



## Texturation et fonctionnalisation de surface au sein de MANUTECH

Yves JOURLIN, [yves.jourlin@univ-st-etienne.fr](mailto:yves.jourlin@univ-st-etienne.fr)



Nicolas COMPERE, [nicolas.compere@manutech-usd.fr](mailto:nicolas.compere@manutech-usd.fr)



<https://manutech-sise.universite-lyon.fr/>

<https://www.manutech-usd.fr/>



**LABEX**  
**MANUTECH-SISE**  
UNIVERSITÉ DE LYON



**anr** ©  
agence nationale  
de la recherche

---

Introduction to Labex Manutech SISE

GIE Manutech facilities and projects

Examples of Labex's projects (ongoing and completed)

Introduction to Labex Manutech SISE

GIE Manutech facilities and projects

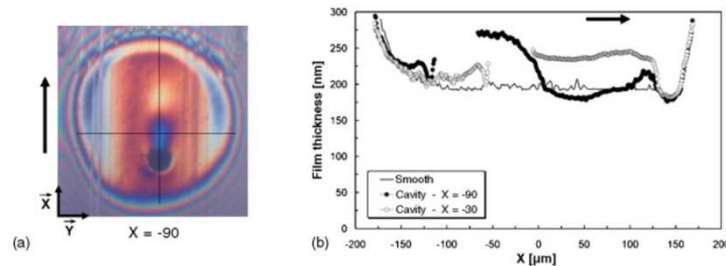
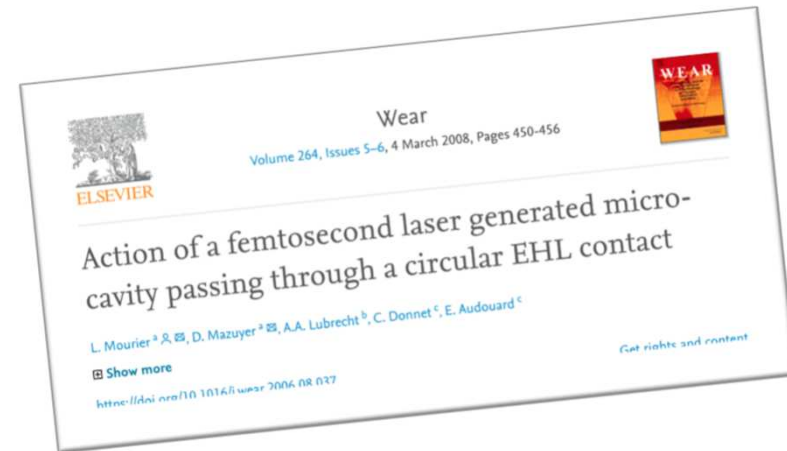
Examples of Labex's projects (ongoing and completed)



2005 – 2008 : First studies of Manutech

**PhD thesis Louis MOURIER 2007**

- D. MAZUYER 
- A.A. LUBRECHT 
- C. DONNET 
- P. MAURIN-PERRIER 





# LABEX MANUTECH-SISE UNIVERSITÉ DE LYON



## Introduction to Labex Manutech SISE

### The **MANUTECH** success story...

2009 →

- Partnership from 1<sup>st</sup> joint PhD L. Mourier 2007:



- 2009 : Launch of initiative MANUTECH

2011 →

- EQUIPEX MANUTECH-USD
- LABEX MANUTECH-SISE
- Surface Engineering
- Advanced Manufacturing
- Public-Private Consortium:



- Alliance Lyon St-Etienne

2015 →

- European position of our labs



- MANUTECH covers over 6: Advanced material, Photonic Manufacturing

- Integration in COM Lyon- St-Etienne



- In the National Research Strategy (NRS)



La Recherche, N° 560 Juin 2020



**LABEX  
MANUTECH-SISE**  
UNIVERSITÉ DE LYON



**anr** <sup>©</sup>  
agence nationale  
de la recherche

## Introduction to Labex Manutech SISE



*Surface and Interface Science Engineering*

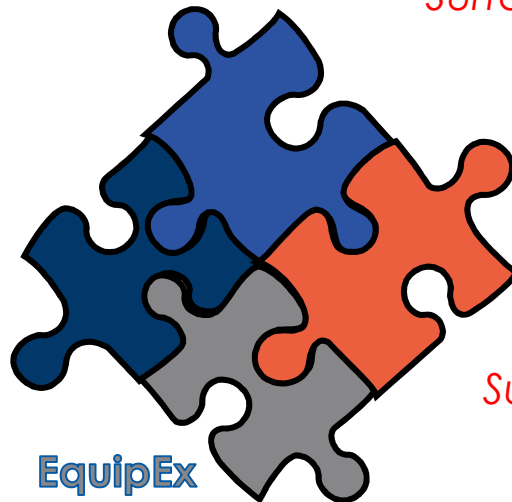
**Ecole Universitaire de Recherche**



**CREATIS**

*Surfaces Light Engineering – Health & Society*

**Formation**



**EquipEx**

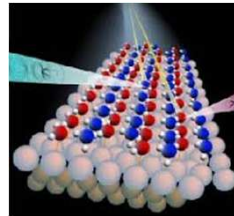
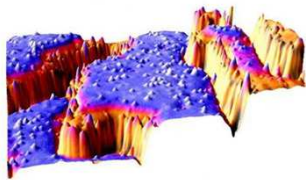


*Ultrafast Surface Design*



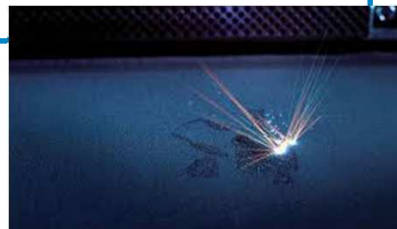


## 2011-2019 to 2020-2024



- Physico-chemistry
- Manufacturing technologies
- Material science

Needs



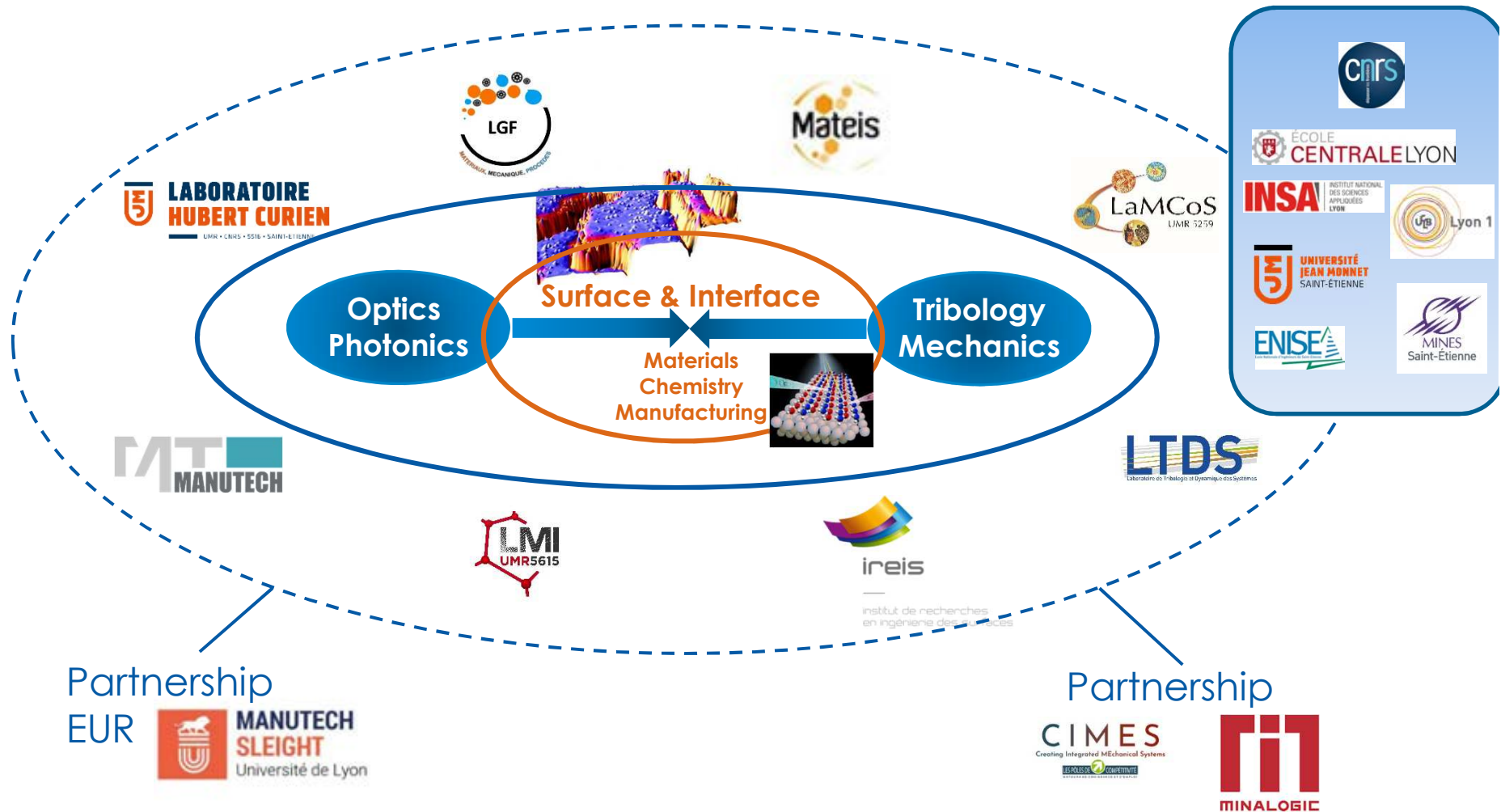
## LABEX 20-24

- 4 new scientific Axes
- 3 new partners
- Towards prototypes
- Label "MANUTECH"





## Introduction to Labex Manutech SISE

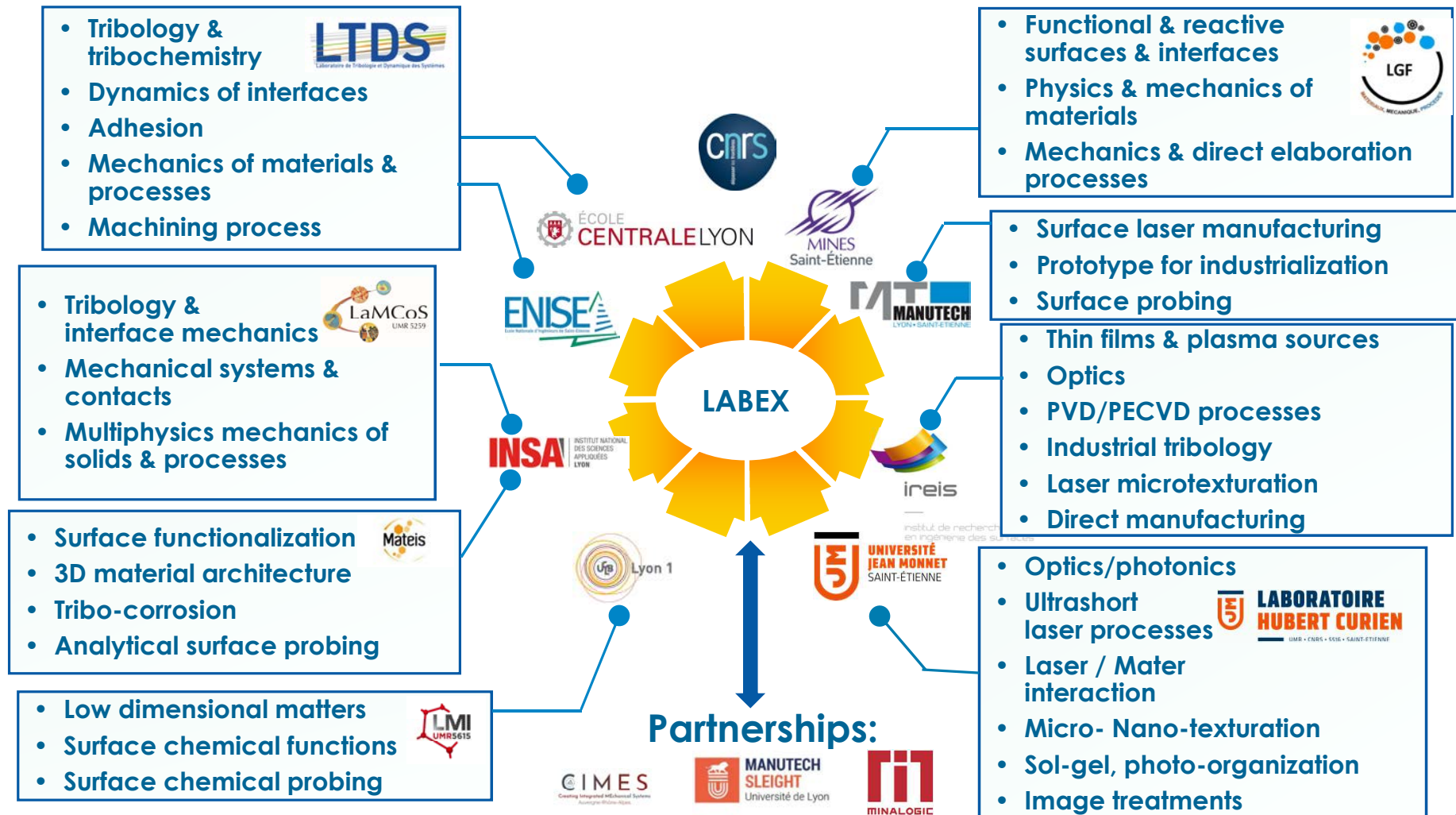






## Introduction to Labex Manutech SISE

### Skills and know-hows of the LABEX MANUTECH-SISE 2020-2024 partners





## Scientific objectives

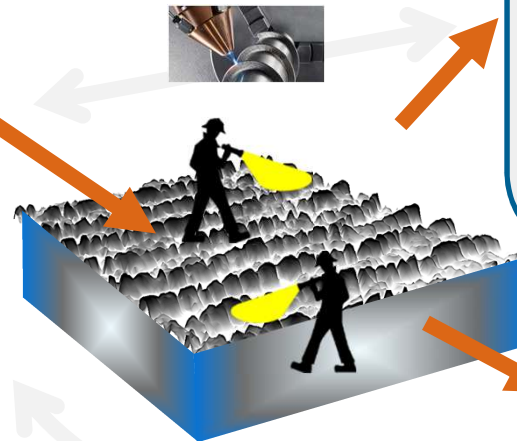
### Modification/conception de surface

Procédés laser, mécanique, chimique, dépôt, FA, fonctionnalisation...

...

Sous contraintes (mécanique, température, milieu...)

...



### Caractérisation / sonde

- Directe / localisée (microscopie, analyse structures, rugosité, dureté..)
- Indirecte (réponse)
- In operando, in situ, Ab Initio (Dynamique des processus/mécanismes)

...



### Propriétés / fonctions

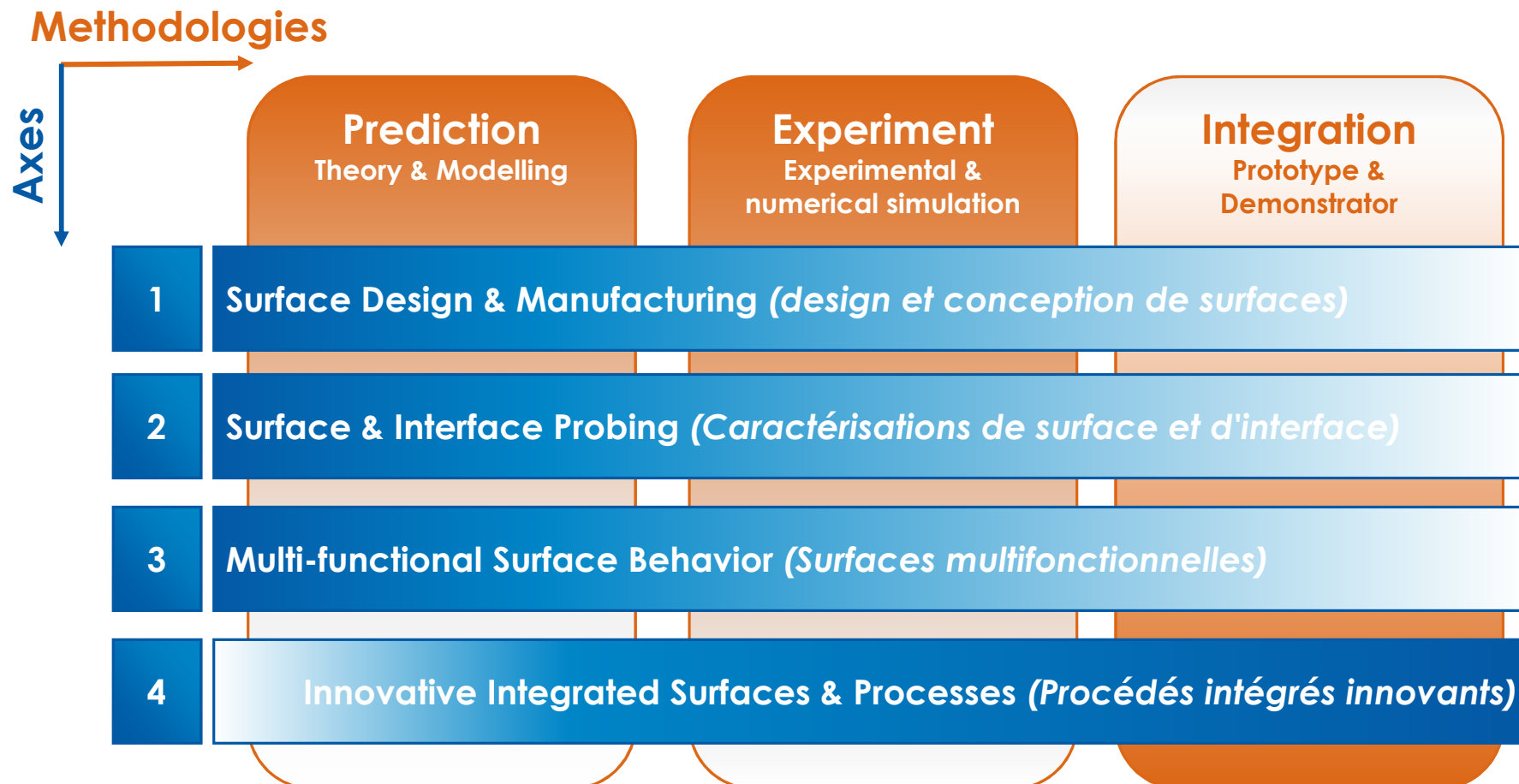
- Mécaniques (tribologie, frottement, usure, dureté...)
- Optique (couleur, capteur, transparence, absorption...)
- Chimiques / Physiques / physico chimiques (mouillabilité, adhésion, sensoriel...)

...

*Energie, santé, éco mobilité, perception sensorielle, capteur, couleurs...*



Axes





**LABEX**  
**MANUTECH-SISE**  
UNIVERSITÉ DE LYON



**anr** ©  
agence nationale  
de la recherche

---

Introduction to Labex Manutech SISE

GIE Manutech facilities and projects

Examples of Labex's projects (ongoing and completed)



**LABEX  
MANUTECH-SISE**  
UNIVERSITÉ DE LYON



**anr**®  
agence nationale  
de la recherche

GIE Manutech facilities and projects

---



GIE MANUTECH USD

FEMTO-SECOND LASER EUROPEAN PLATFORM

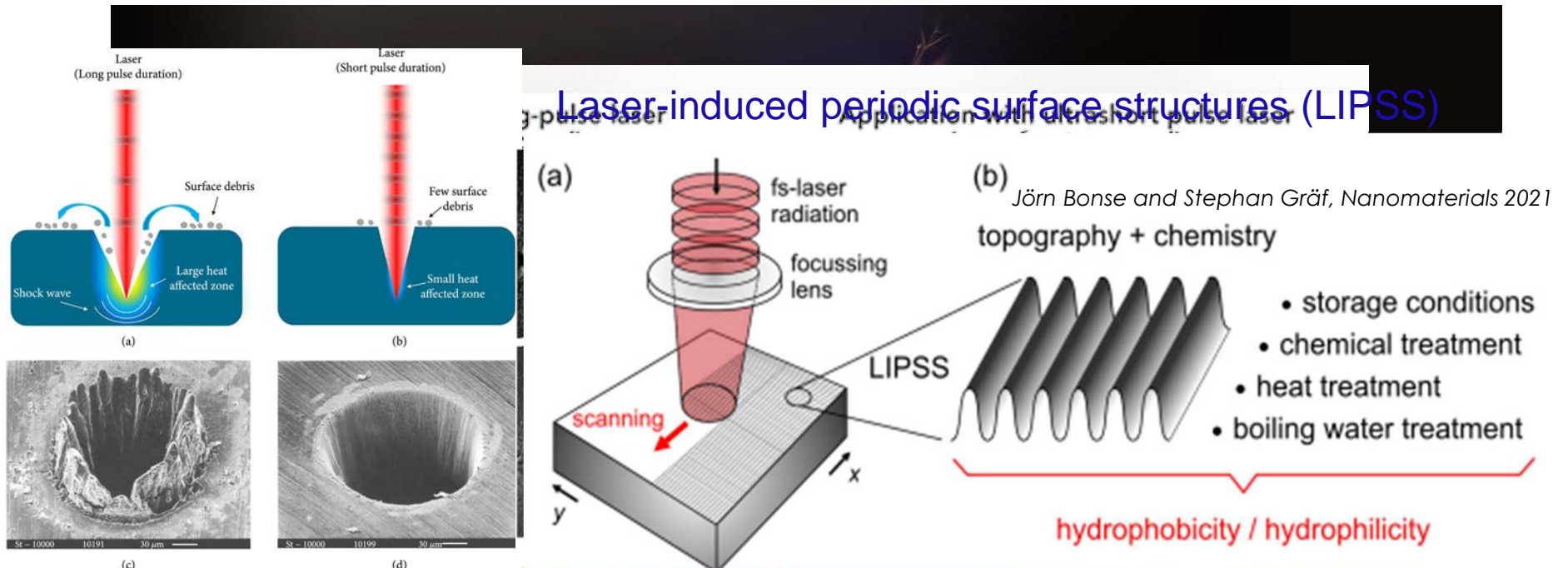
**Which tool is able to sublimate all kind of materials  
with micrometric precision?**

Nicolas Compère Vice-Président

[nicolas.compere@manutech-usd.fr](mailto:nicolas.compere@manutech-usd.fr)



## Laser-induced periodic surface structures (LIPSS)

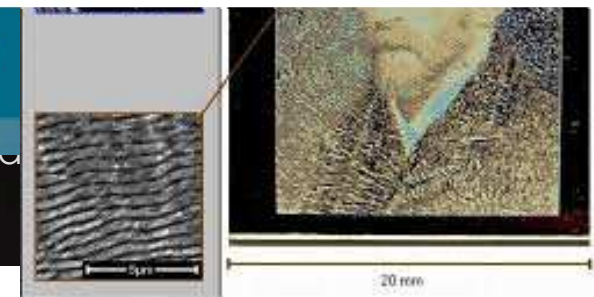


heat transfer to surrounding material

No shock waving

reproducibility and minimization of thermal effects.

Stephen Hypsh, Geoff Shannon, Laser Focus World, 2015



Dusser et al, Optics Express 2010



**LABEX  
MANUTECH-SISE**  
UNIVERSITÉ DE LYON



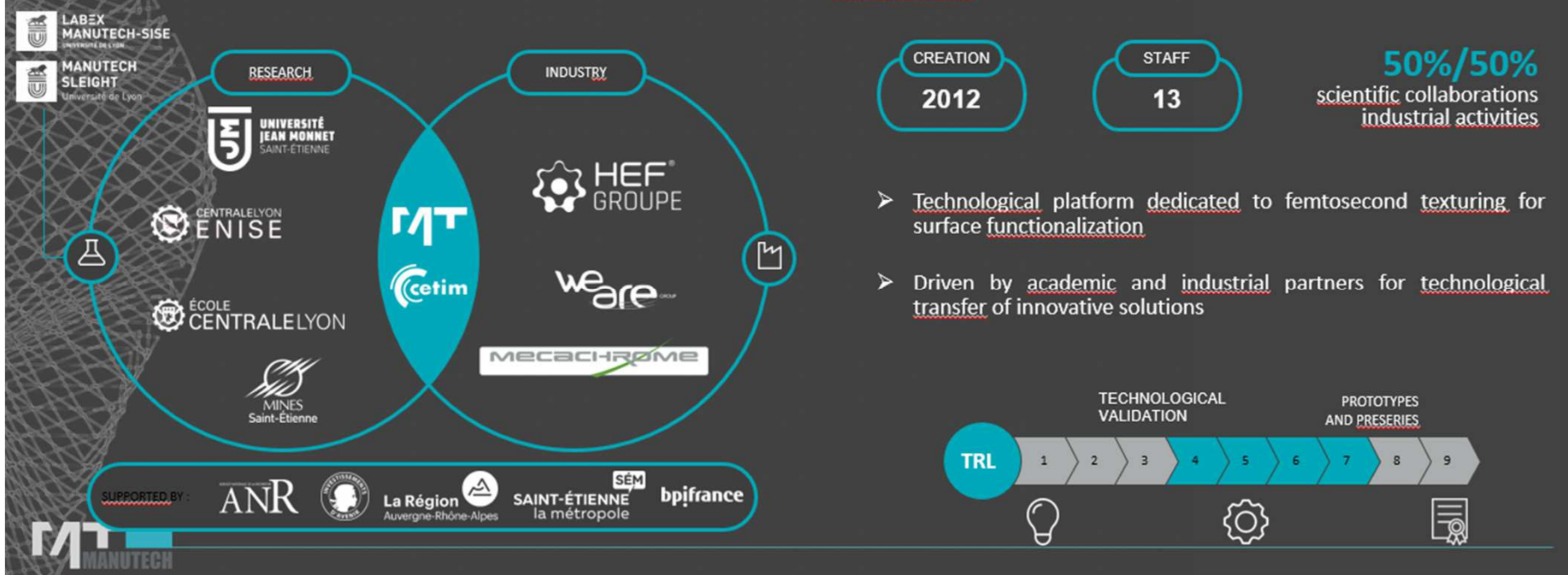
**anr**®  
agence nationale  
de la recherche

## GIE Manutech facilities and projects

...in an ecosystem promoting scientific transfer to industry



### ECONOMICAL CONTEXT





### EQUIPMENTS AND CAPACITIES

**10** Femtosecond laser ( $\leq 300$  W)

**6** XYZ $\theta$  stages (0.1 $\mu$ m to 0.8m)

**2** Robot arms

**12**  
Laser  
platforms

**4**  
Characterization  
platforms

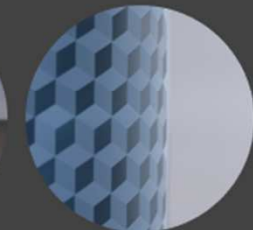
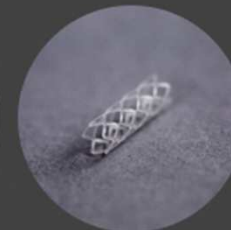
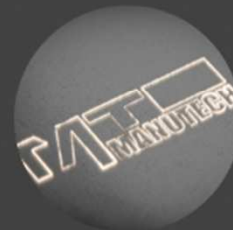
**1** AFM

**4** Optical microscopes

**1** SEM / FIB

**3** Topographic probes (Confocal & interferometric)

- Specialized in **femtosecond** laser processes
- **All types** of materials (polymers, metals, ceramics, organiq...)
- Industrial **upscaling** optics and modules (beam shaping, fibering...)



**ISSUES**

**Complex parts**

**Quality Repeatability**

**Time processes**







## UNIQUE TOOL FOR LIMITLESS APPLICATIONS

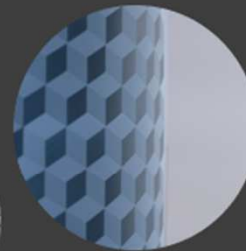
- Etanchéité
- Piège à photons
- Antibactérien
- Anticalcaire
- Antigivre
- Esthétique
- Hydrophobie
- Autonettoyant
- Conservation alimentaire
- Anti-moisissure
- Anti arc EM ...
- Préparation collage





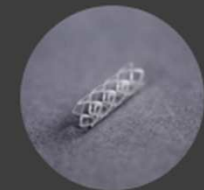
## GRAVURE ET MARQUAGE

- Topographie contrôlée jusqu'au nanomètre
- Designs complexes à grande vitesse
- Variation de coloration



## DÉCOUPE

- Effets thermiques limités
- Précision micrométrique
- Pas d'usure d'outil



## FONCTIONNALISATION

- Performances matériaux optimisées
- Propriétés de surfaces personnalisées
- Utilisation réduite de produits chimiques

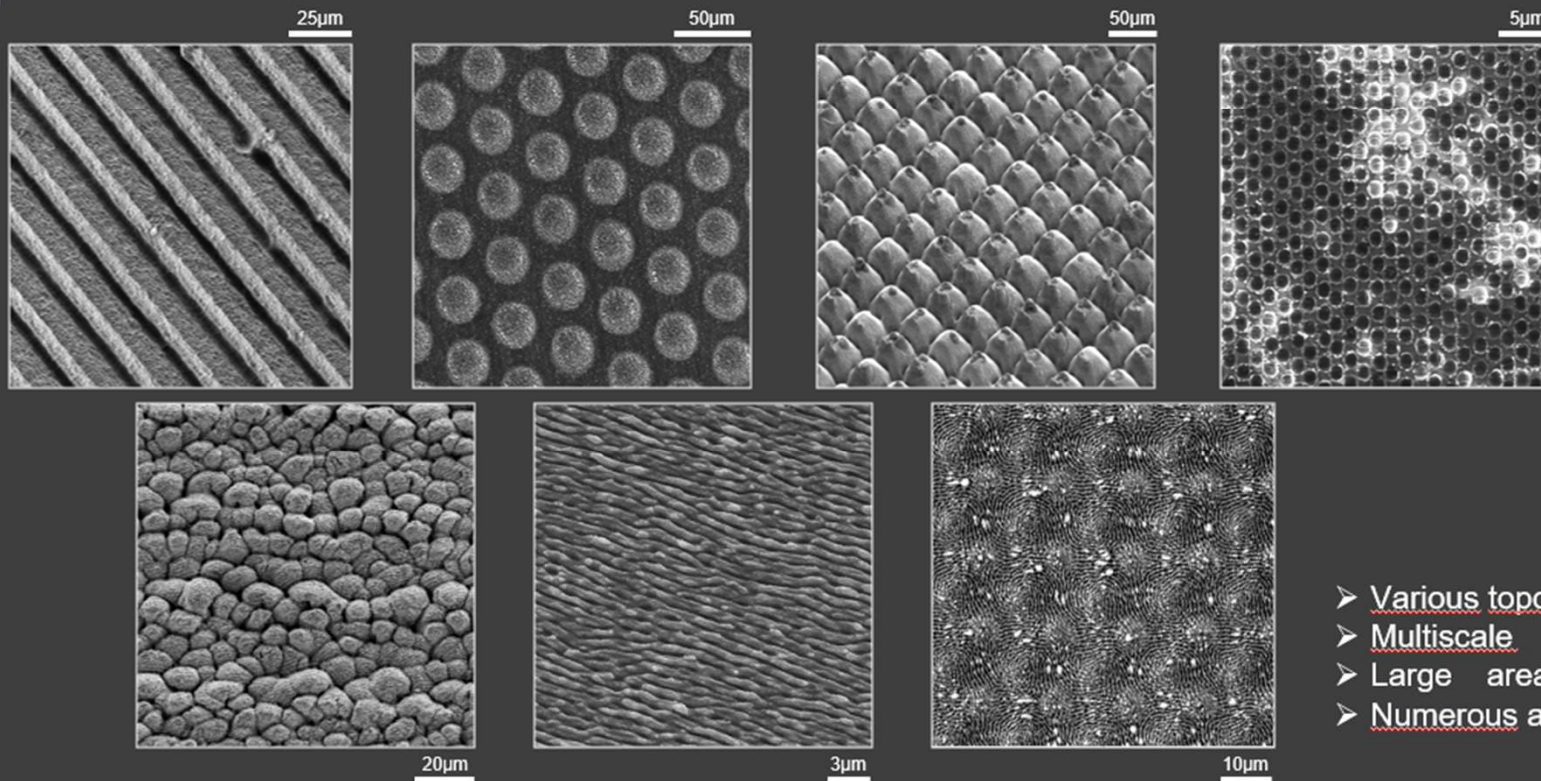


- Adhérence
- Frottement
- Mouillabilité
- Croissance cellulaire
- Conductivité
- Embellissement
- Auto-nettoyage
- ...





## UNIQUE TOOL FOR LIMITLESS APPLICATIONS

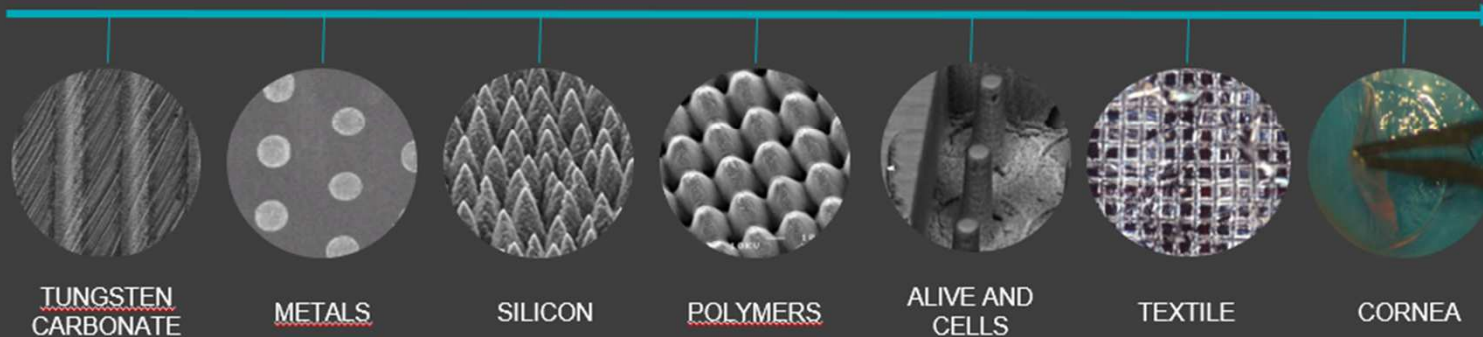


- Various topography
- Multiscale
- Large area
- Numerous application fields

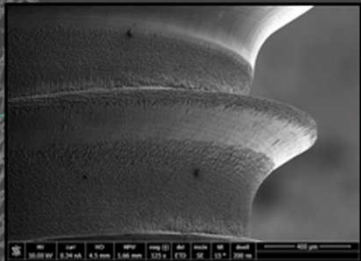
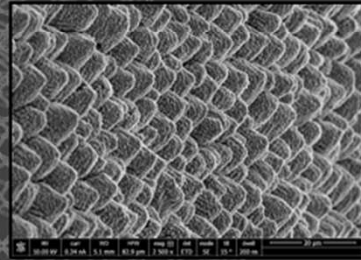


## ALL TYPE OF MATERIALS

few tens of nm to hundred of  $\mu\text{m}$








## EUROPEAN PROJECT

### LASER IMPLANT







**6 partners**




**Budget**



**Objectives**

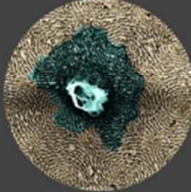





European Commission | Horizon 2020  
European Union funding  
for Research & Innovation  
Grant Agreement no: 951730

**1.94M€**

Budget over 2 years



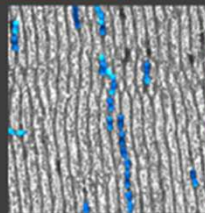
- Surface Design on TA6V
- Biological characterization
- Production demonstrator



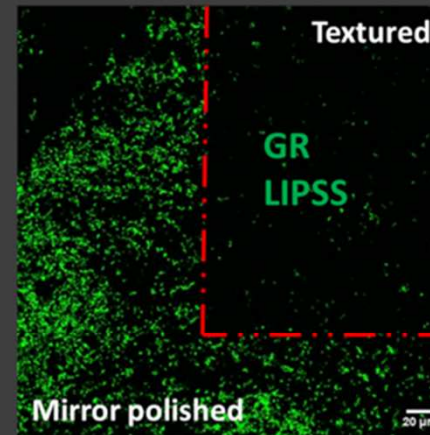
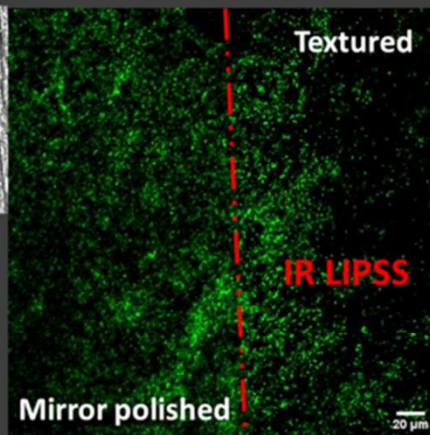


# 1 – RECHERCHE DE TEXTURATIONS ADAPTÉES ⇒ COLLABORATIONS AVEC LES CHERCHEURS

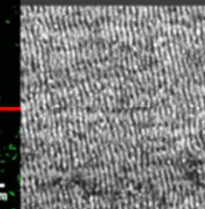
## BACTÉRIES



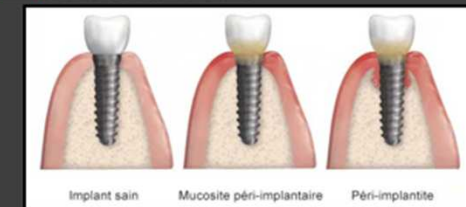
$\lambda = 1030\text{nm}$   
 $\Lambda = 600\text{nm}$



$\lambda = 515\text{nm}$   
 $\Lambda = 400\text{nm}$



*Streptococcus mutans* coloré en vert (images au microscope à fluorescence)  
Bactéries les plus courantes dans la salive, responsables de la péri-implantite





**1 – RECHERCHE DE TEXTURATIONS ADAPTÉES**  
⇒ COLLABORATIONS AVEC LES CHERCHEURS

CELLULES

**Amélioration de la generation de protéines de fibronectine** nécessaire à la minéralisation des ostéoblastes (cellules osseuses)

**Fibronectin area (%)**

Surface	Fibronectin area (%)
Polished	~15
Linear LIPSS	~14
Radial LIPSS	~18

Logos: MAT MANUTECH, UNIVERSITÉ JEAN MONNET SAINT-ÉTIENNE, SAINBIOSE Santé Ingénierie Biologie Saint-Etienne U1059 • INSERM • SAINT-ÉTIENNE, CENTRALE LYON ENISE, LMI UMR5615, LABORATOIRE HUBERT CURIEN UMR • CNRS • ICM • SAINT-ÉTIENNE



**MT MANUTECH**

# 1 – RECHERCHE DE TEXTURATIONS ADAPTÉES

⇒ COLLABORATIONS AVEC LES CHERCHEURS

CELLULES

200µm  
50µm  
5µm  
micro  
nano

**Surface microstructurée**

**Surface polie**

**UNIVERSITÉ JEAN MONNET SAINT-ÉTIENNE**  
**SAINBIOSE**  
Santé Ingénierie  
Biologie Saint-Etienne  
U1055 • INSERM • SAINT-ÉTIENNE

**CENTRALE LYON ENISE**

**LMI UMR5615**

**LABORATOIRE HUBERT CURIE**  
UMR 5086 • UMR 5087 • UMR 5088 • SAINT-ÉTIENNE

30µm





## UNIQUE TOOL FOR LIMITLESS APPLICATIONS

Anti-moisture



T<sub>0</sub> without texturing

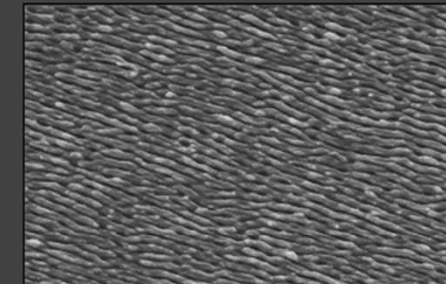


Cleaning after 7 weeks



Texturation laser n°1

5µm



Cleaning after 7 weeks



Cleaning after 7 weeks



Texturation laser n°2

Without texturing

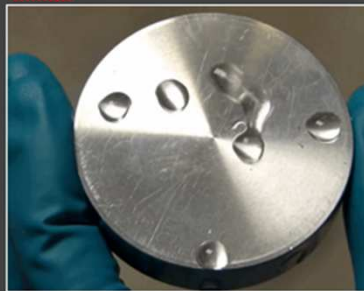
- Easy cleaning
- Enhance lifetime



## UNIQUE TOOL FOR LIMITLESS APPLICATIONS

wettability : Hydrophobia / Hydrophilia / repealance

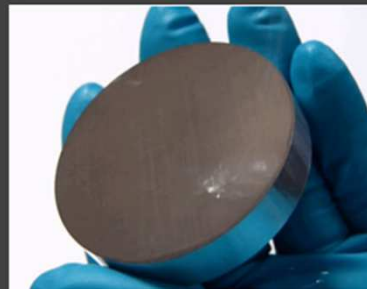
Raw aluminium



Super-Hydrophobie



- Self cleaning surface
- Dry process (chemistry less)



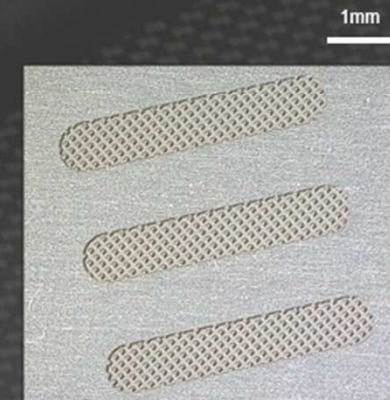
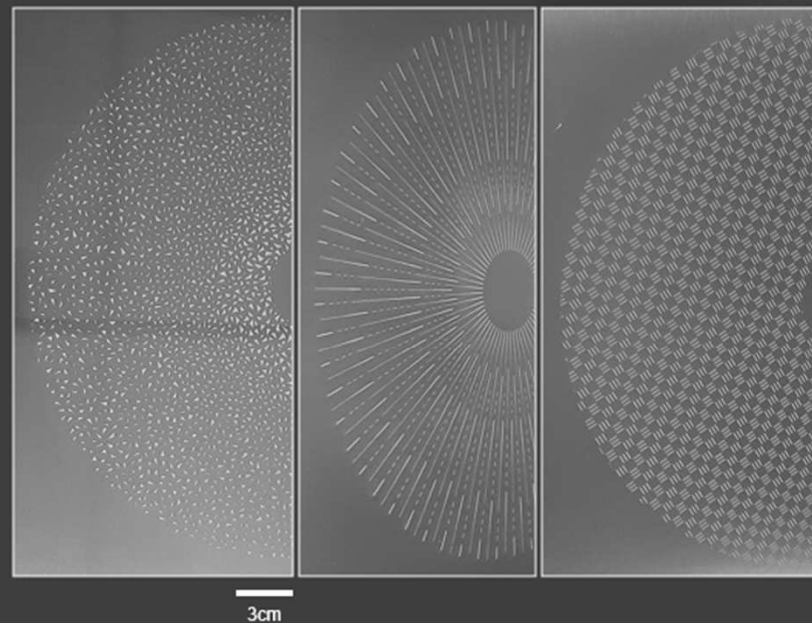
Aluminium with laser texturing





## UNIQUE TOOL FOR LIMITLESS APPLICATIONS

aesthetic



➤ Customizing



**LABEX**  
**MANUTECH-SISE**  
UNIVERSITÉ DE LYON



**anr** ©  
agence nationale  
de la recherche

---

Introduction to Labex Manutech SISE

GIE Manutech facilities and projects

Examples of Labex's projects (ongoing and completed)



**LABEX  
MANUTECH-SISE**  
UNIVERSITÉ DE LYON



**anr**®  
agence nationale  
de la recherche

Examples of Labex's projects (ongoing and completed)

## SODYRACT

Suivi Optique de la Dynamique de Rupture Rapide des Interfaces de Contact Texturées

## SODYRACT



J. Scheibert



C. Ducottet



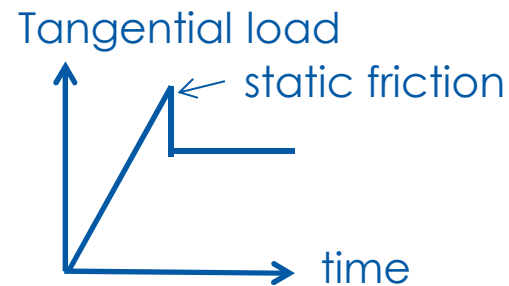
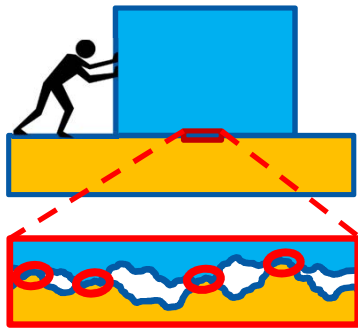
Contacts:  
Julien SCHEIBERT (julien.scheibert@ec-lyon.fr)



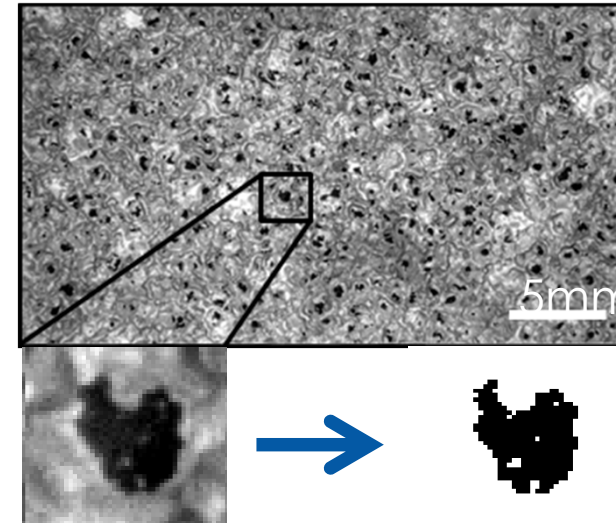
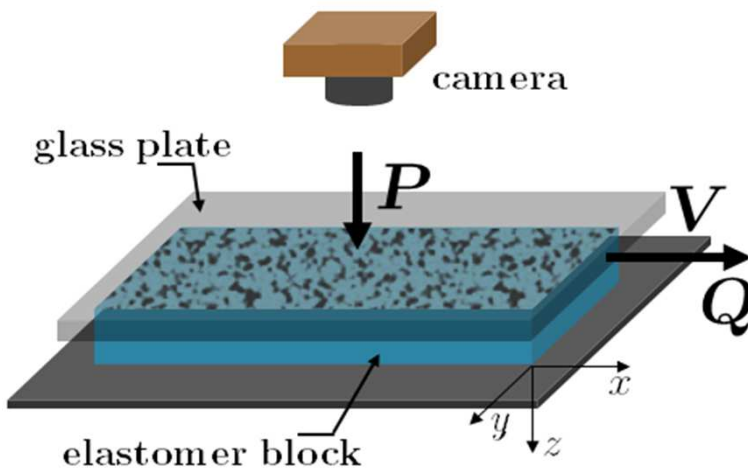
Examples of Labex's projects (ongoing and completed)

## Understanding the onset of sliding

## SODYRACT



Strategy:  
*in situ* observations of the  
phenomena preceding static  
friction



→ Develop and use *quantitative* analysis of contact images



**LABEX  
MANUTECH-SISE**  
UNIVERSITÉ DE LYON



**anr**®  
agence nationale  
de la recherche

Examples of Labex's projects (ongoing and completed)

## Resources

## SODYRACT

**Combine competencies** in:  
Tribology/experimental mechanics  
&  
Optics/image analysis



**PhD** of Riad Sahli funded by Manutech-SISE



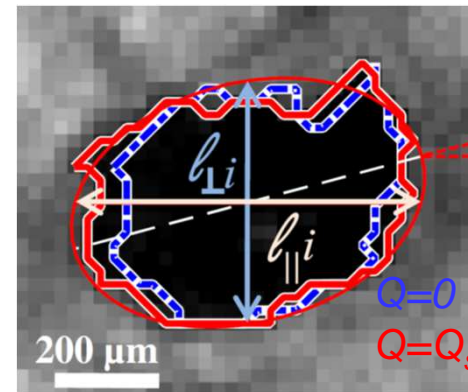
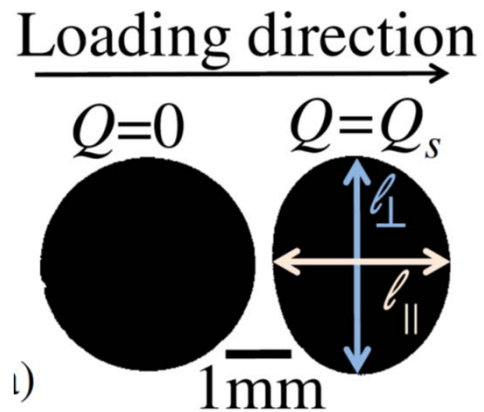
**Leveraging effect** to obtain a complementary funding from Institut Carnot I@L  
(project MANIFEST, LTDS/IMP)





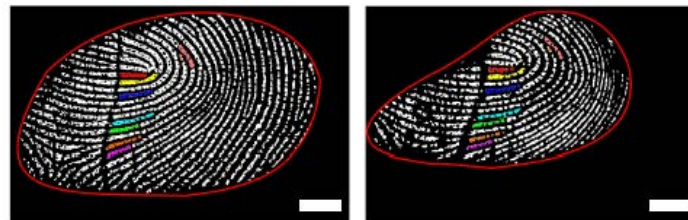
## Main results

## SODYRACT



Shear-induced contact area reduction & growth of anisotropy

- not included in current models
- affect the macroscopic response (friction, conduction,...)
- generic to soft materials (elastomers, skin,...)







**LABEX  
MANUTECH-SISE**  
UNIVERSITÉ DE LYON



**anr** ©  
agence nationale  
de la recherche

Examples of Labex's projects (ongoing and completed)

## Projet TACMUST

### Texturation multi-échelle des surfaces et effet sur le comportement tribologique d'un cartilage artificiel

#### Etude d'un hydrogel à double réseau (DN gel)



**LTDS**



**Doctorante** : Laura Jay <sup>1,2</sup>

**Superviseurs** : Pr. Hassan Zahouani <sup>1</sup> & Pr. Koshi Adachi <sup>2</sup>

**Co-superviseur** : Pr. Philippe Kapsa <sup>1</sup>

<sup>1</sup> Laboratoire de Tribologie et Dynamique des Systèmes (LTDS), UMR 5513  
École Centrale de Lyon

<sup>2</sup> Mechanical engineering department, Adachi . Kanda Laboratory  
Tohoku University

Contacts:  
Hassan ZAHOUANI, hassan.zahouani@ec-lyon.fr



## Examples of Labex's projects (ongoing and completed)

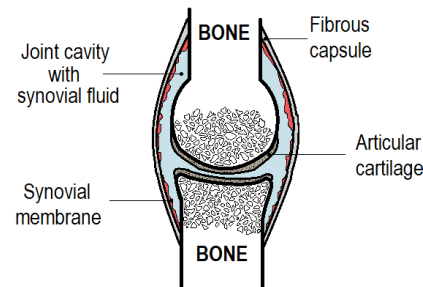
### Introduction sur le cartilage hyalin

### TACMUST

- Au niveau des articulations



- Dans la capsule synoviale

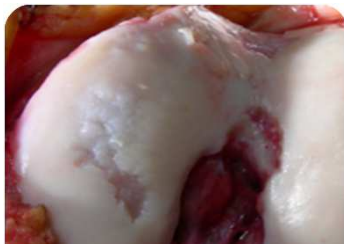


Solution actuelle : retirer articulation, remplacer par prothèse

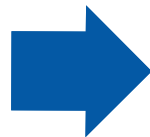


- Solutions futures et pour petits dommages est l'autogreffe puis allogreffe  
→ bon résultat mais prélèvement difficile

- Donc les solutions sont la culture cellulaire sur biomatériaux (car les cellules du cartilage se différencient en culture classique)  
→ Utilisation du DN gel comme support



Cartilage ne se répare pas facilement de façon spontanée



Les autogreffe et allogreffe donne de bon résultats



Il y a de grands progrès dans la domaine des biomatériaux

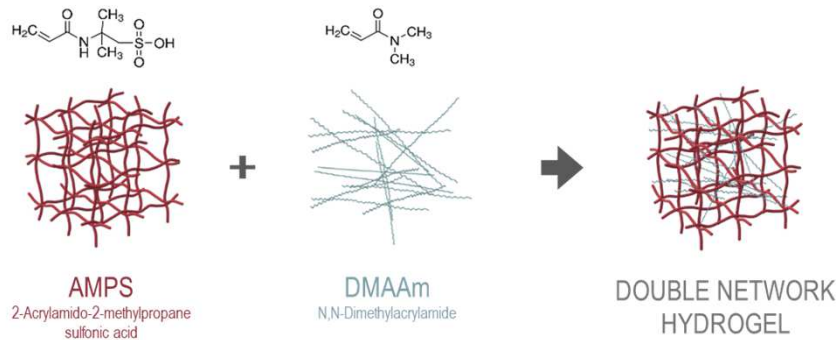


Examples of Labex's projects (ongoing and completed)

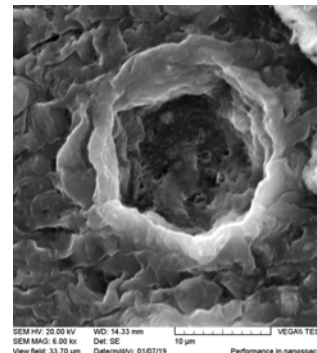
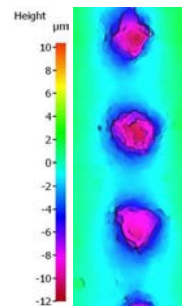
**Dispositifs utilisés**

**TACMUST**

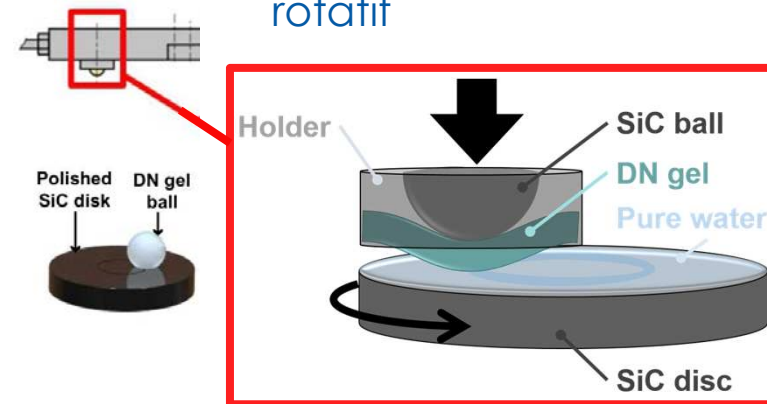
- DN gel fabriqué au LTDS et au Japon



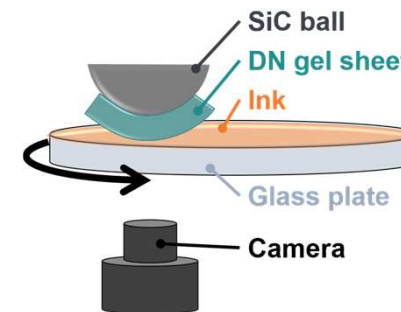
- Texturation laser du DN gel par Manutech Sise
- Observation au MEB et microscope optique



- Utilisation d'un tribomètre rotatif



- Observation directe de l'interface



L'influence de la texture sur le frottement, l'usure et la repousse cellulaire a été étudié



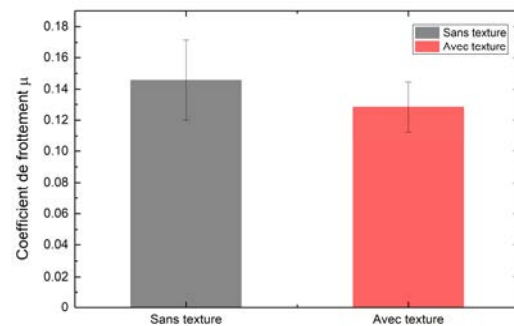
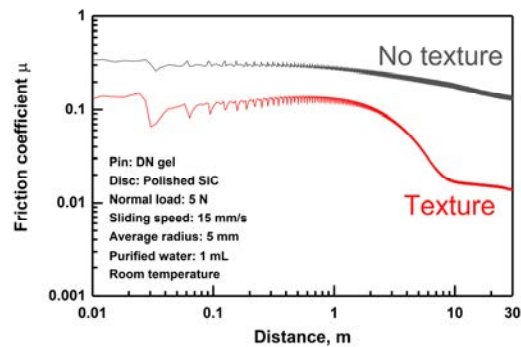
Examples of Labex's projects (ongoing and completed)

TRIBOLOGIE

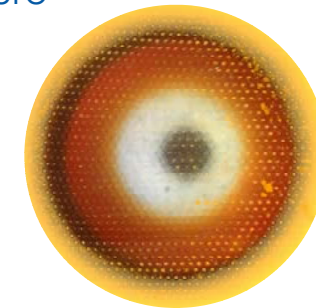
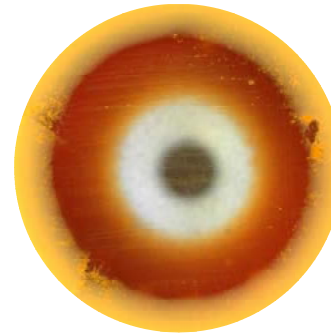
Résultats influence texture sur les propriétés tribologique du DN gel

TACMUST

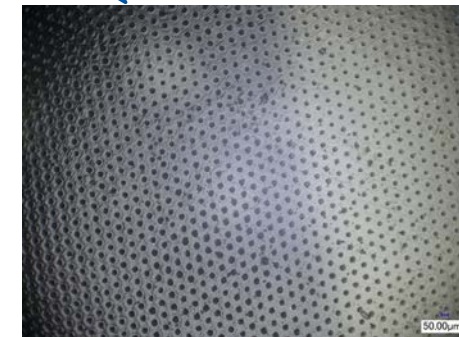
- Sur le frottement



- Sur l'usure



Sens de frottement



La texture a une influence positive non significative sur le coefficient de frottement  
(plus d'influence du procédé de fabrication)  
En revanche influence très positive sur l'usure (peu d'usure)



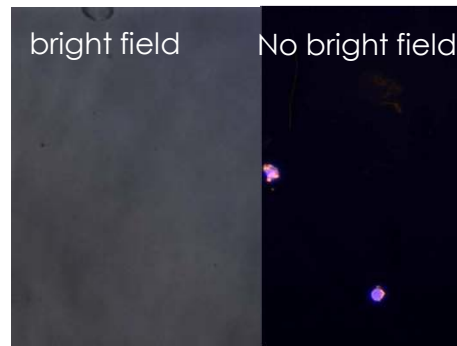
## Examples of Labex's projects (ongoing and completed)

### BIOLOGIE

### Résultat influence texture sur les propriétés biologiques du DN gel

### TACMUST

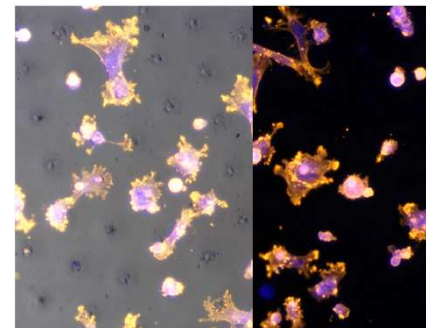
- Sur la repousse cellulaire



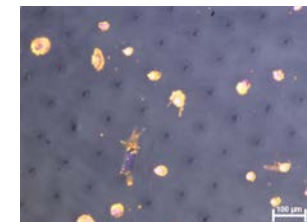
DN gel non texturé



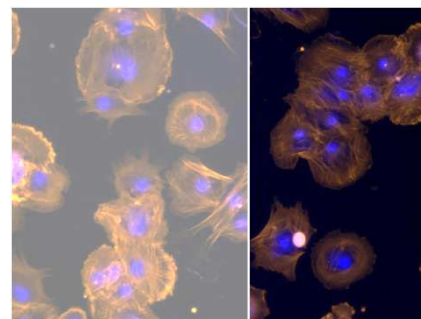
24h post seeding



DN gel texturé

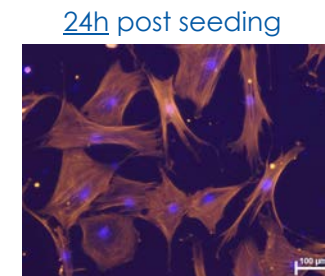


24h post seeding



Boîte de Petri  
en plastique

2h post seeding



24h post seeding

L'application d'une texture sur le DN gel améliore considérablement la repousse cellulaire, contrairement à un gel non texturé

Contacts:  
Hassan ZAHOUANI, hassan.zahouani@ec-lyon.fr



**LABEX  
MANUTECH-SISE**  
UNIVERSITÉ DE LYON



**anr** ©  
agence nationale  
de la recherche

Examples of Labex's projects (ongoing and completed)

## Projet R2EX

Micro structuring for Manufacturing Resonant  
Gratings with Extreme Efficiency

## PROTECT

Low Temperature Commutation of Thermo-chromic based  
VO<sub>2</sub> Thin Films for the Protection of Electronic and Optical  
Devices

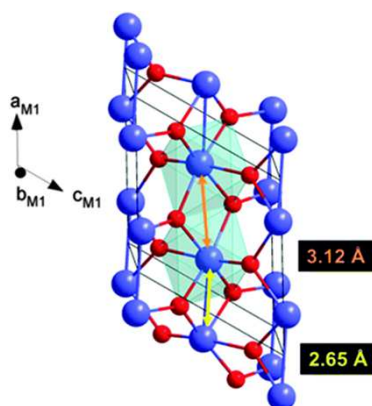


Contacts:  
Christophe Donnet ([Christophe.Donnet@univ-st-etienne.fr](mailto:Christophe.Donnet@univ-st-etienne.fr))

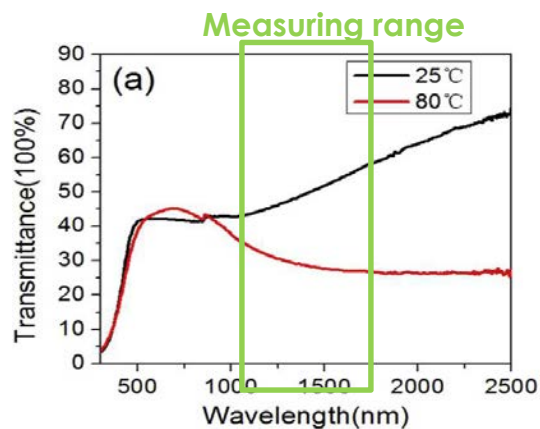


VO<sub>2</sub> Material : **metal-insulator transition**

**T < 68° C -  
Monoclinic**

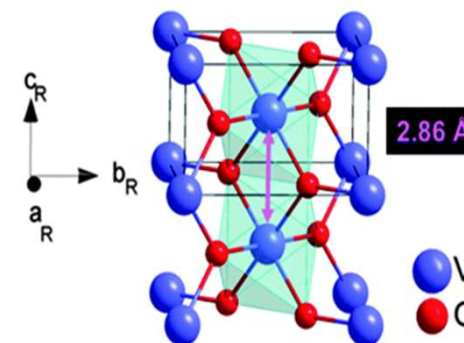


Dielectric material  
**Transparent in the IR  
region**



*Melnik et al., Materials Letters 68, 215-217 (2012)*

**T > 68° C - Rutile-Tetragonal**



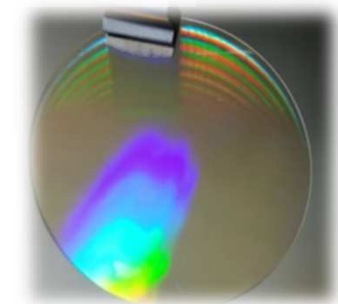
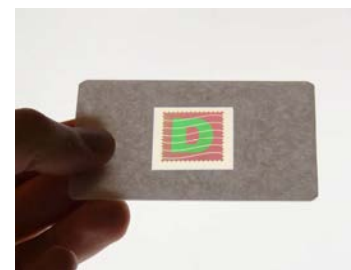
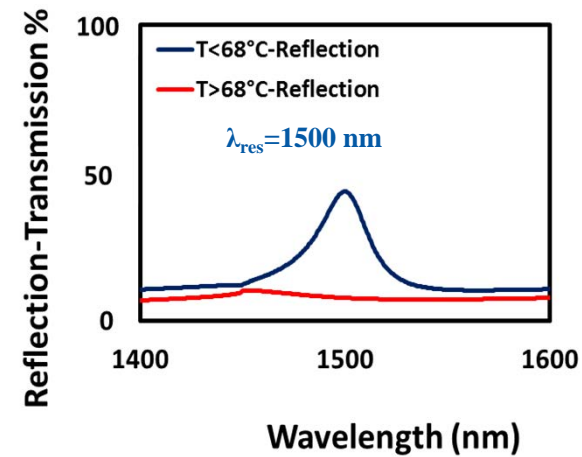
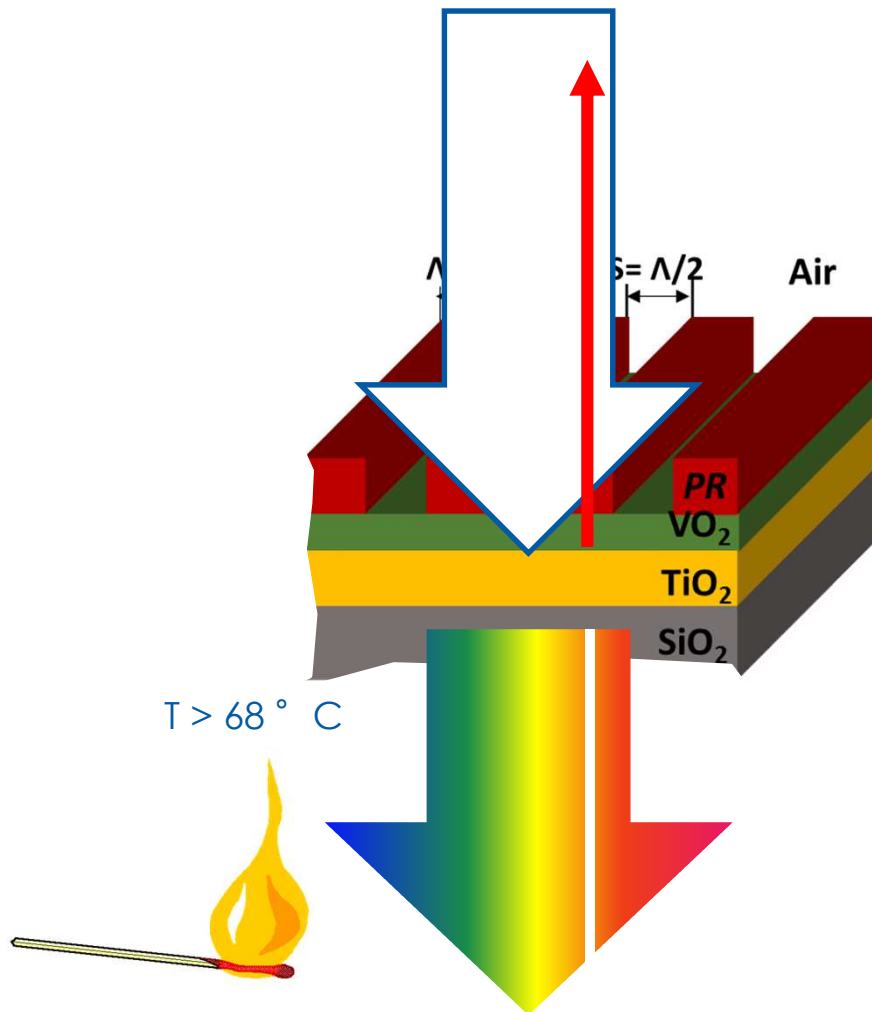
Metallic material  
**Opaque in the IR  
region**



Examples of Labex's projects (ongoing and completed)

**R2EX**

Thermally Activated Waveguide Resonant Grating (VO<sub>2</sub> thin layer)





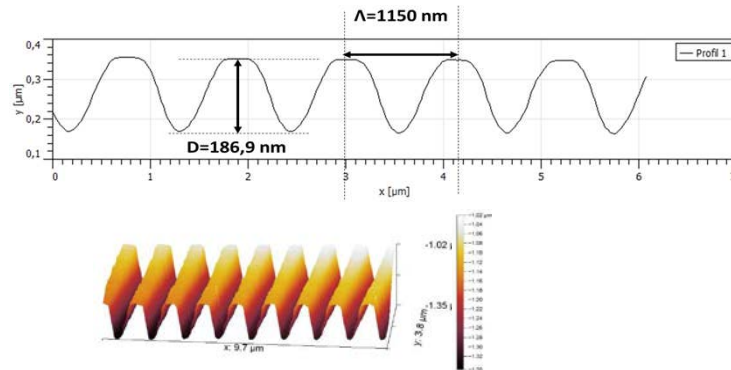


## Examples of Labex's projects (ongoing and completed)

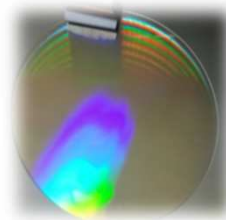
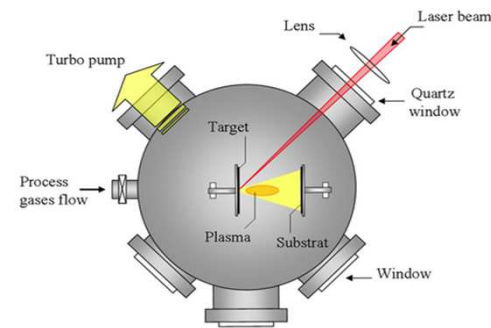
### Fabrication and optical measurements

TiO<sub>2</sub> sol-gel deposition  
VO<sub>2</sub> layer deposition (PLD)

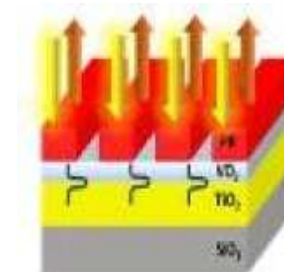
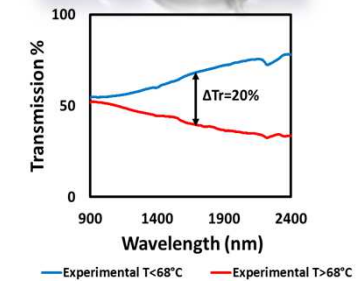
Grating writing (LIL)



### PLD (Pulsed Laser Deposition)



### R2EX

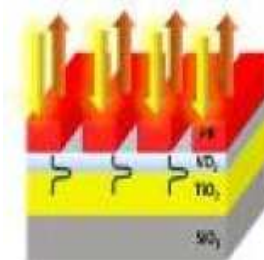
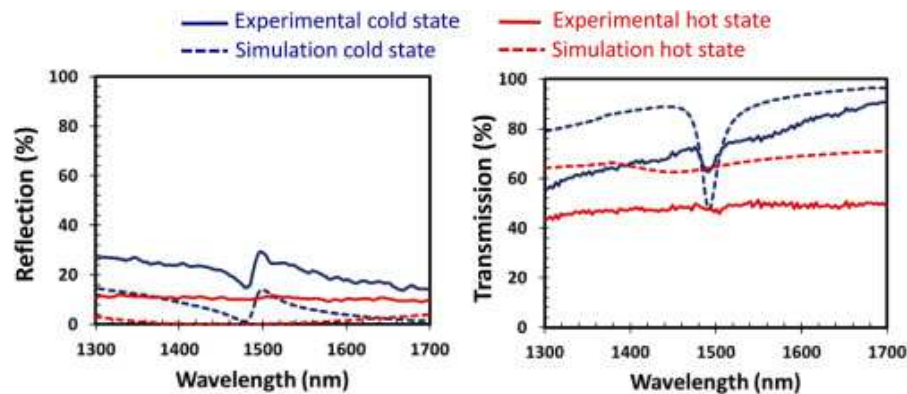
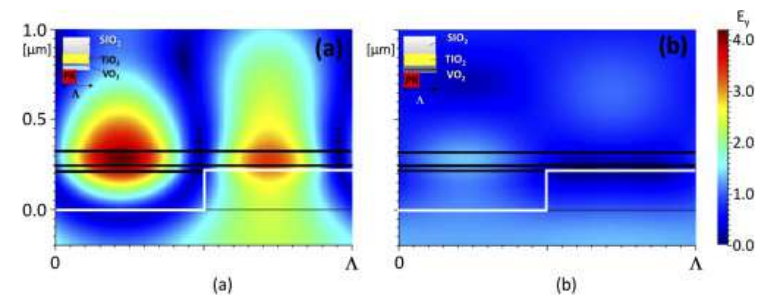
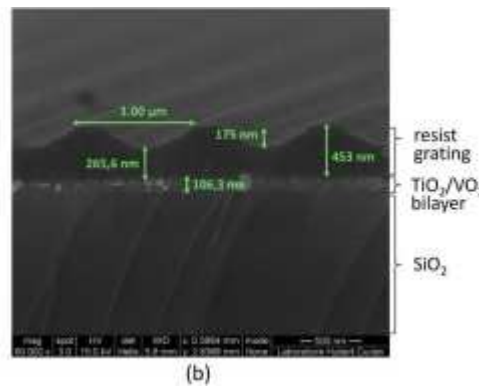
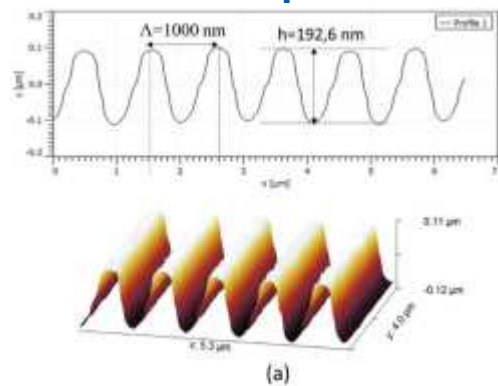




Examples of Labex's projects (ongoing and completed)

Fabrication and optical measurements

R2EX



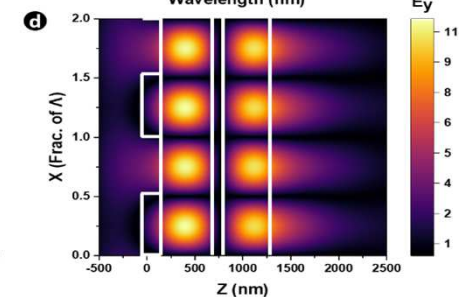
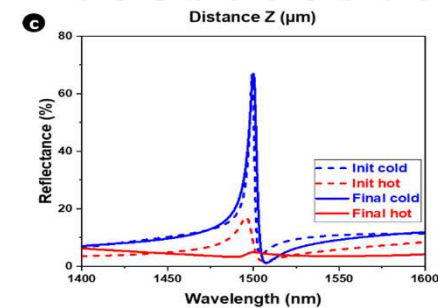
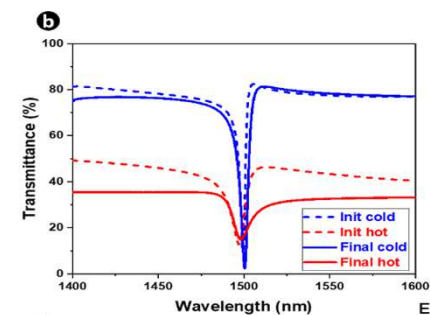
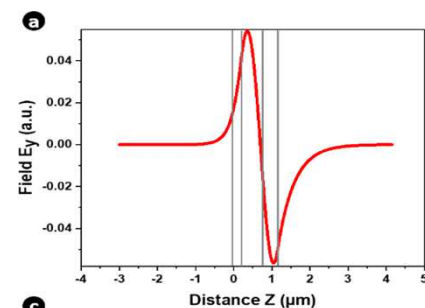
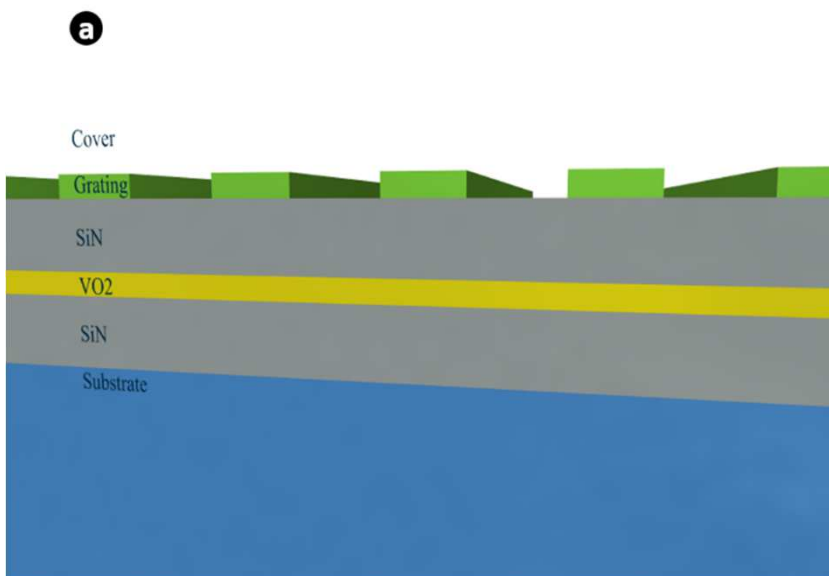
Koussi et al, "Thermally activated resonant grating using a vanadium dioxide waveguide" *Opt. Mat. Express* 11(4), 2021



## Examples of Labex's projects (ongoing and completed)

### New design (PROTECT)

### PROTECT

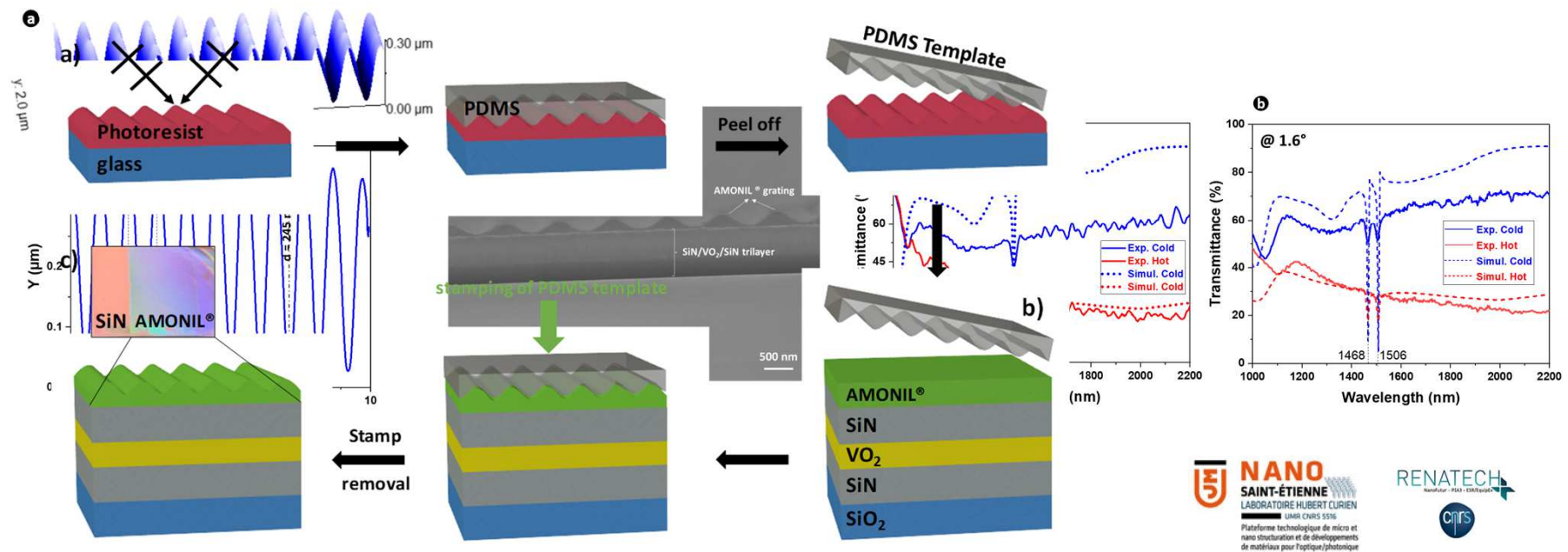




Examples of Labex's projects (ongoing and completed)

Fabrication and optical measurements

**PROTECT**



Bleu et al, "SiN/VO<sub>2</sub>/SiN sandwich-based resonant waveguide grating to produce thermally activated optical components", *Advanced Optical Materials*, May 2023, DOI: 10.1002/adom.202300126

## Manutech

- Surface texturing using fs laser and UV lithography
- Various materials
- Multiscale
- 3D and complex substrates
- Various applications fields (wetting, tribology, Optical, health, sensors...)

Merci pour votre attention

### Contacts

Yves JOURLIN ([yves.jourlin@univ-st-etienne.fr](mailto:yves.jourlin@univ-st-etienne.fr))

Nicolas COMPERE ([nicolas.compere@manutech-usd.fr](mailto:nicolas.compere@manutech-usd.fr))

<https://manutech-sise.universite-lyon.fr/>  
<https://www.manutech-usd.fr/>



<https://twitter.com/LabexManutech>



<https://www.linkedin.com/company/labex-manutech-sise/>



<https://www.facebook.com/LabexManutechSise/>