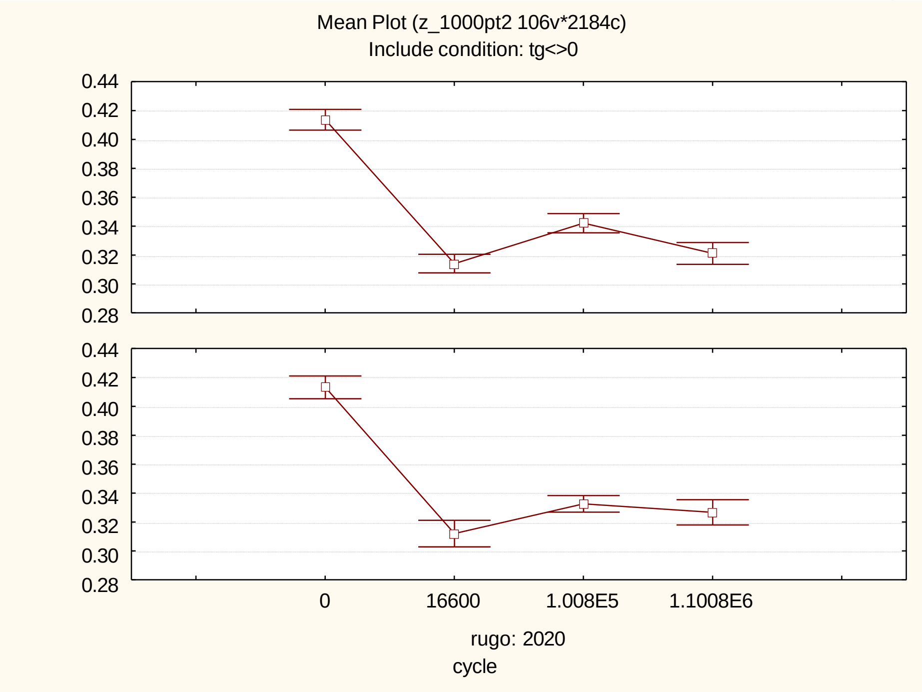
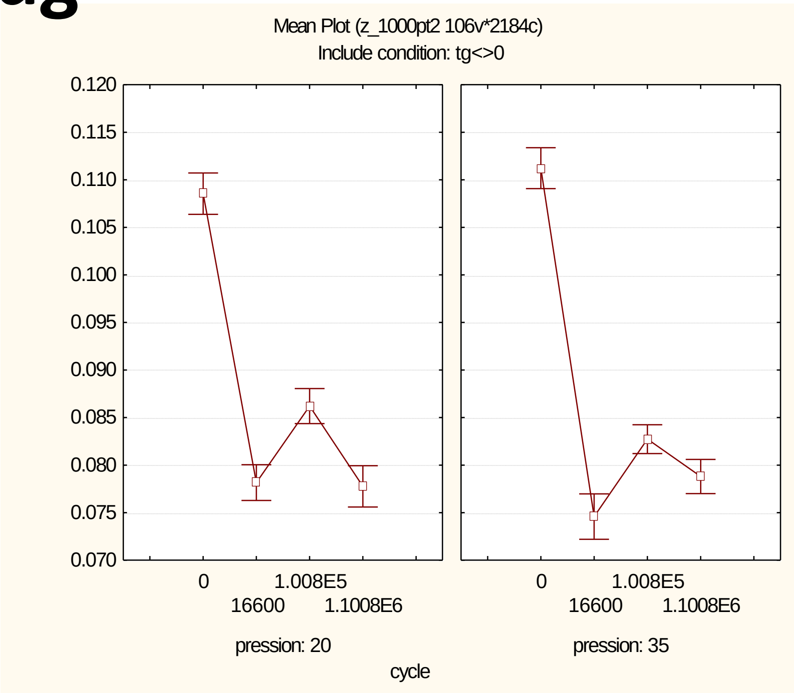
Rolling contact fatigue

The slope of profile best discriminates wear on rolling wear

Linked to the wear of asperities caused bye the contact angle

Mesrug





3^{th} Mesrug analysis

What is the best roughness Parameter to characterize a non linear relation between a physical surface properties and surface morphology

Method : Non linear regression with a bank of model + bootstraped data for each roughness parameters

An exemple: Relations between the surface morphology and cells adhesion (human osteoblast)

Validation

Experiments design

Material : Titanium alloys (TA6V)

Different roughness : amplitude and frequency

Processes : acid etching, grinding, tooling, electro-eroding, sandblasting

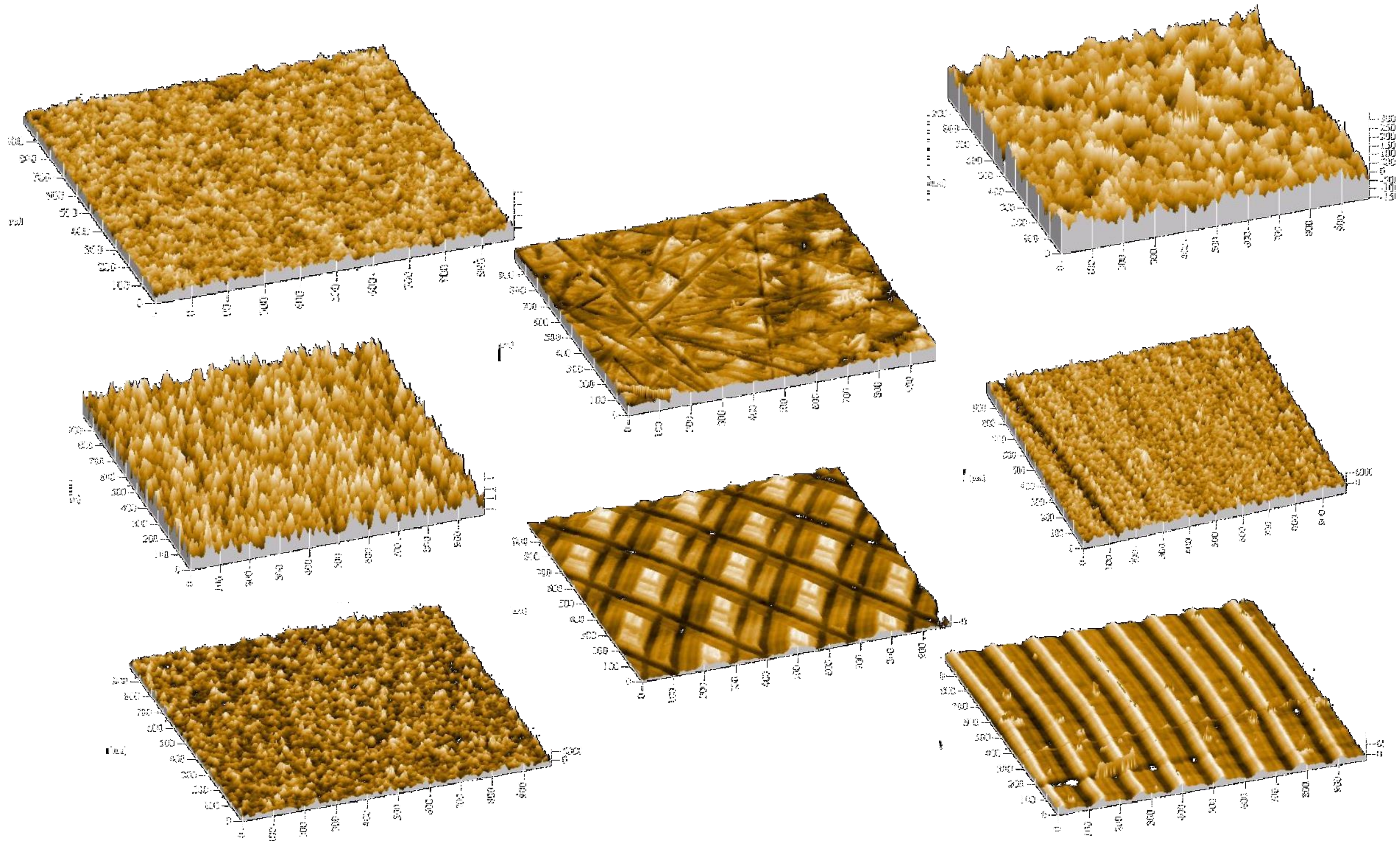
with 2 levels of amplitude

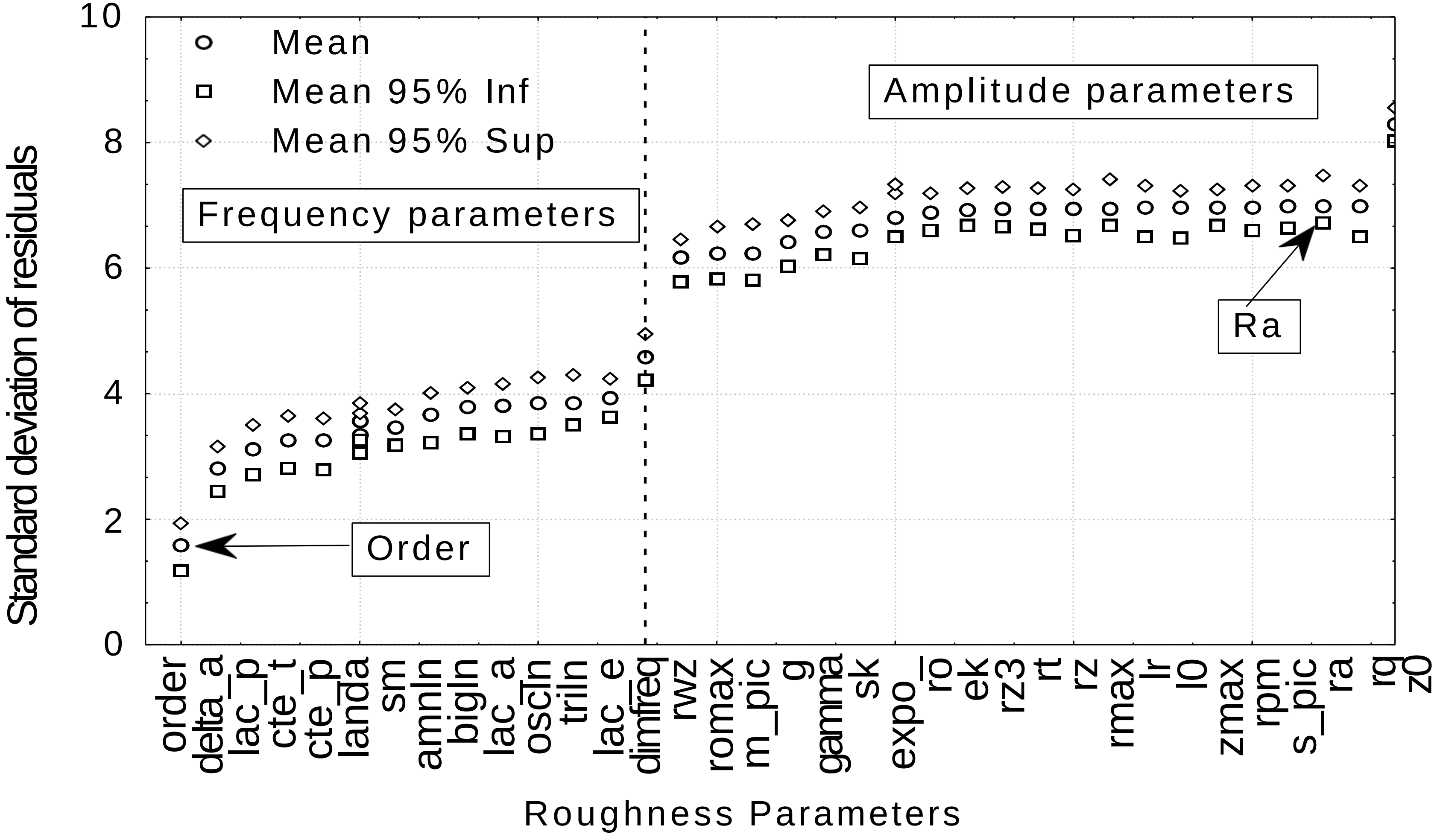
With and without thin coating with Au/Pd PVD

Dissociate chemistry effect / roughness effect

1400 samples, 16 Millions human osteoblastes, 400 experiments

Titanium roughness's

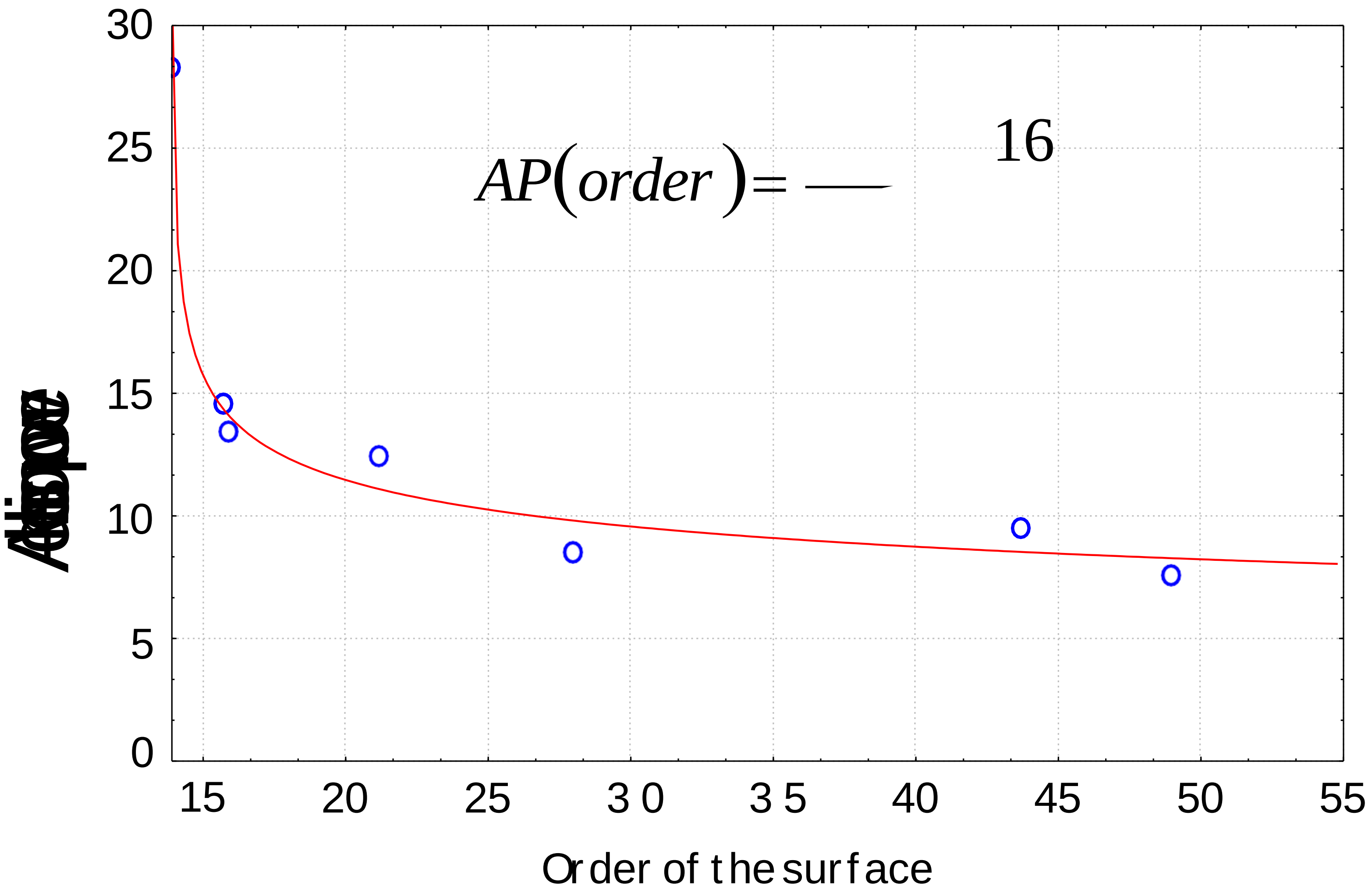




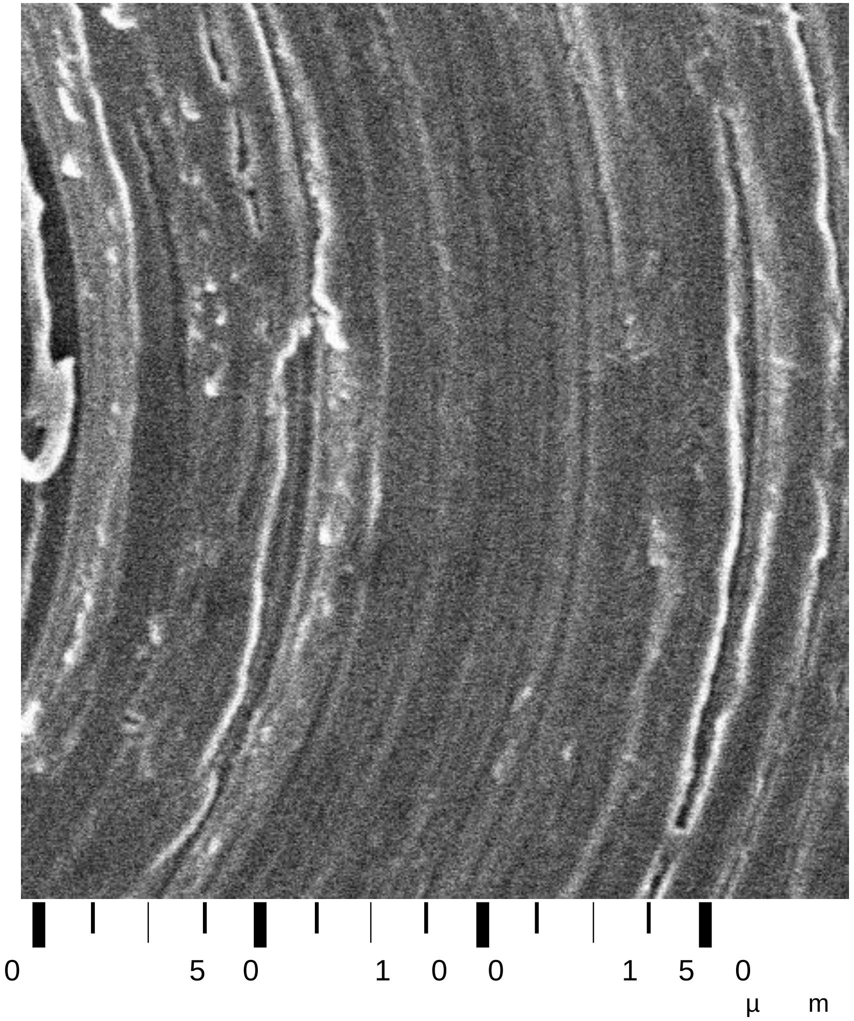
Classification of the relevance of 35 roughness parameters with regard to cell adhesion power (AP). Roughness parameters divided into 14 frequency parameters and 21 amplitude parameters. The lower the standard deviation of the residuals, the higher the correlation with AP.

Surface order

Most relevant parameter

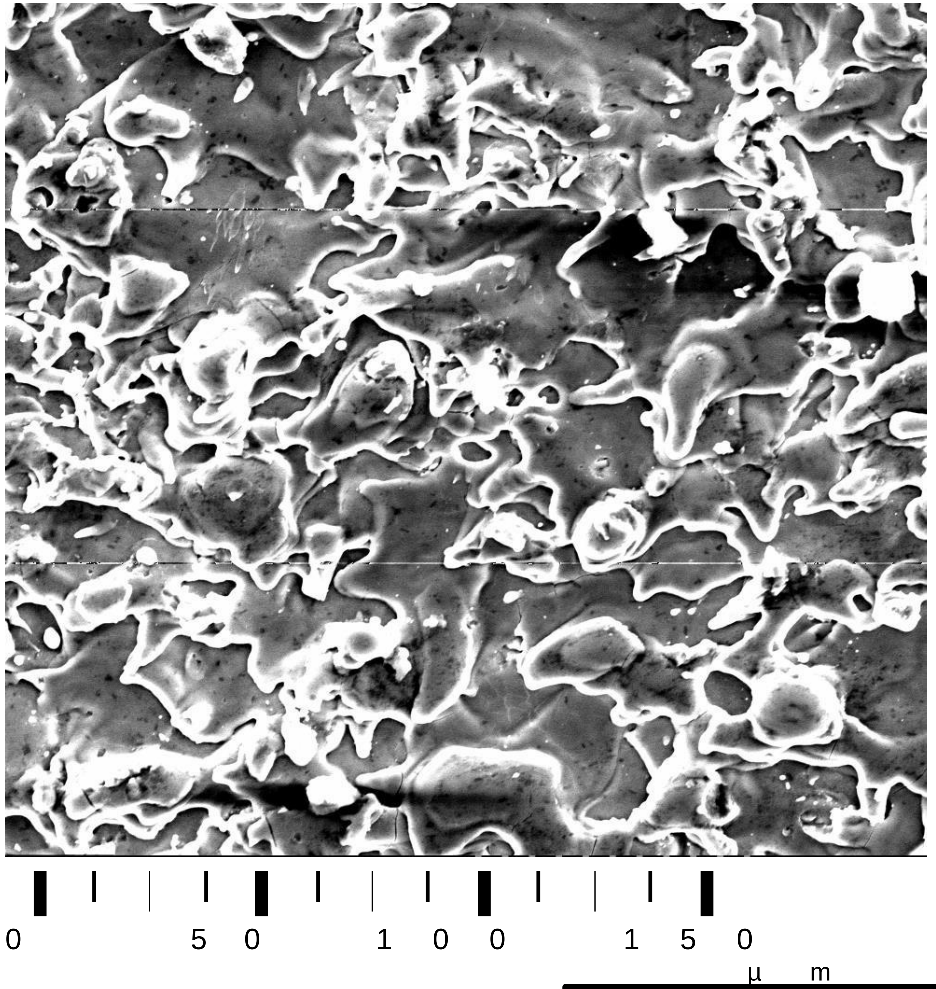


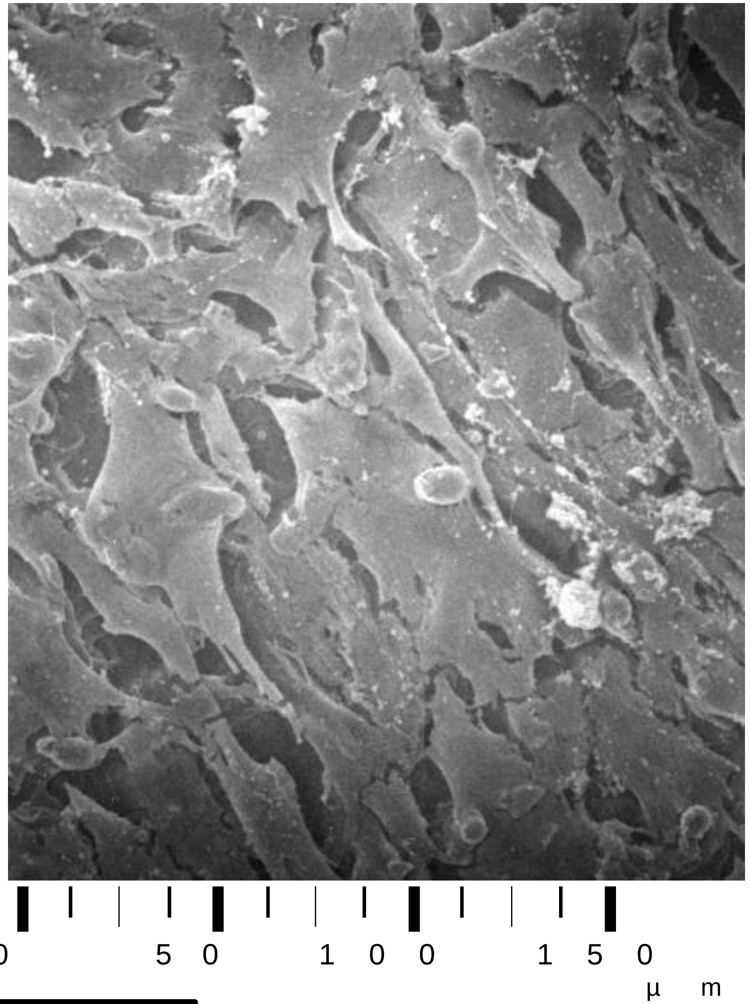
Adhesion on tooled surface



Ordre = 49 %

Adhesion on EDM surface





Ordre = 14%

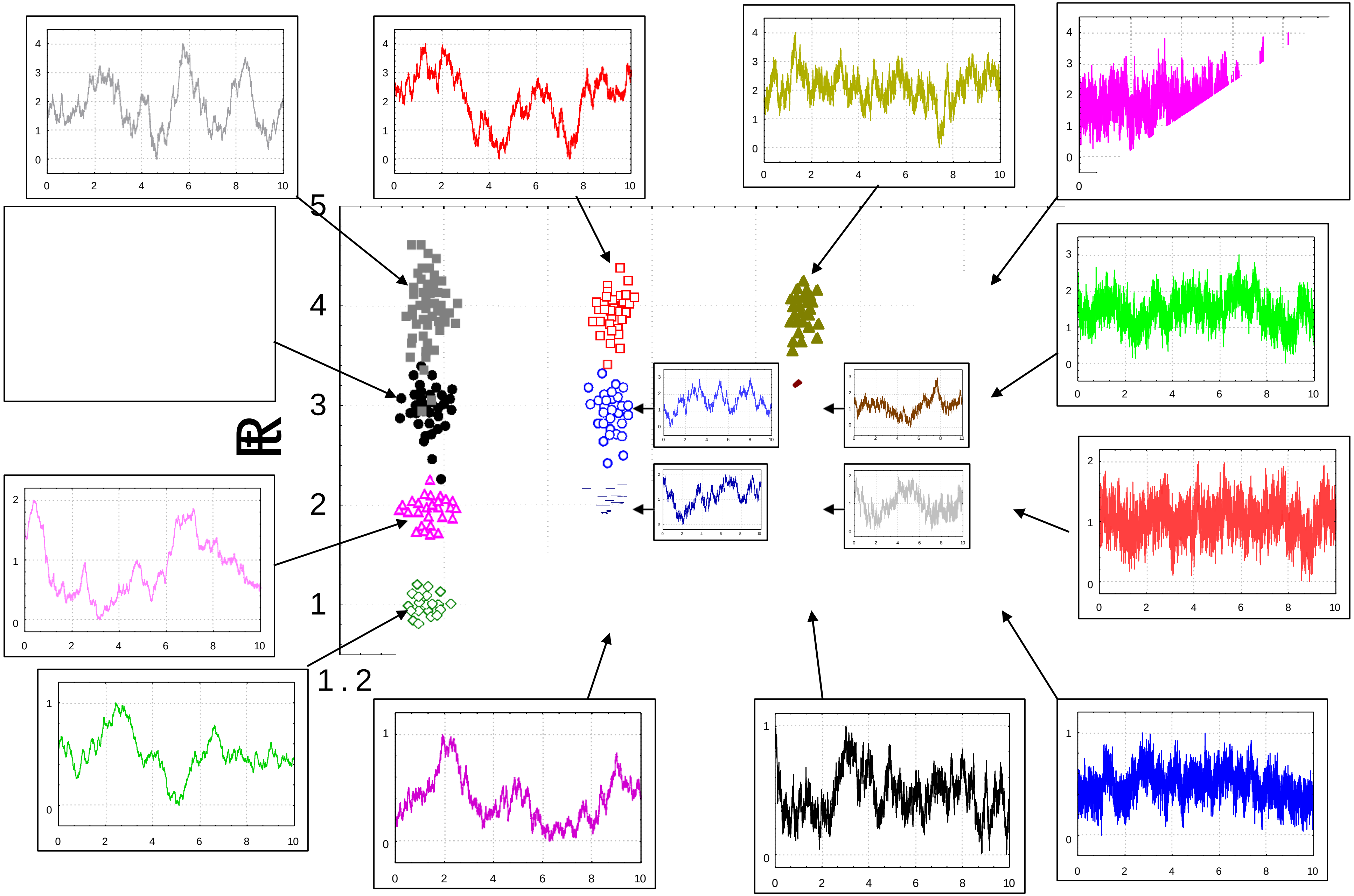
4^{th} Mesrug analysis

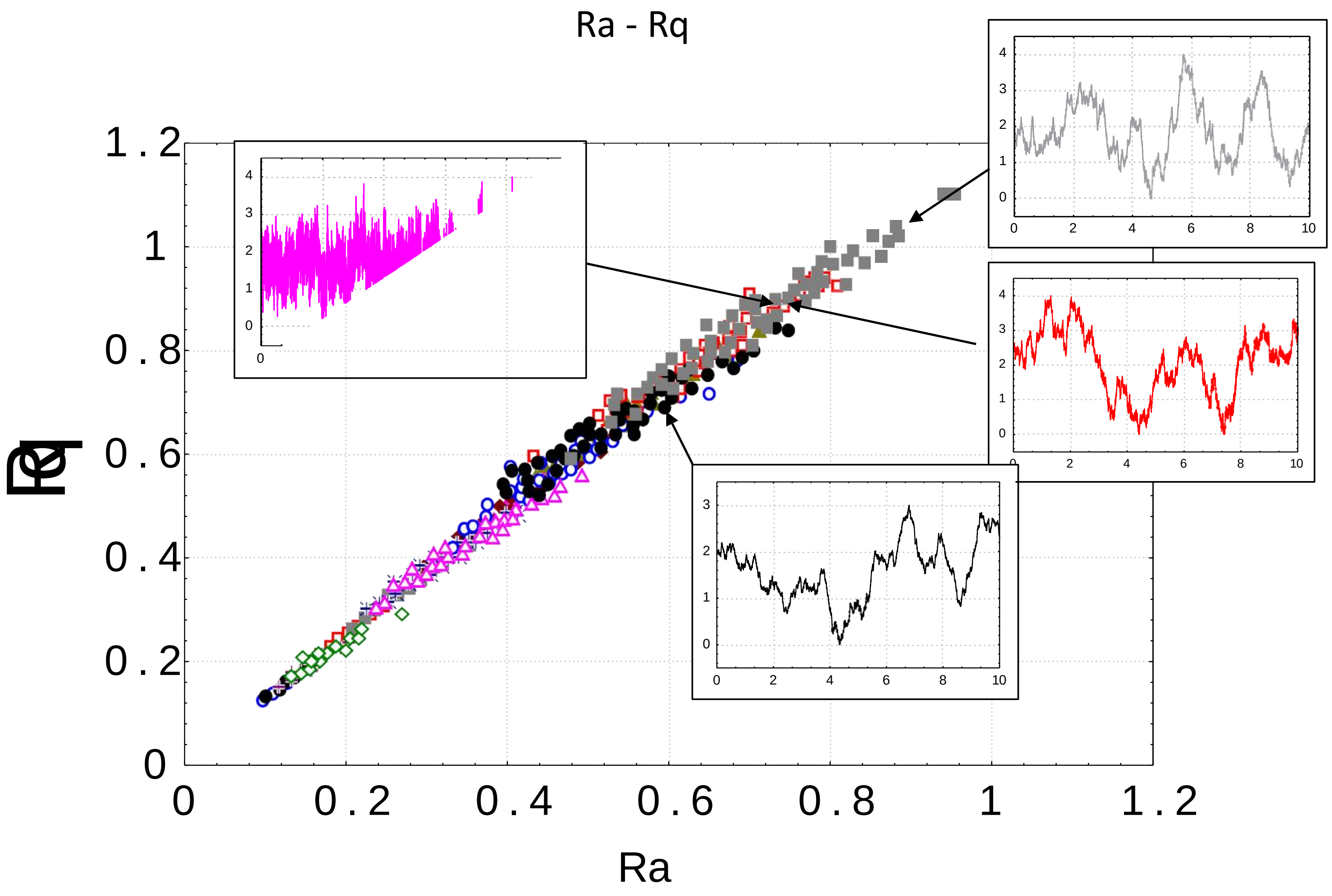
What is the best pair of roughness Parameter to characterize relation between a physical surface properties and surface morphology

Method : Discriminant Analyses on bootstraped data for each pair of roughness parameters

An exemple: Identify the mechanism of scratch generation of a retrieved titanium (TA6V) femoral head through an accurate characterisation of its surface topography

Rt - Fractal Dimension (calculated by the Anam method)





Parameters are correlated, it becomes more difficult to make a clear distinction between each group

parameters

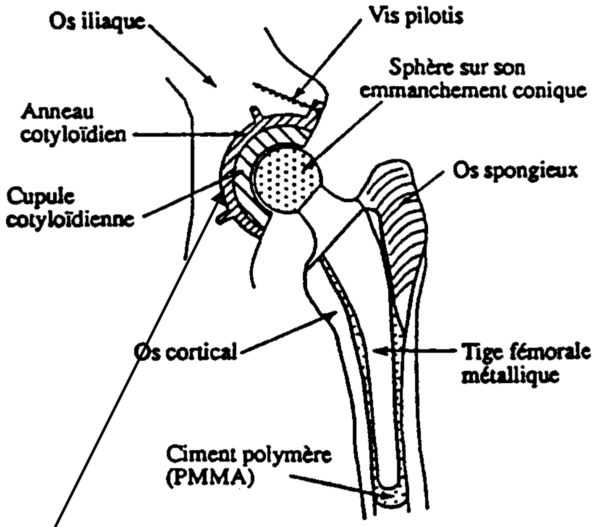
* Percentage of well classified decreases from 99% to 10%

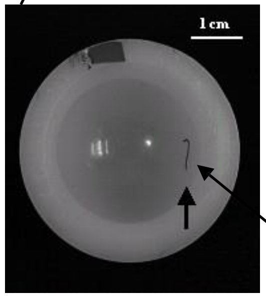
*The best pair parameters that discriminate classes are the Rt and fractal dimensions calculated by four different methods: the oscillation, the structure method and two authors’ methods (AMN and BIGLN).

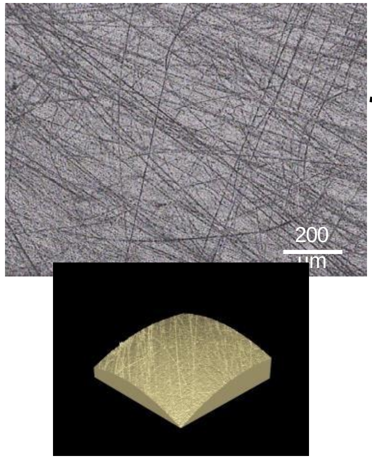
Application to wear of hip prosthesis

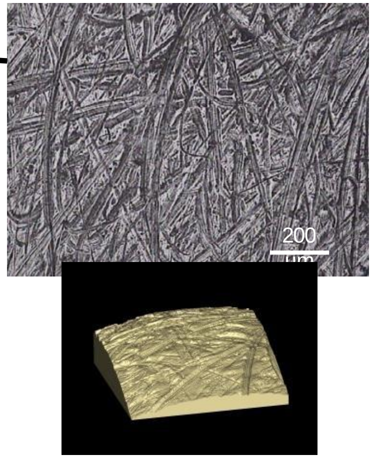
- Objectif: Identify the mechanism of scratch generation of a retrieved titanium (TA6V) femoral head through an accurate characterisation of its surface topography

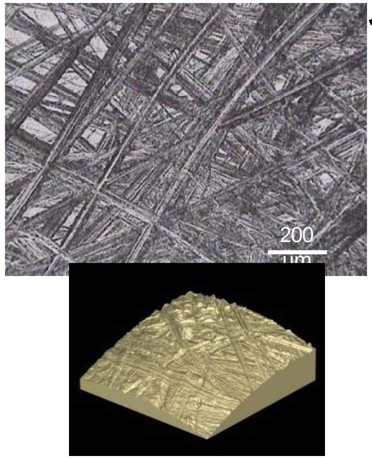
Four damage zones

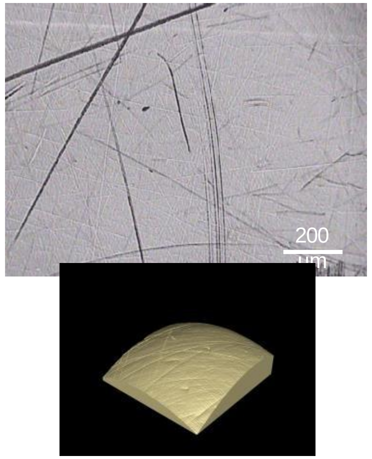




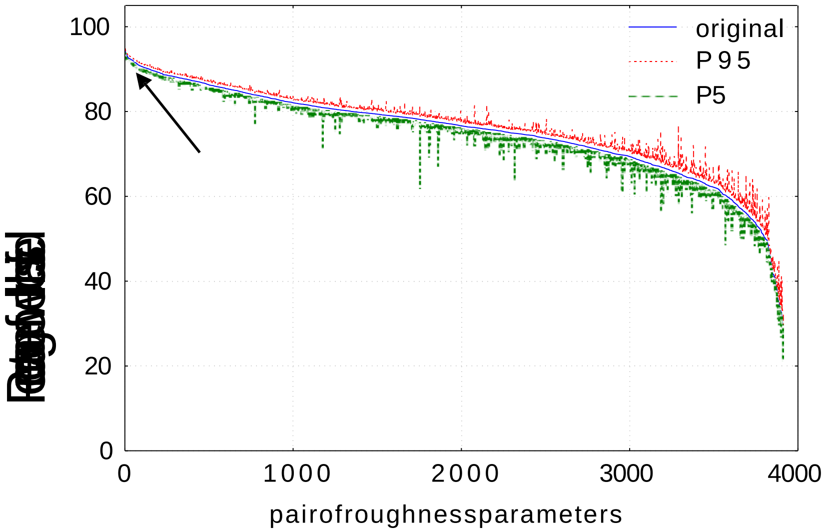


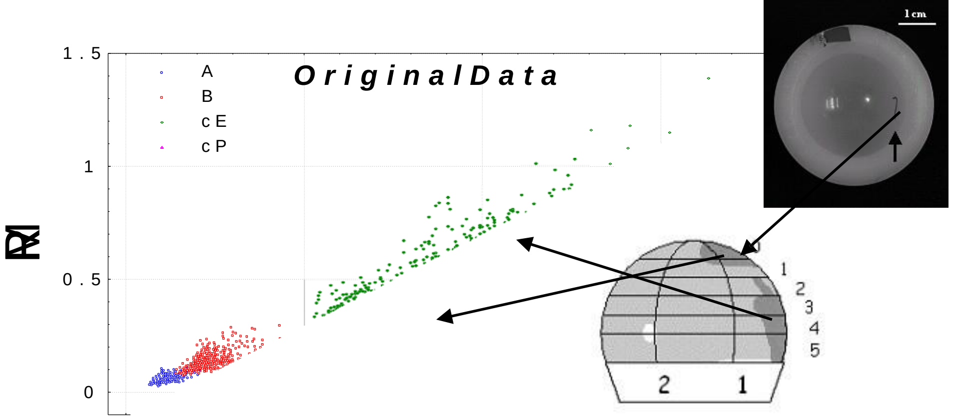






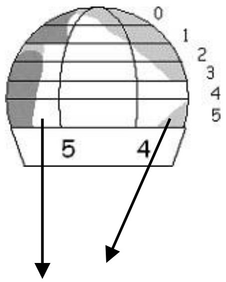
Fibermesh





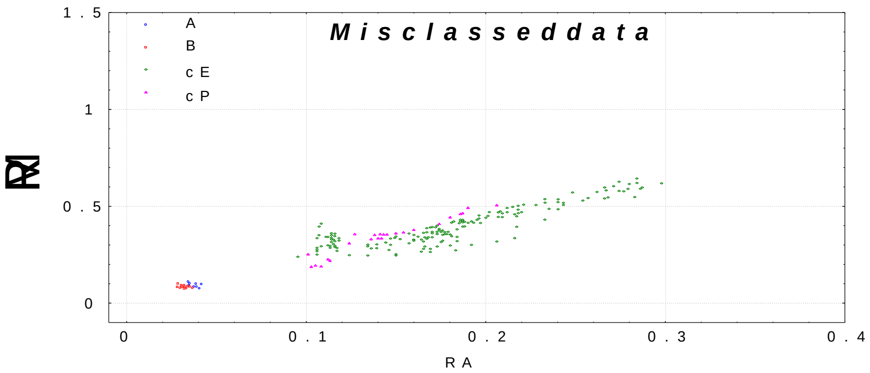
More pertinent pair parameters

Rpm- Ra



RPM : Mean peak amplitude

- 95 % of well classified data.
-For high roughness (CE, CP), both Mean roughness and peaks amplitude are discriminant.



Foreign third bodies on the scratching of metallic femoral heads of the Charnley type prostheses erodes peaks.

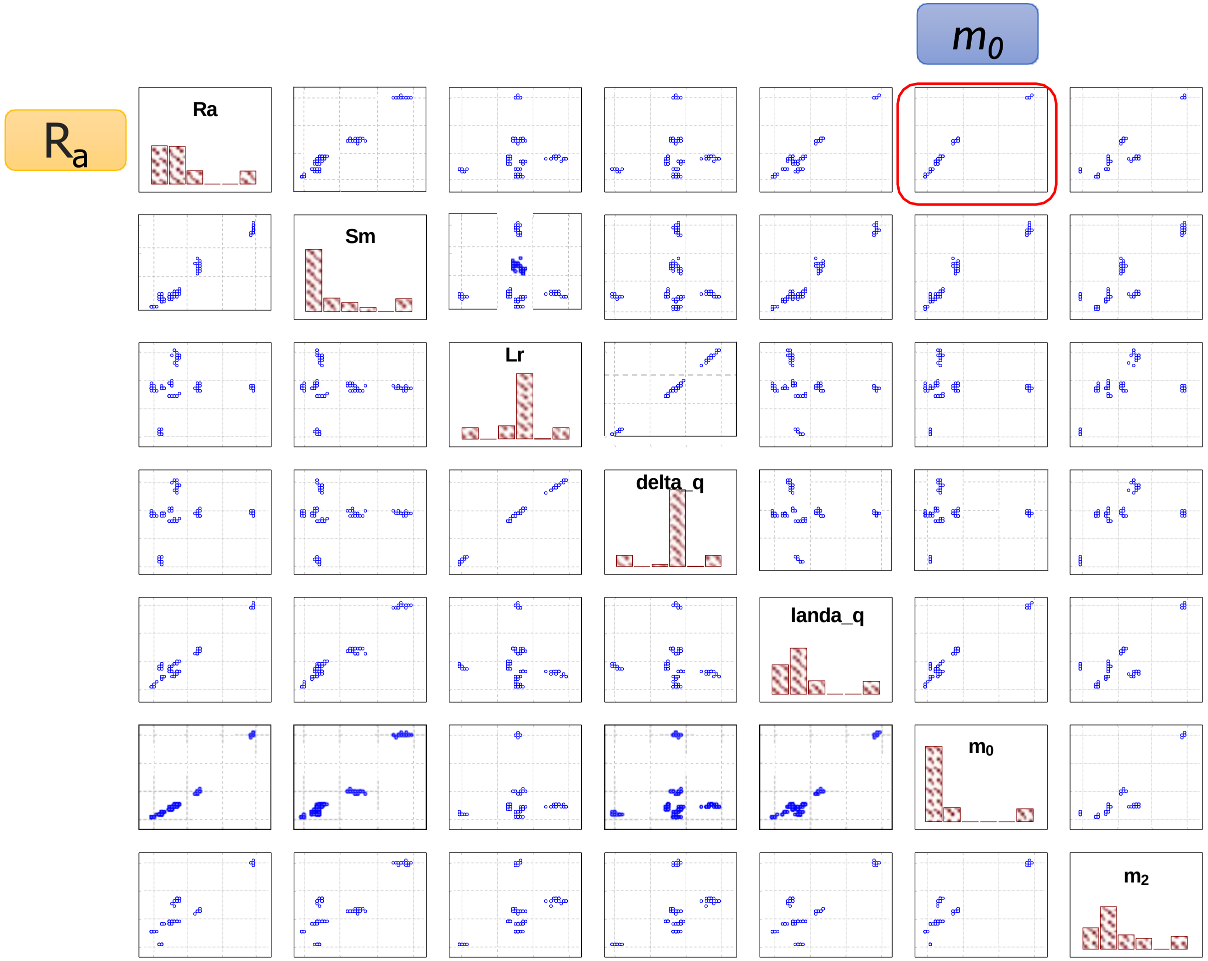
5^{th} Mesrug analysis

What is the best pair of roughness Parameter to characterize on linear relation between a physical surface property and surface morphology

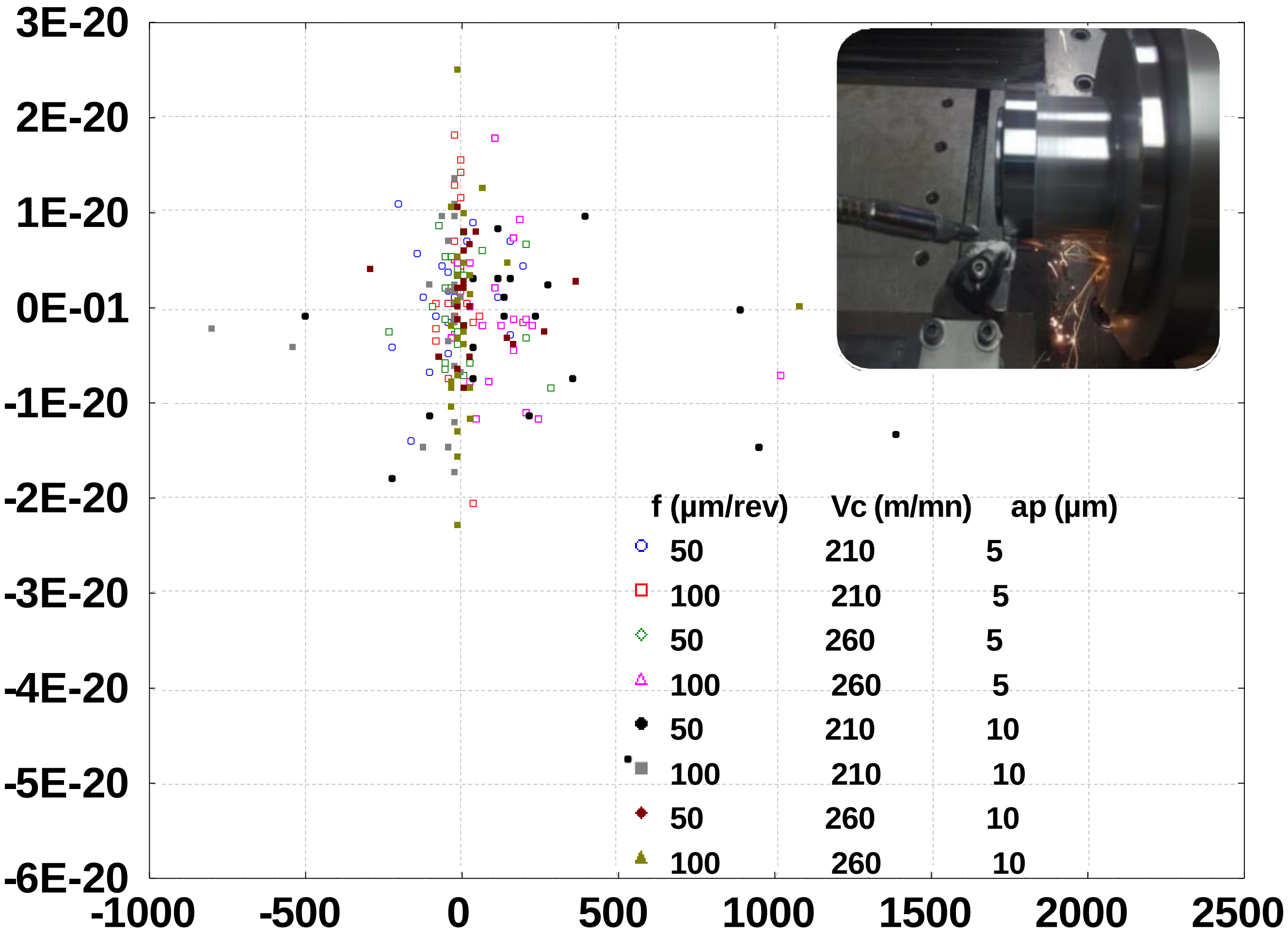
Method : Discriminant Analyses + Correlation analyses on bootstraped data for each pair of roughness parameters

An exemple: High precision tool machining

Some parameters are highly correlated



Low discrimination, low correlation

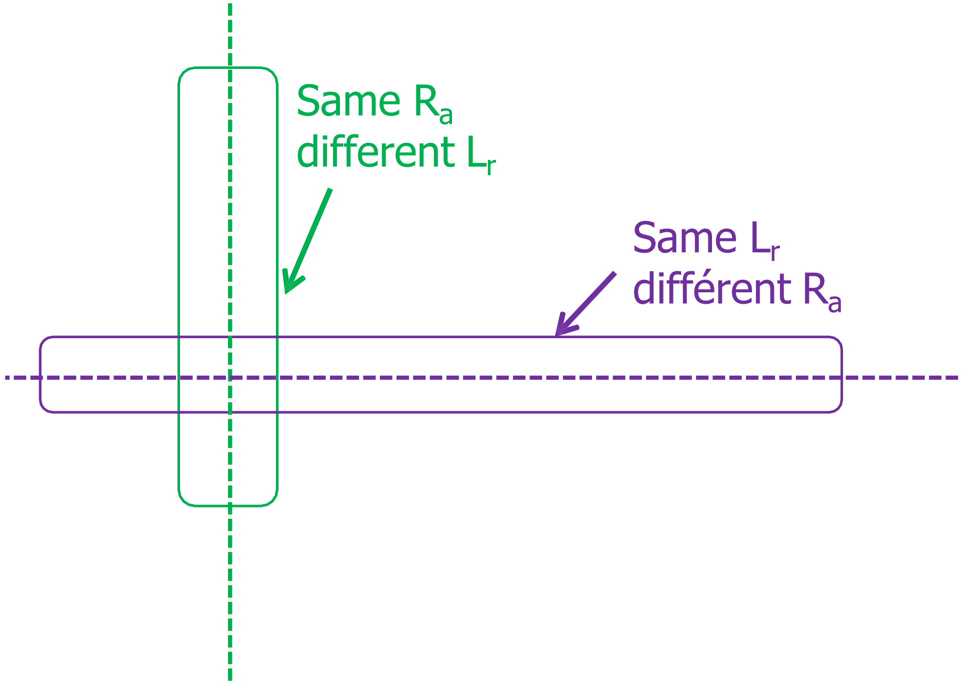


(q_1,q_2)	$I(q_1,q_2)$
(Angle, R_o)	**4.52**

High discrimination, High correlation

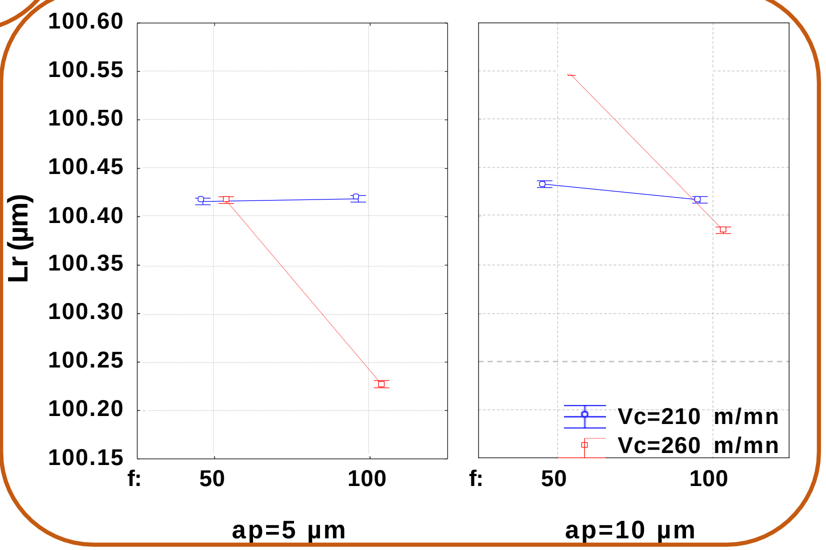
(q_1,q_2)	**$I(q_1,q_2)$**
(m_0, λ_q)	**1.8 10^{110}**

High discrimination, Low correlation



(q_1,q_2)	**$I(q_1,q_2)$**
(L_r, R_a)	**$6.37\ 10^{-11}$**

For a low cutting speed (210 m/min), the value of Ra increases with the feed rate, while the value of Lr is constant.

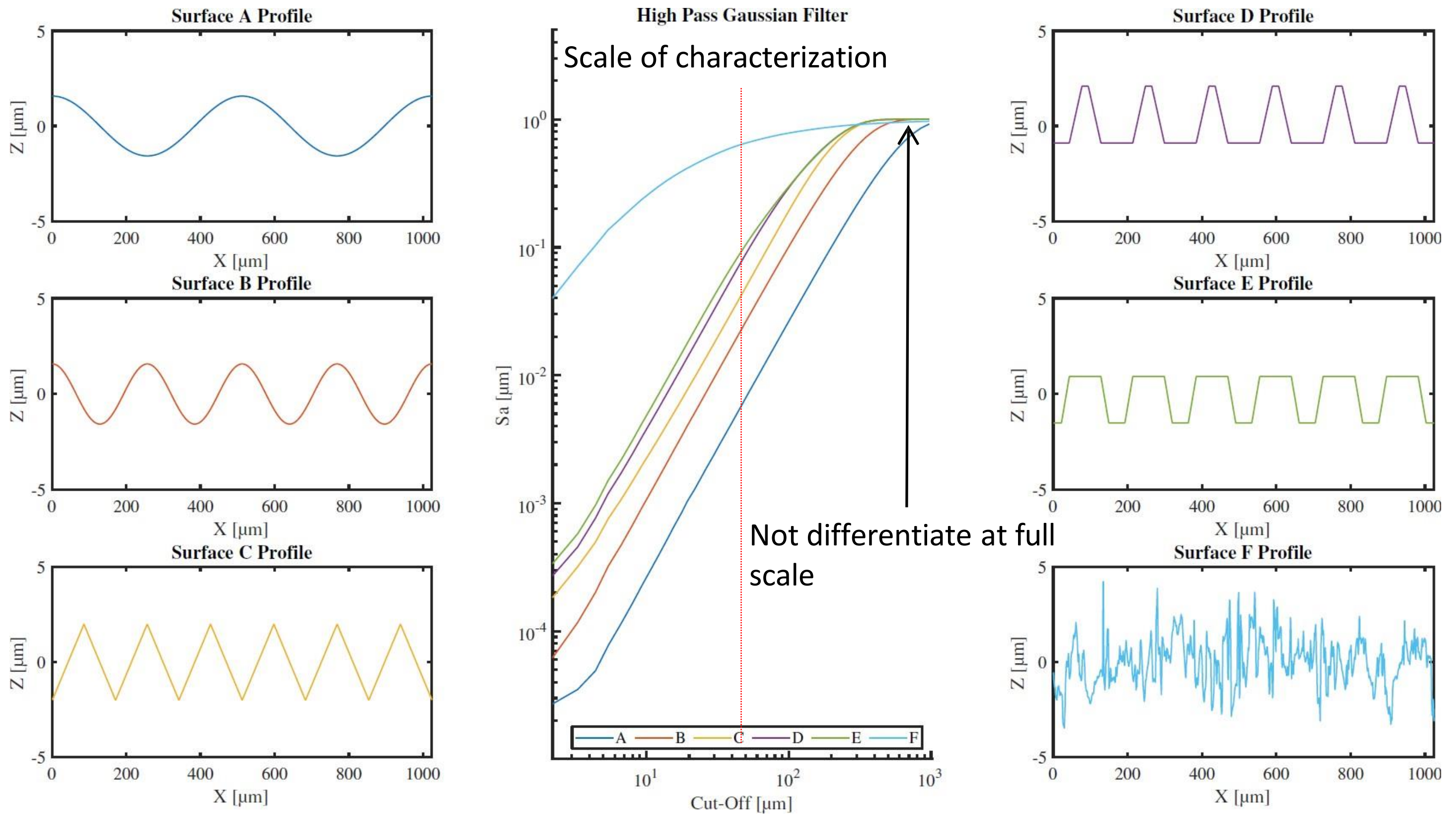


For a high cutting speed (260 m/min), the value of Ra is constant with increasing feed rate, while the value of Lr decreases.

Multi-scale analyses

Multi-scale characterization method: Stick-slip application

- Example multi-scale analysis using Ra parameter (arithmetic mean deviation) to differentiate surface topography with different “profiles”, filtered with High-pass gaussian filter



- Sa more used roughness parameter in surface control in the industry

- Sa doesn’t discriminate surface topography differences at full scale but is able to distinguish all surfaces using multi-scale analysis.

6th Mesrug analysis

What is the best roughness parameter and at which scale must it be evaluated to characterize the effect of the process on the surface

Method : Generalized linear model on bootstraped data for each roughness parameter and each scale

An exemple: Estimate the influence of molding (Polymer) process conditions on parts surface

Multiscale analysis of roughness measurements

The scale pertinence

Multiscale analysis of roughness measurements

Experiment design

Roughness study based on the real case of plastic injection

<u>Purpose :</u>

Estimate the influence of process conditions on parts surface roughness

Influence of 4 parameters was studied :

- Injection temperature (180°C and 250°C)
- Injection speed (5mm/s and 140 mm/s)
- Dosing pressure (5 bars and 15 bars)
- Cooling time (18 s and 55 s)

Multiscale analysis of roughness measurements

Introduction

Experiment design

Roughness analysis

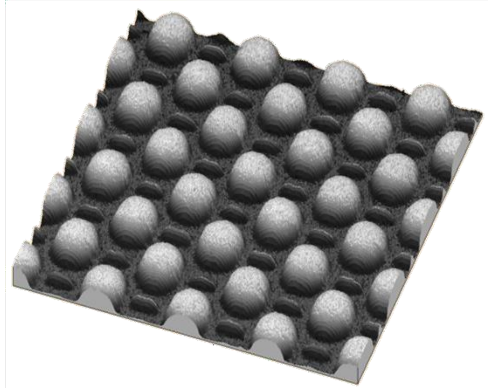
Results

Conclusion

Material and Measurements

Specimens are 20% talc filled polypropylene sheets

The surface of samples is grained to be in the same configuration of a real part (dashboard)

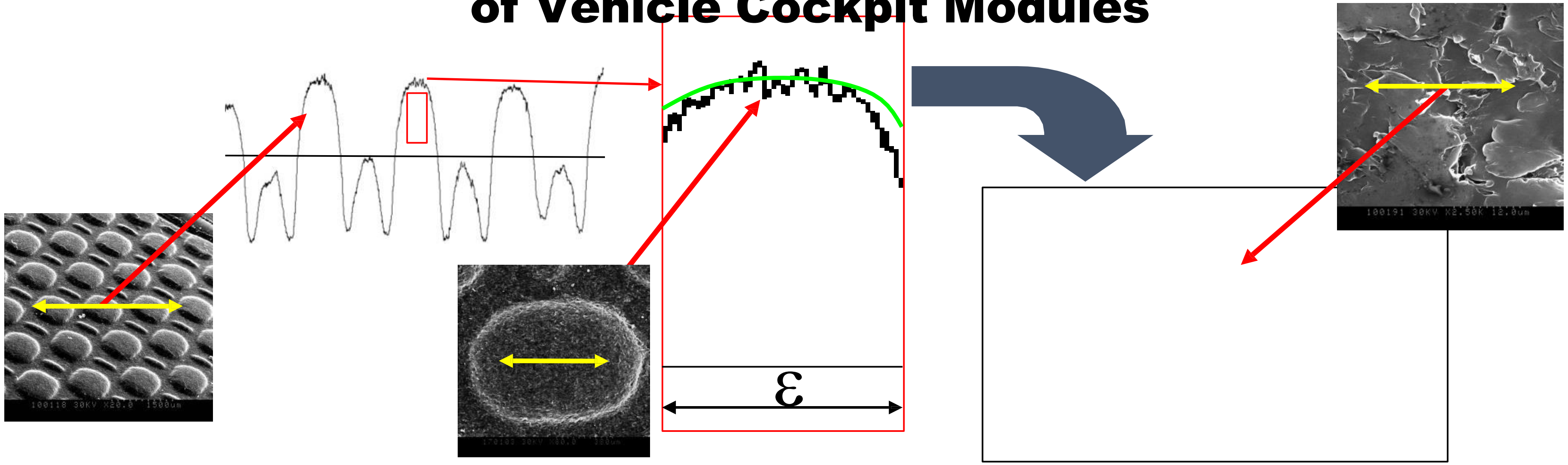


Injection direction

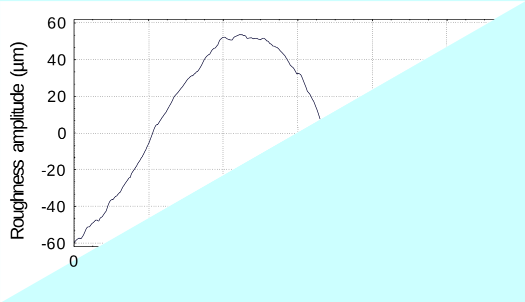
60 profiles were recorded on each configuration with a tactile profilometer 3D KLA TENCOR® P10 with a 1µm stylus radius loaded with 5 mg :

- 30 in the injection direction
- 30 in the perpendicular one

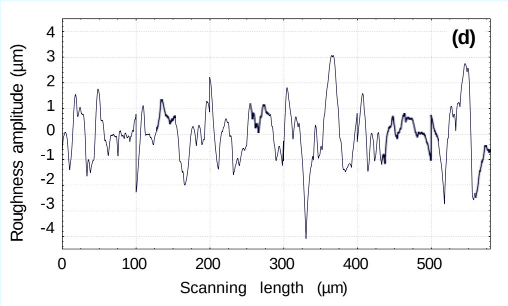
Effect of injection temperature on PP surface roughness of Vehicle Cockpit Modules



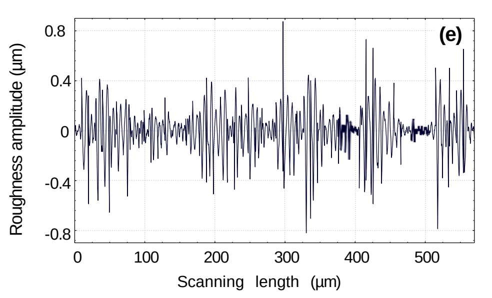
ε = 7950 μm



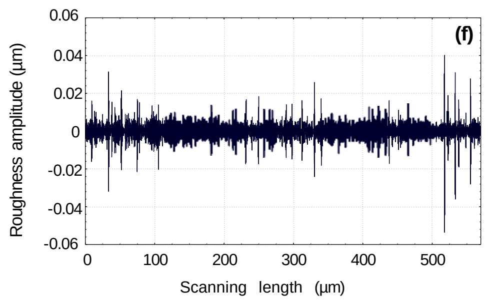
ε = 1000 μm



ε = 100 μm



ε = 10 μm



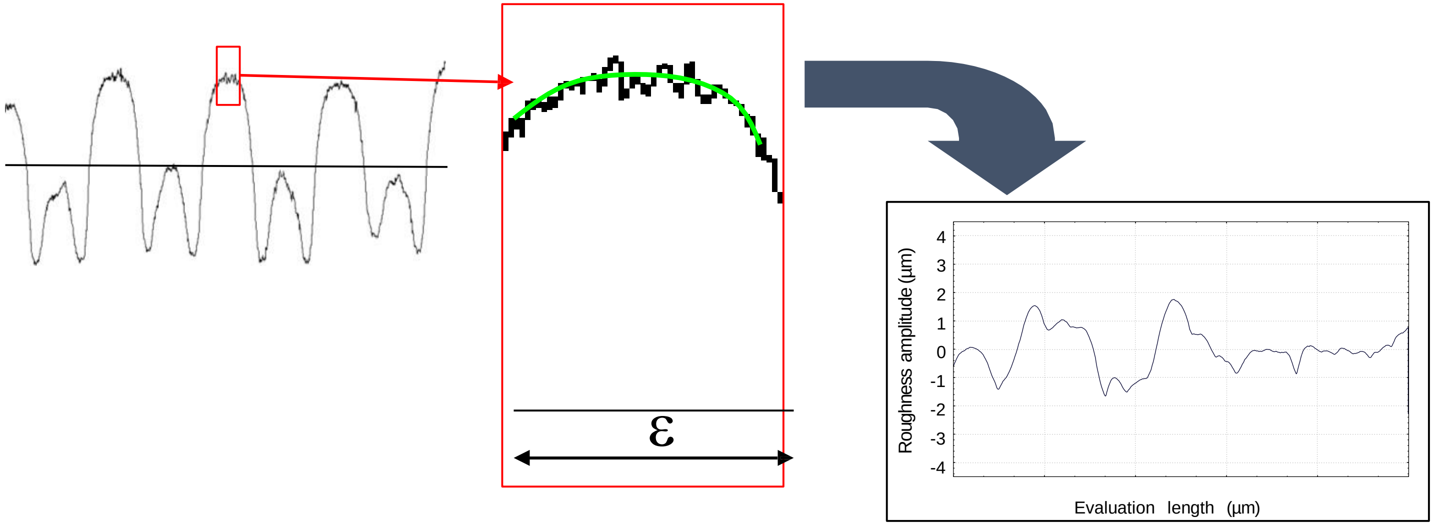
ε = 1 μm

The Evaluation length

Each profile was previously rectified by a third degree polynomial fitting on their total length (8mm)

Considering a current scale ε that define a current window, a second rectification was performed by a polynomial fitting.

Roughness parameters were calculated on the resulting profile, defining values of these parameters at the scale ε.



Multiscale analysis of roughness measurements

Introduction

Experiment design

Roughness analysis

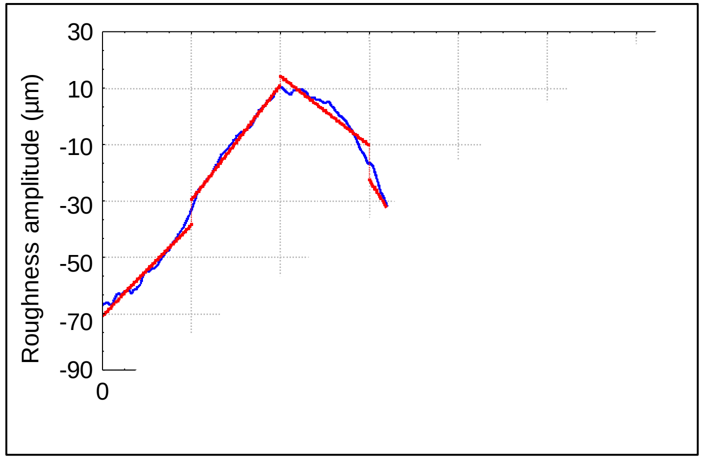
Results

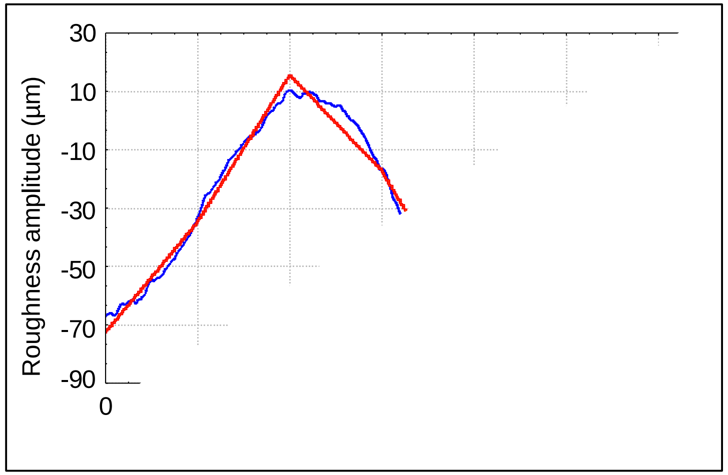
Conclusion

Fitting methods

Two types of fitting were studied :

Discontinuous method





Continuous method

The continuous fitting method was used for the next results

Multiscale analysis of roughness measurements

Introduction

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Roughness analysis

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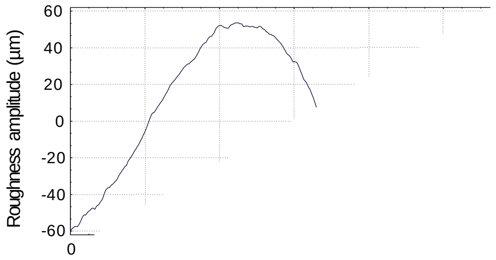
Filter effect of the method

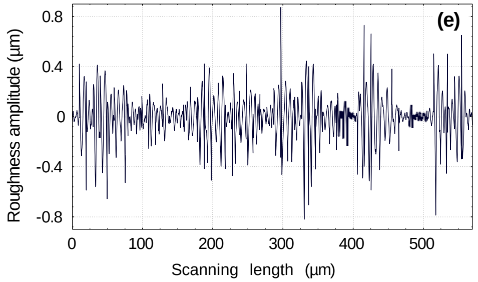
This method corresponds to filter high wavelengths which make the micro-roughness apparent.



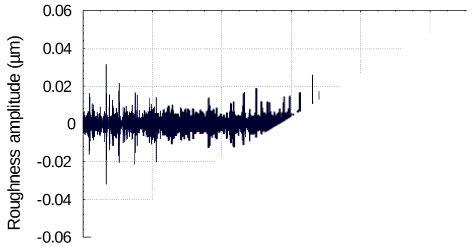
ε = 7950 µm

ε = 1000 µm

ε = 100 µm

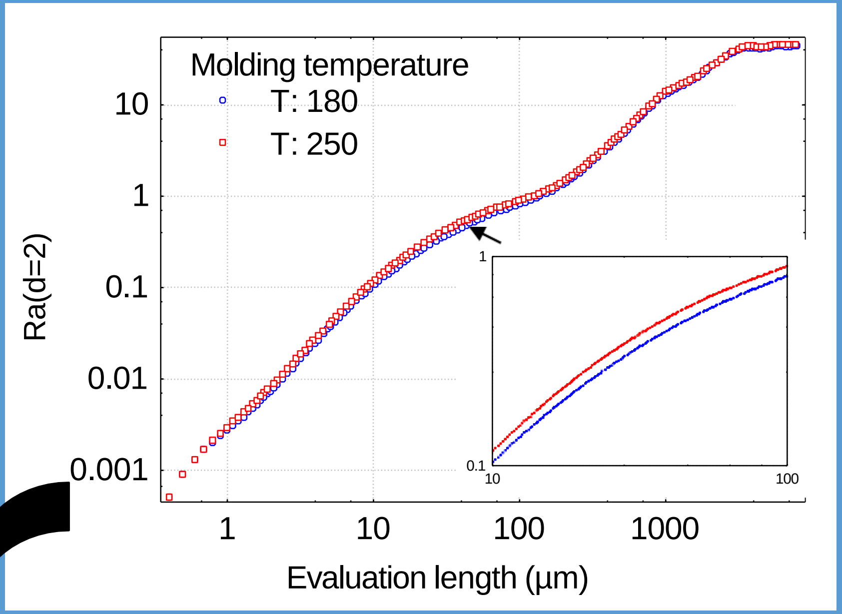


ε = 10 µm

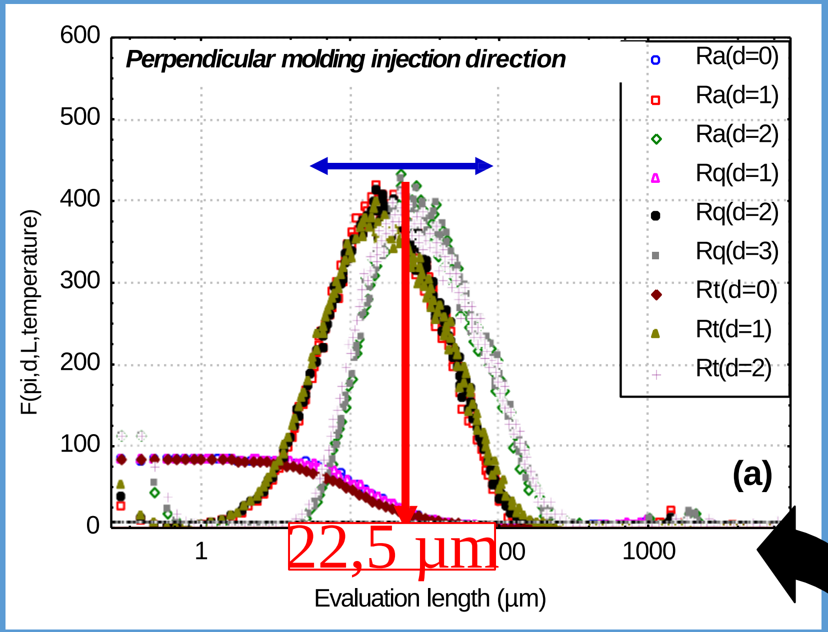


ε = 1 µm

Multiscale roughness parameter



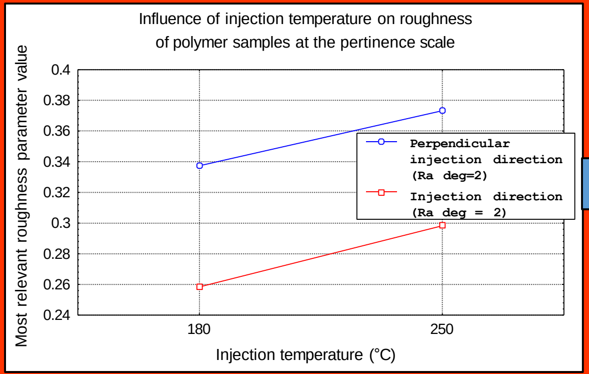
Graph of relevance of the scale



Relevance function (experimental design)

$$p_i(d,L,k_1,k_2,\cdots,k_p,n)=\alpha_0+\sum^{p}\alpha_{j,k}\,(i,d,L)+\sum^{p}\quad p$$

Temperature effect on Ra at 22.5 µm



Profiles at the maximal value of relevance