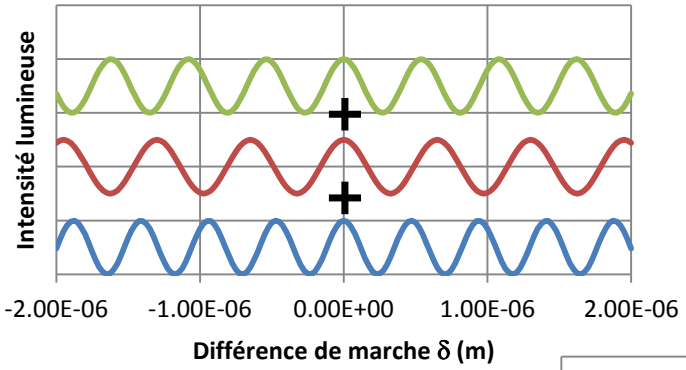


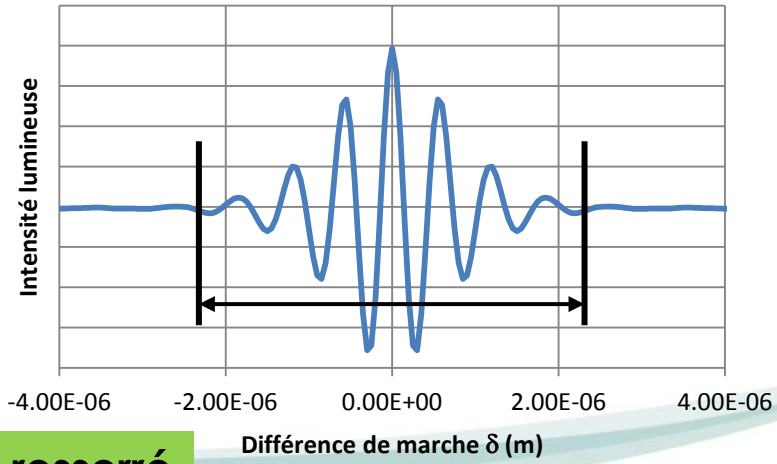
Rappels d'interférométrie

- Lumière blanche: spectre de longueurs d'onde



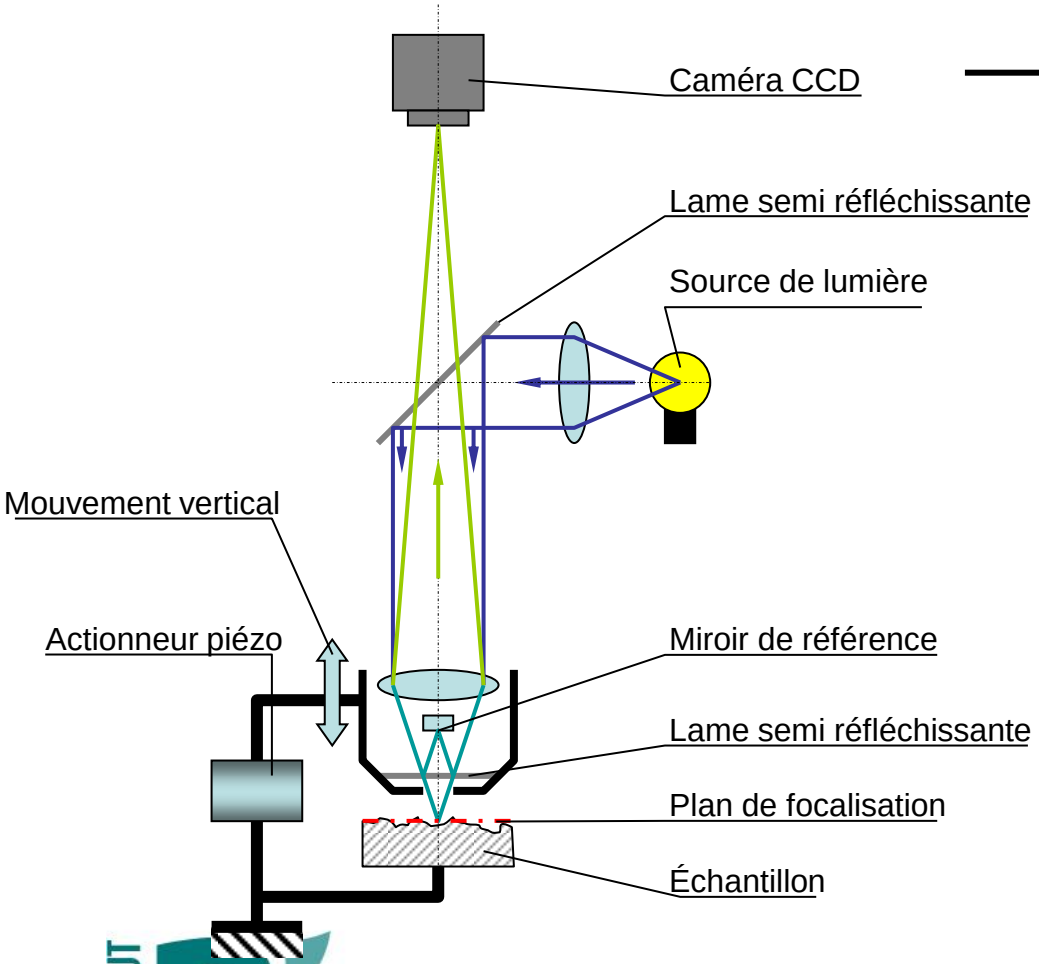


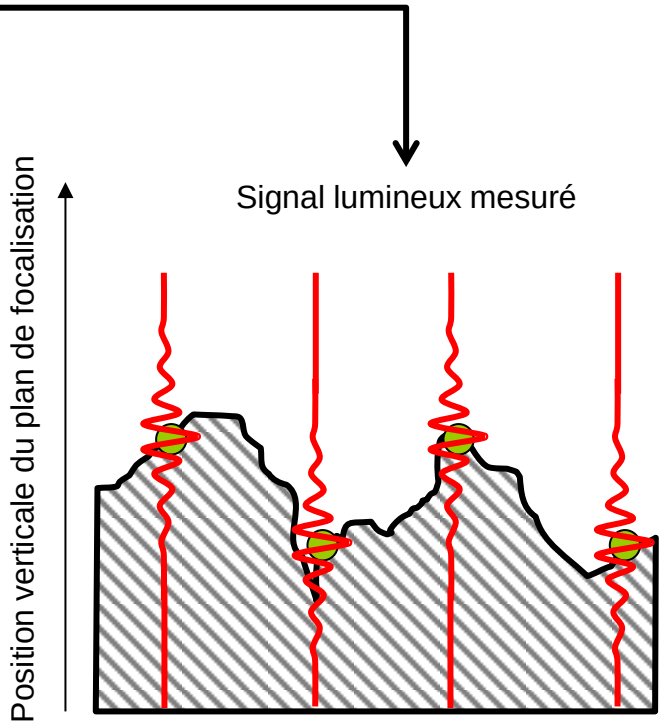




Spectre de franges très resserré

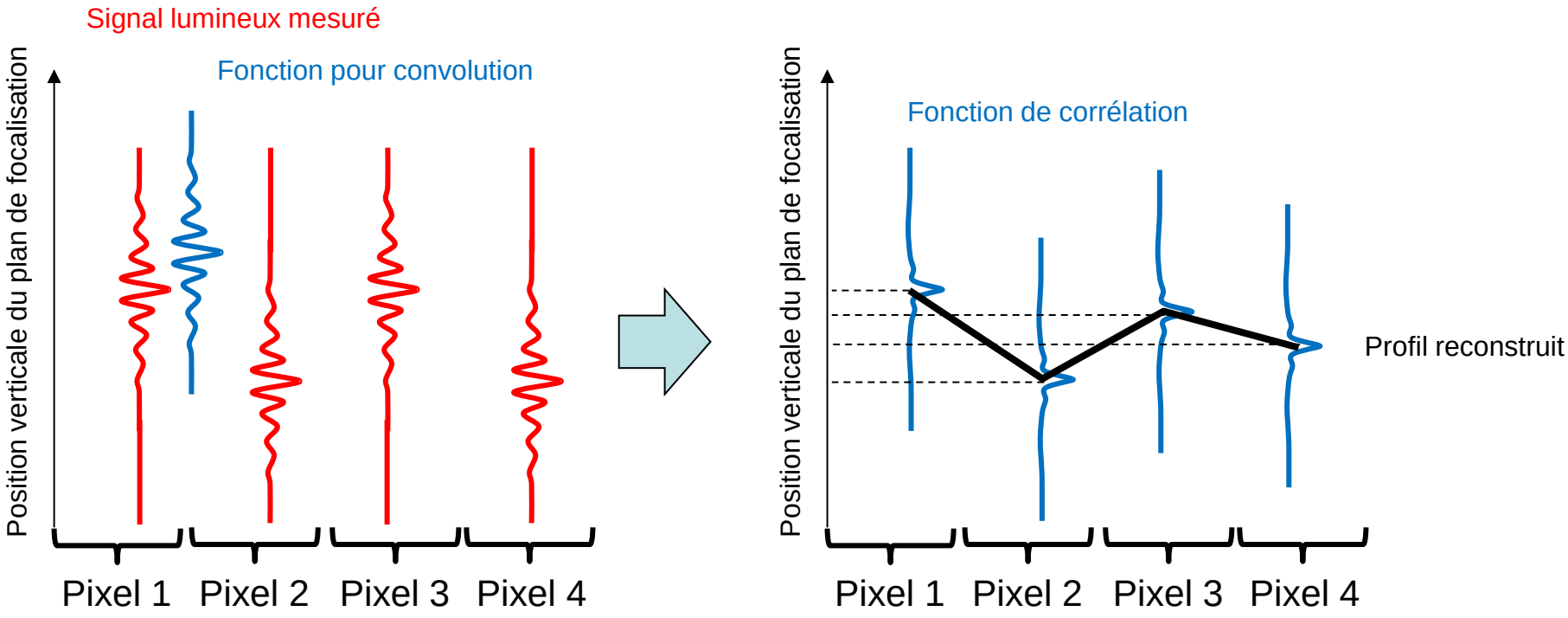
Mesure d'altitude





Un signal par pixel

Mesure d'altitude



Caractéristiques du microscope

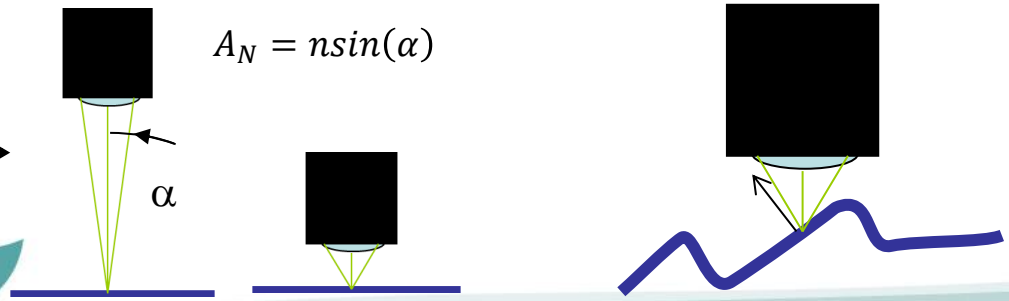
Caméra CCD N&B 1024x1024 (Low noise)

Objectif	Champ de vision (µm)	Ech. latéral (µm)	Limite latéral, Sparrow (µm)	Distance de travail (mm)	A_N	Angle max(°)
5X	3600	3.6	2.12	9.3	0.13	3.5
10X	1800	1.8	0.92	7.4	0.30	8
20X	900	0.9	0.69	4.7	0.40	14.5
50X	360	0.36	0.50	3.6	0.55	22

Surface lisse

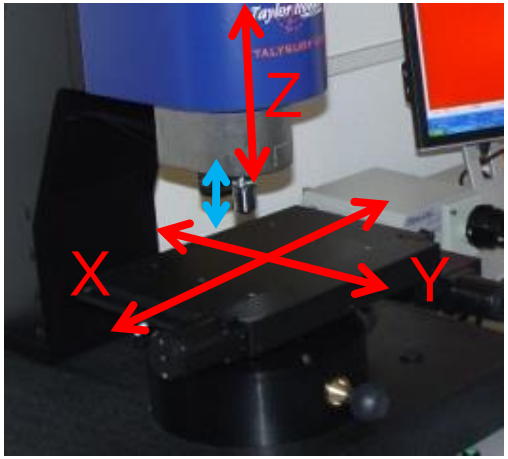
Surface rugueuse

$$A_N = nsin(\alpha)$$



Caractéristiques du microscope

- Etendue de mesure



Amplitude piezo : 250 µm

Recollement d'images
Table motorisée X Y: 150x150 mm
Tête motorisée Z : 100 mm

- Résolution verticale (tous les objectifs)

Résolution ~ 0.01nm
Précision ~ 10^{-4} à 10^{-3} amplitude du scan

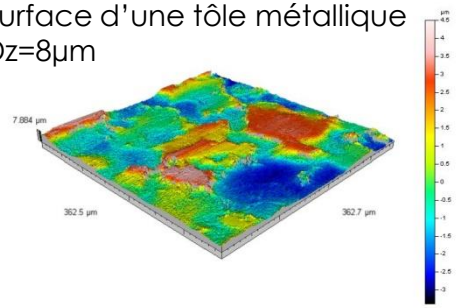
Caractéristiques du microscope

- Calibrations du microscope
  - Z: mesure d'une marche étalon (5 ou 50µm)
  - X, Y: mesure d'un cercle étalon
  - Miroir: plan étalon (x8)

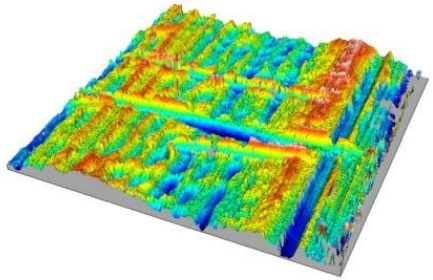
Exemples d'application

- Mesure d'état de surfaces

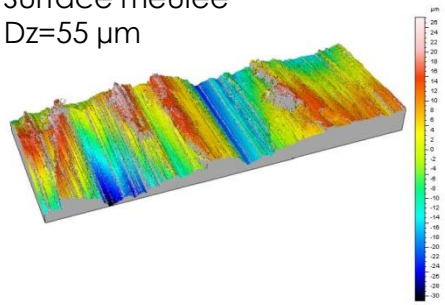
Surface d'une tôle métallique
Dz=8µm



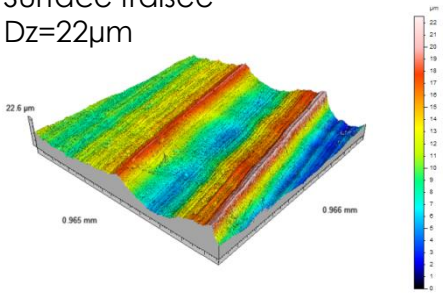
Surface percée



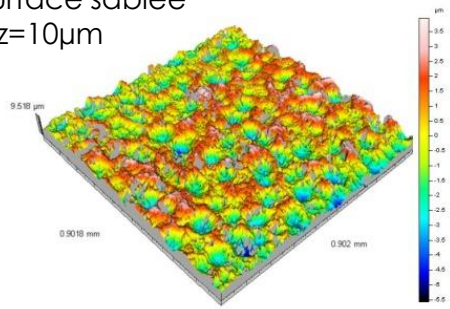
Surface meulée
Dz=55 µm



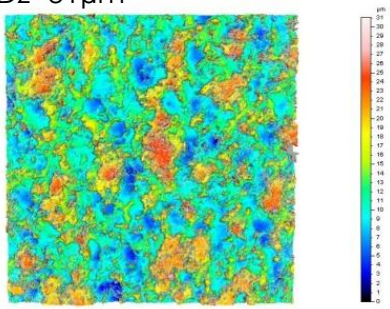
Surface fraisée
Dz=22µm



Surface sablée
Dz=10µm



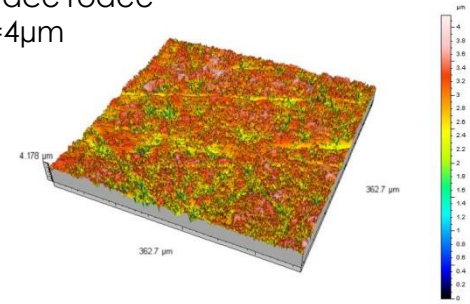
Surface électro-érodée
Dz=31µm



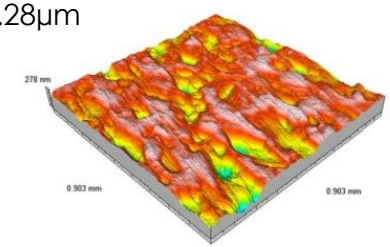
Exemples d'application

- Mesure d'état de surfaces

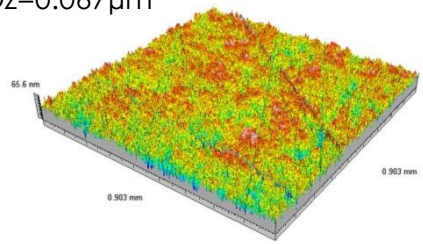
Surface rodée
Dz=4µm



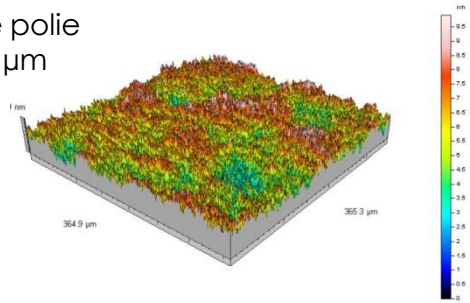
Surface polie
Dz=0.28µm



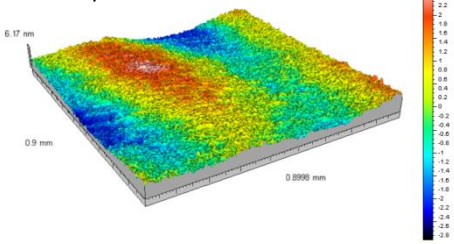
Surface polie
Dz=0.067µm



Surface polie
Dz=0.01µm



Surface disque dur
Dz=0.006µm

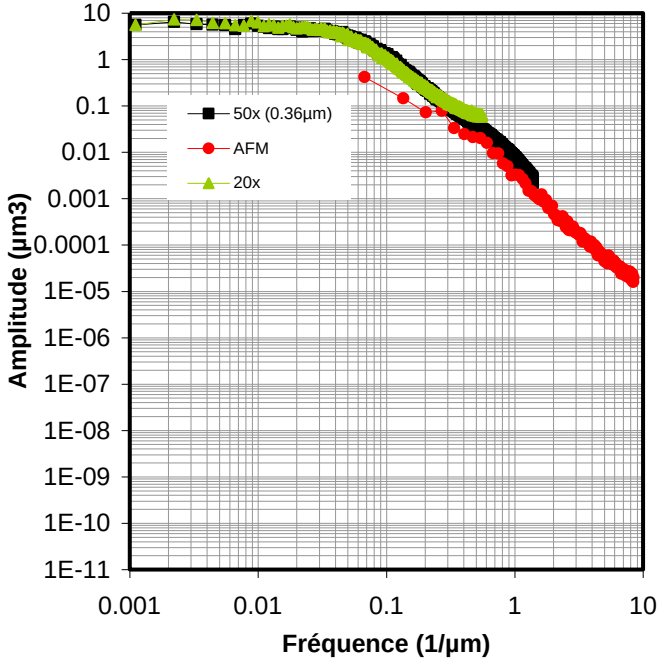


Surfaces mesurées:
Dz de 6nm à 55 µm
Une **plage de détection** de 55 µm/6nm ~ **10^4**

Exemples d'applications

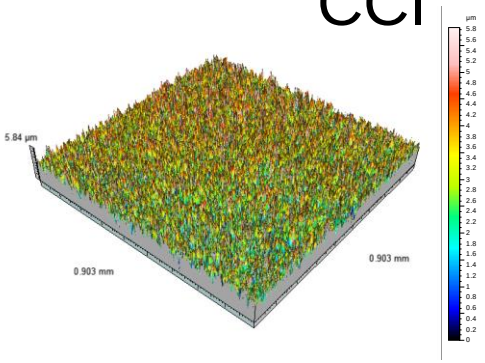
- Mesure d'état de surface

Comparaison AFM – Interféromètre
Densité spectrale de puissance

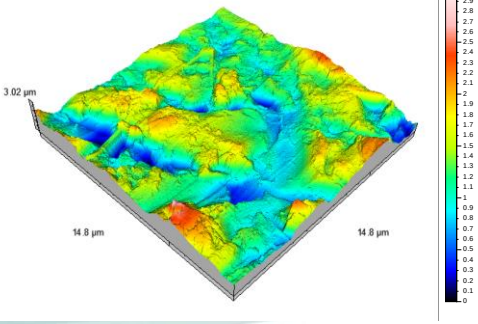


σ(20x)=0.928µm
σ(50x)=0.919µm
σ(AFM)=0.369µm

CCI

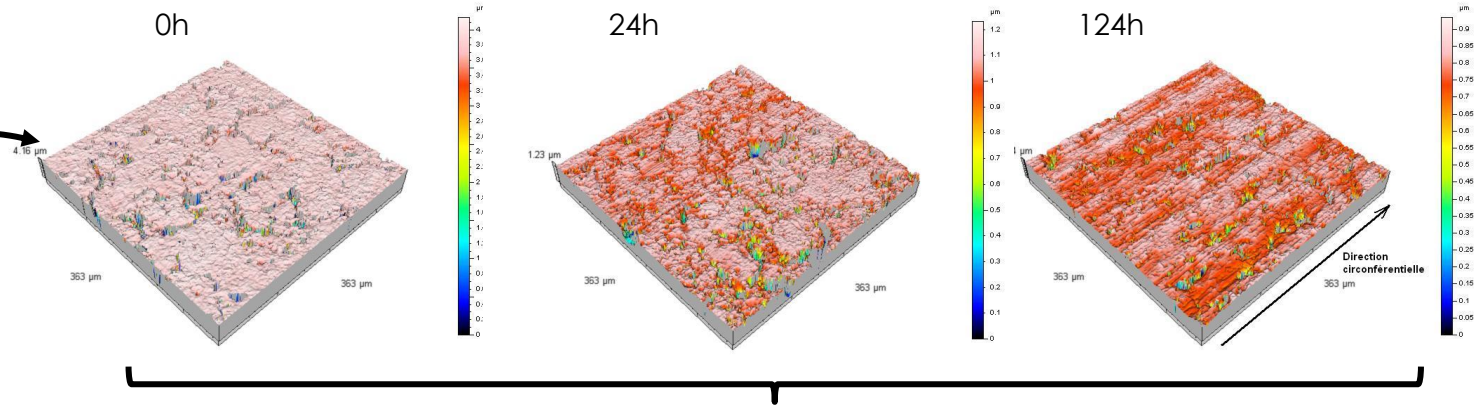


AFM

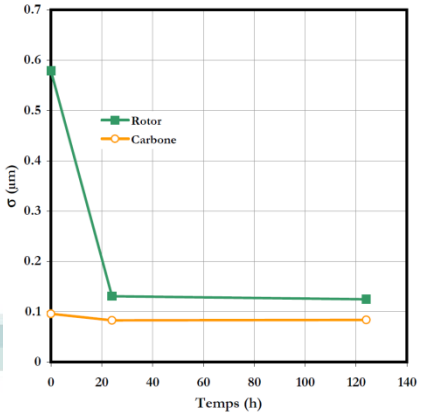


Exemples d'applications

- Etude tribologique



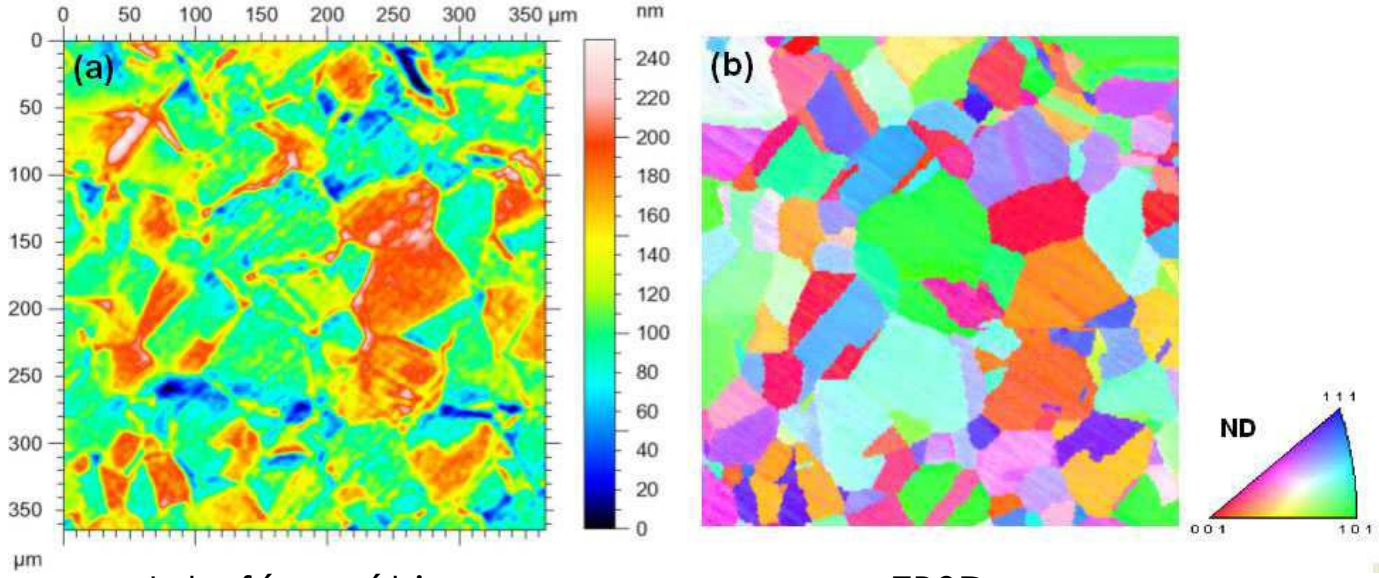
Evolution de l'état de surface d'une garniture mécanique (Thèse C Minet, 2009)



Exemples d'applications

- Etude matériaux

Gonflement des grains d'un acier inox lors de la nitruration (Thèse J-C Stinville, 2010)

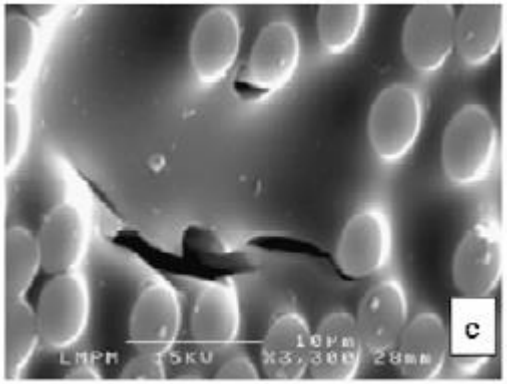


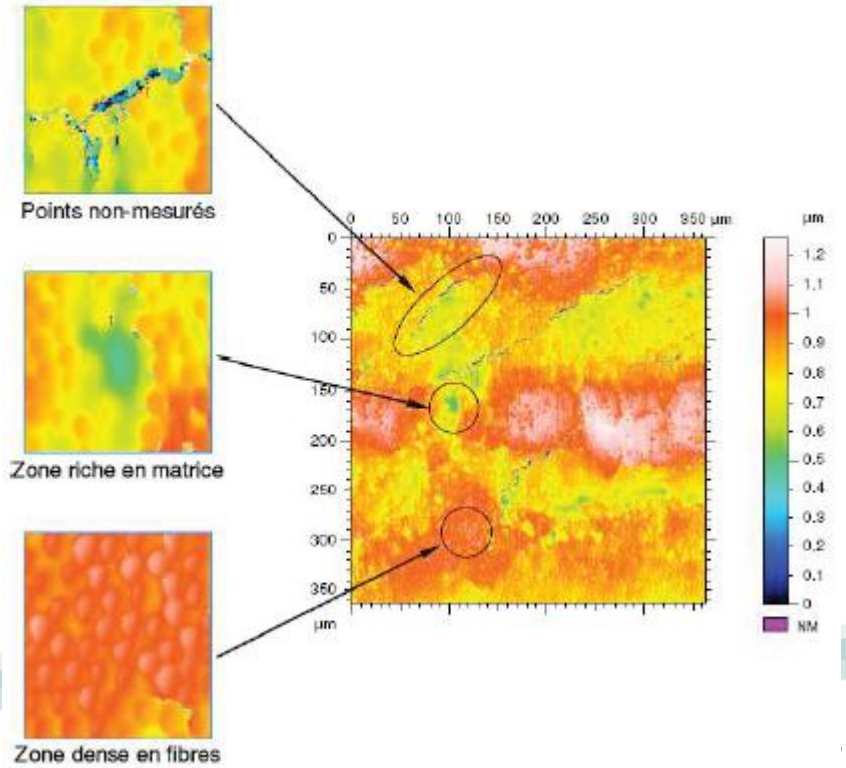
Interférométrie EBSD

Exemples d'applications

- Etude matériaux

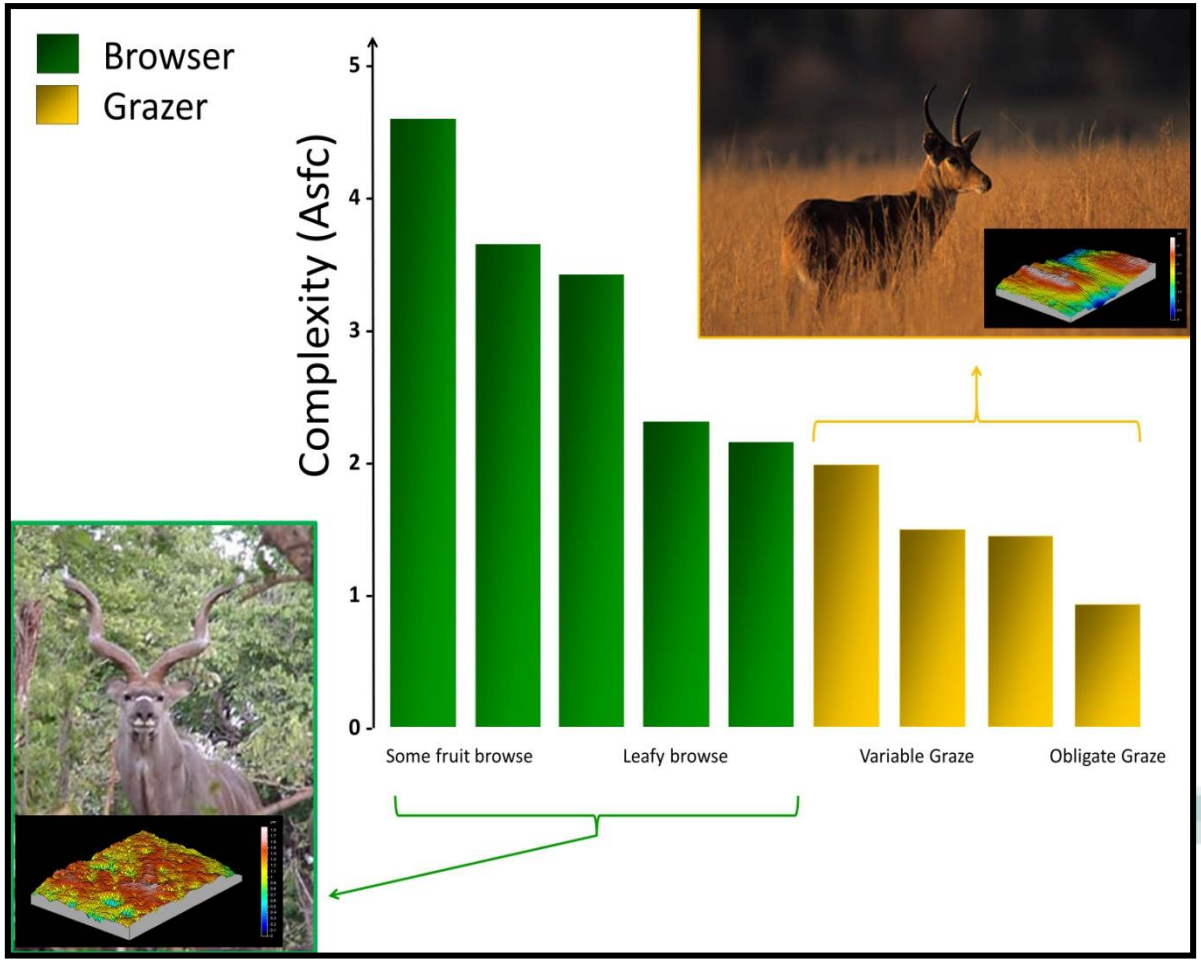
Thermo oxydation de matériaux composites (Gigliotti et al., 2009)





Exemples d'applications

- Paléontologie

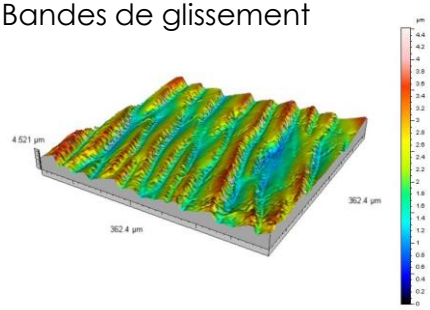


Surfaces dentaires:
Reconstitution du régime alimentaire des fossiles
Reconstitution de la flore locale
(G. Merceron, Iphep, 2012)

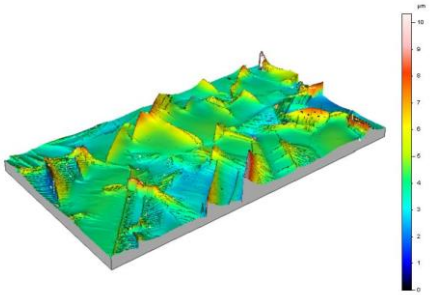
Conclusions

- Larges possibilités de mesure de surfaces:
  - X,Y: de 360 µm à 150mm
  - Z : de qq nm à 250 µm
  - Résolution X,Y ~ 1µm
  - Résolution Z < 1nm
- Ouvert à la communauté P' et scientifique (après formation)
- 66 utilisateurs, 83 personnes formées (D1, D2, D3, SiC, Iphep)
- 1380 utilisations (presque 1 par jour) et 13800 surfaces mesurées (au 17/5/2013)

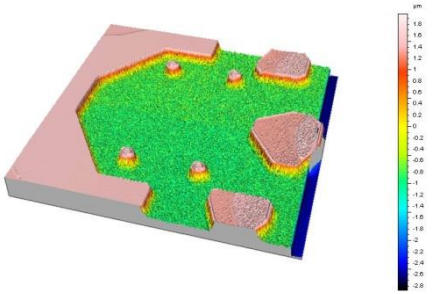
Bandes de glissement



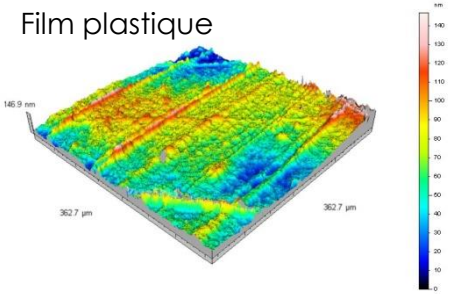
316L Nitruré



Tête disque dur

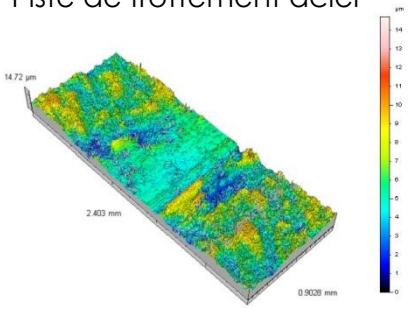


Film plastique

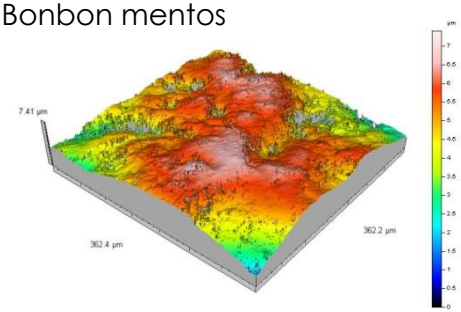


Merci de votre attention

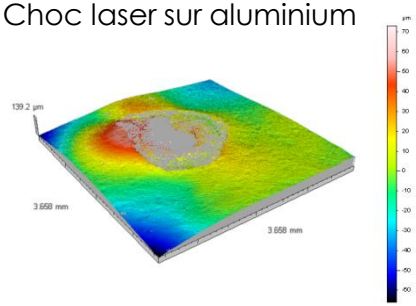
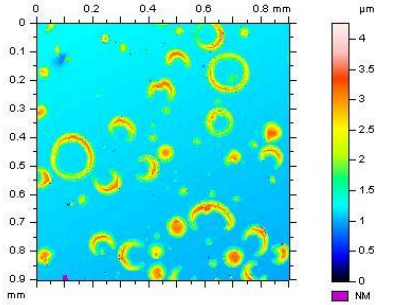
Piste de frottement acier



Bonbon mentos



Choc laser sur aluminium



Film d'or décollé