



AFU Ludine
GROUNDBREAKING TECHNOLOGY



Groupama • FDJ
ÉQUIPE CYCLISTE

Analysis method of surface roughness

Focal-variation microscopy approach

M. COGNARD

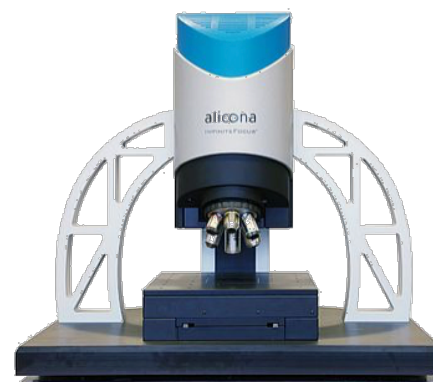
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X. ROIZARD

S. BERGERET



- **Located in Dole**
- **Social capital: 75 202€**
- **Staff : 12**





AFU lab

- Expert in surface analysis
- Non-destructive method
- Knowledge of professional sport

AFU dev

- Research & Development Lab
- Partnership with teams
- Boost sport technology

AFU chem

CHEMICAL PRODUCTS

- Enhance the performance
- Reduce friction and wear
- Stabilize the effort



SUMMARY



Context of the study



Presentation of the
analysis method



Introduction to FV
Microscopy



Results & discussion





Context of the study

THE ACTORS



- Enacts rules for cycling disciplines
- Fight against doping (chemical & mechanical)



- 1st French engineering Lab
- Specialized in tribology
- Specialist in mechanical performance



Groupama • **FDJ**
ÉQUIPE CYCLISTE

- Knowledge of the textile
- Profesional cycling team
- Specialist in performance

- R&D Lab specialized in surface treatment
- Chemical products & performance

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CONTEXT OF THE STUDY

- **Methodology** : from regulation to control & expertise

UCI Cycling Regulations

PART 1 CHAPTER 3
EQUIPMENT
§1.3.033



RIDER'S CLOTHING

- Morphology : threading, weaving or assembling
- Original texture
- No self-supporting element or rigid parts



MEASUREMENT

The measure of surface roughness modification shall be made without pressure or traction on the clothing.



METHOD

- Optical
- Non-Destructive
- Fast
- Replicable



ANALYSIS

- Certification
- Control
- Expertise



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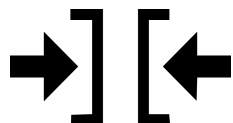
Regulation

Constraint

Specification

Understanding

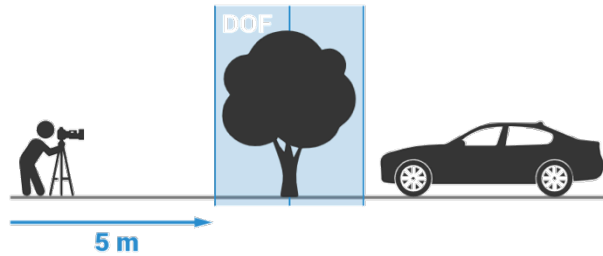
Control



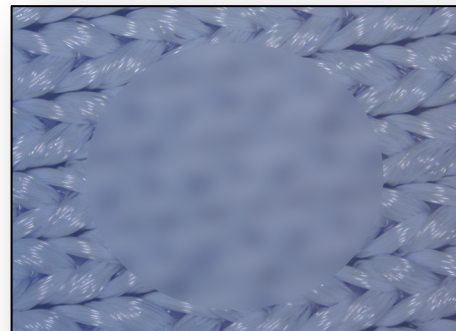
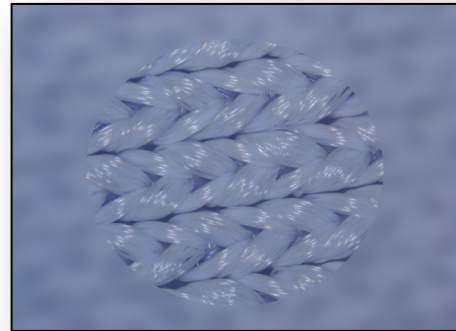
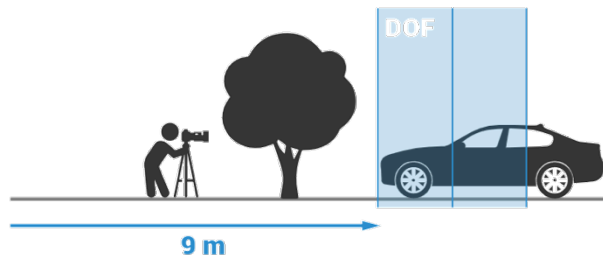


Focal-Variation Microscopy

Focal-Variation Microscopy



↓
Focal sweep



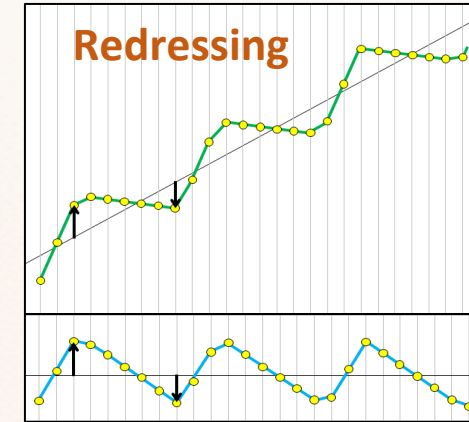
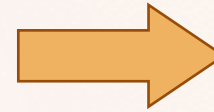
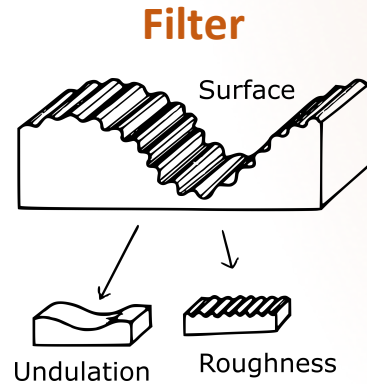
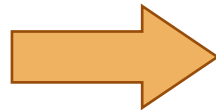
Reconstituted 3D Image

Technical Specifications

Measurement principle : *non-contact, optical, three-dimensional, based on Focus-Variation*

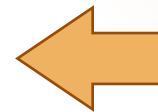


x 5 → x 20

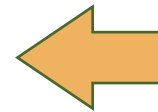


Min detectable roughness

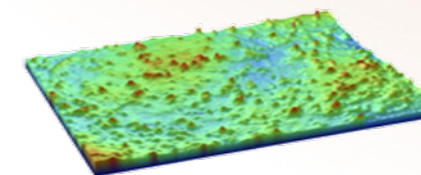
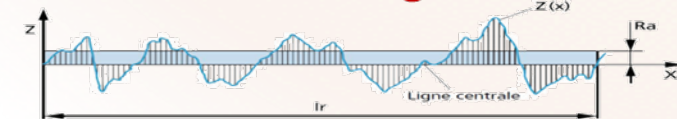
1,2 μm



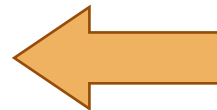
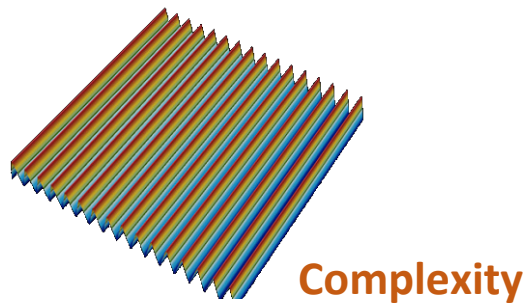
0,6 μm



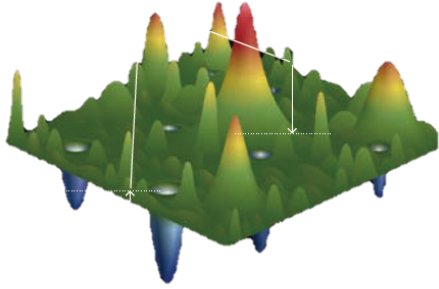
Ra : Profile roughness



Sa : Area roughness



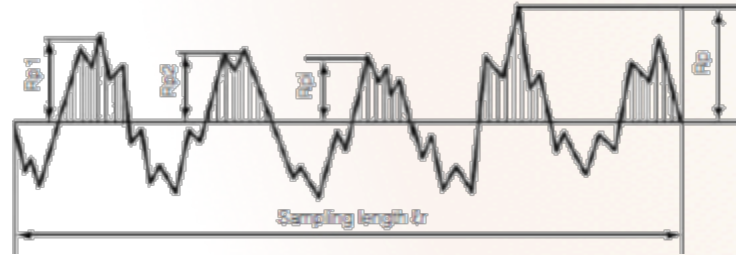
Technical Specifications



Sa : Average Height / Roughness



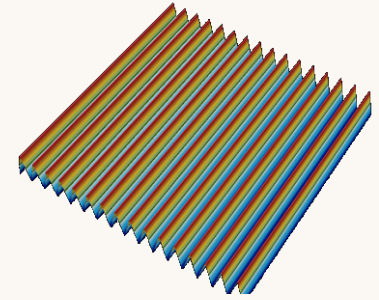
Precision 1000 times higher
than UCI's recommendation



S10Z : Maximum height of 10 peaks



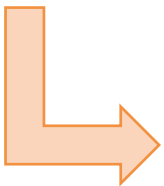
Evaluation of singularities
Spatial repartition



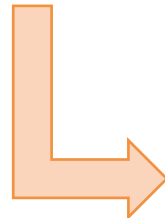
Sdr : Complexity
Developed Interfacial area Ratio



Evolution of the threading
Modification of original texture



The precision of the measurement is adapted to the constraints of the UCI



How to adapt this technology to UCI's specifications ?



Method of Analysis

STEPS OF VALIDATION

1

AIM OF THE STUDY

Develop a method to control the morphology of items of clothing. Measure the surface roughness.

2

DATA & CONFIGURATION

- Jerseys and full suits
- No traction or pressure
- New jersey – after race ?

3

MEASURES & UNCERTAINTIES

- Non-destructive method
- Measurement accuracy
- Rapid and effective procedures

4

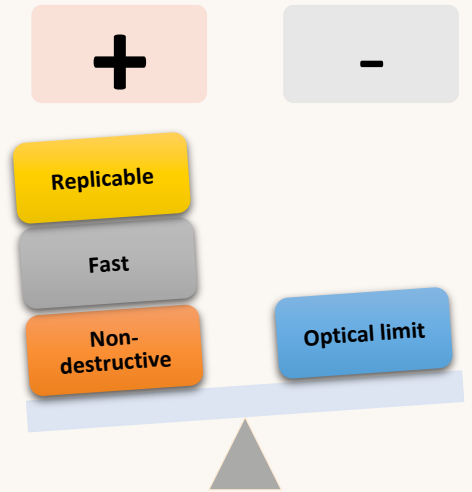
REPLICABILITY

- 5 points of measurement
- Evaluate the deviation
- Analyze sample 'B'

5

VALIDATION

- Certification of jerseys





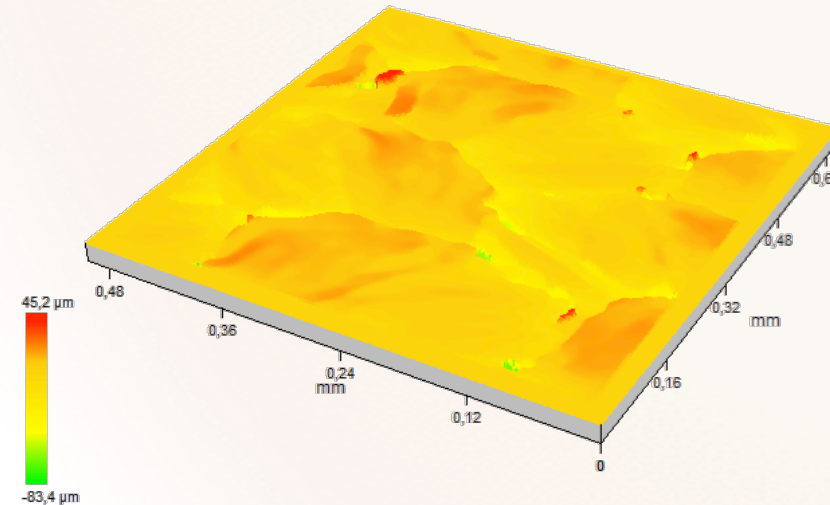
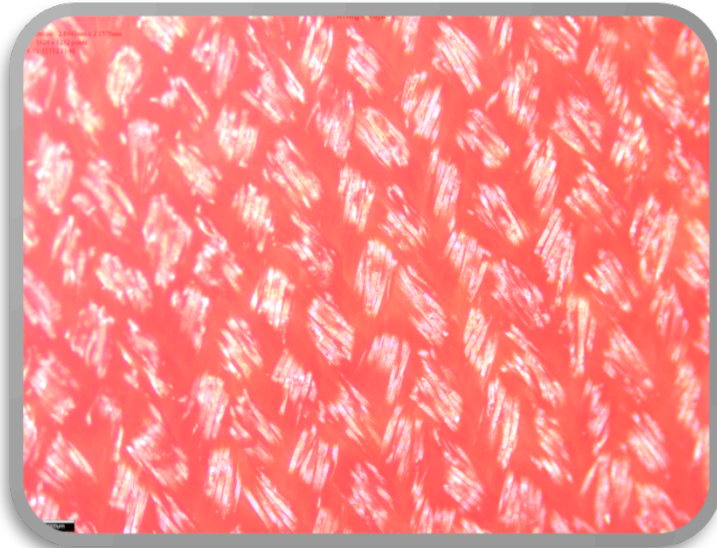
Results & Discussion



Experimental results



Sample 1 – Low complexity



Low complexity
Sdr = 46,3 % ± 3,3 %

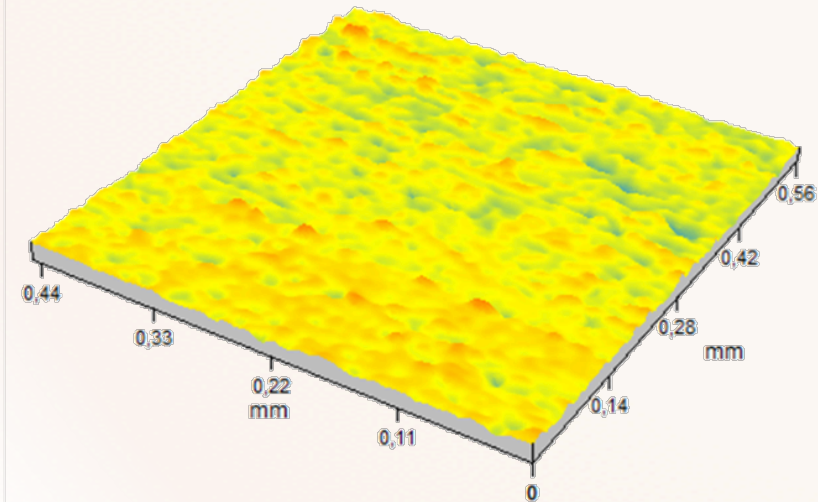
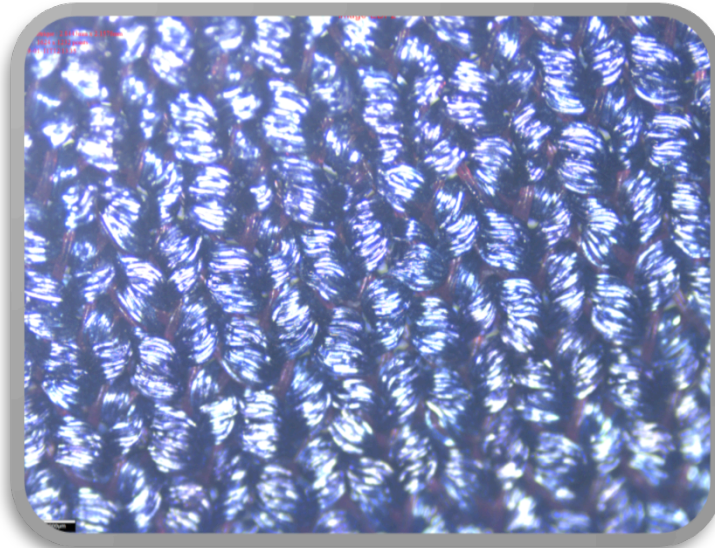
Roughness
Sa = 4,6 μm ± 2 %

Max peak height
S10Z= 0,1 mm ± 3 %

Experimental results

Sample 2 – Medium complexity

APPROVED



Medium complexity

Sdr = 118,3 % \pm 5,5 %

Roughness

Sa = 6,0 μm \pm 2 %

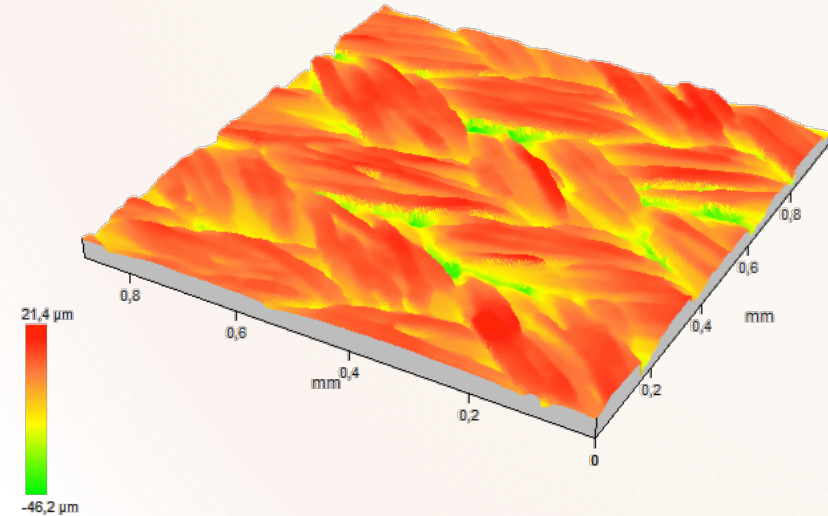
Max peak height

S10Z = 0,1 mm \pm 4 %

Experimental results

APPROVED

Sample 3 – High complexity



High complexity
Sdr = 386 % ± 3,7 %

Roughness
Sa = 32,1 μm ± 1 %

Max peak height
S10Z= 0,5 mm ± 3 %

Discussion

New method of analysis

- Accurate whatever complexity
- Quantitative & Qualitative data
~~~~~
- Experimental plan for validation
- Sensibility & replicability of the measure
- Validation by the competent authorities

*“Modifications to the surface roughness of clothing are authorised but may only be the result of threading, weaving or assembling of the fabric.”*

- Which basis garment? Start of the season?
- Evolution of the database

1

2

*“Surface roughness modifications shall be limited to a profile difference of 1mm at most.”*

- Roughness max: 1mm  
Uncertainty ? Replicability?
- Average height ( $S_a$ )? Max peak height ( $S_{10Z}$ )?



3

4

*“Items of clothing [...] of which the purpose is not exclusively clothing or protection, is forbidden.”*

- Impact of roughness on performance ?
- Database of surface condition
- Specification of protection / clothing



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# Analysis method of surface roughness

## Focal-variation microscopy approach

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