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MANUTECH-SISE
UNIVERSITÉ DE LYON

Texturation et fonctionnalisation de surface au sein de MANUTECH

Yves JOURLIN, yves.jourlin@univ-st-etienne.fr

Nicolas COMPERE, nicolas.compere@manutech-usd.fr



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

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



Introduction to Labex Manutech SISE

GIE Manutech facilities and projects

Examples of Labex's projects (ongoing and completed)



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Examples of Labex's projects (ongoing and completed)



Introduction to Labex Manutech SISE

2005 – 2008 : First studies of Manutech

PhD thesis Louis MOURIER 2007

D. MAZUYER



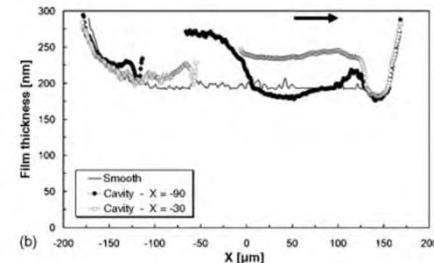
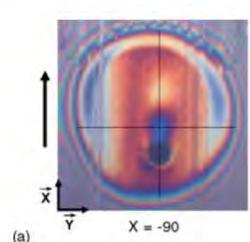
A.A. LUBRECHT



C. DONNET



P. MAURIN-PERRIER





Introduction to Labex Manutech SISE

The **MANUTECH** success story...

2009 →

- **Partnership**
from 1st 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 cover over 6:
Advanced material
Photonic
Manufacturing
 - Integration in COM
Lyon- St-Etienne



- In the National Research Strategy (NRS)

La Recherche, N° 560 Juin 2020



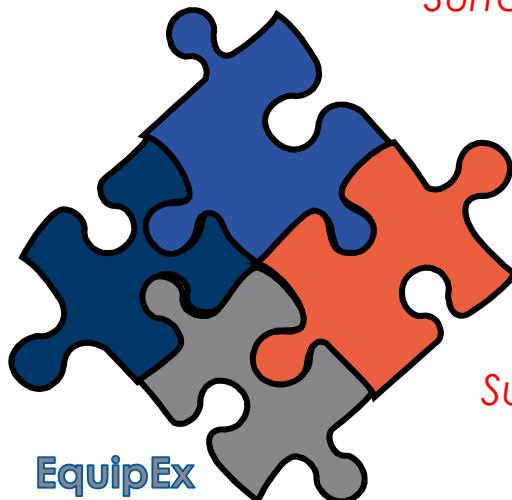
Introduction to Labex Manutech SISE

LabEx



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Surface and Interface Science Engineering



Formation



EquipEx



Ultrafast Surface Design

Ecole Universitaire de Recherche



MANUTECH
SLEIGHT
Université de Lyon

Surfaces Light Engineering – Health & Society

LABORATOIRE
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CREATIS



ÉCOLE CENTRALE LYON



ENISE



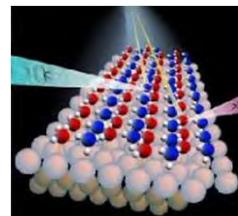
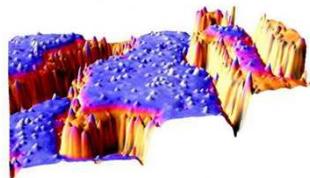
INSA INSTITUT NATIONAL
DES SCIENCES APPLIQUÉES LYON



KERANOVA

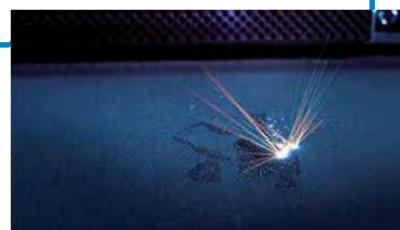


2011-2019 to 2020-2024



- Physico-chemistry
- Manufacturing technologies
- Material science

Needs



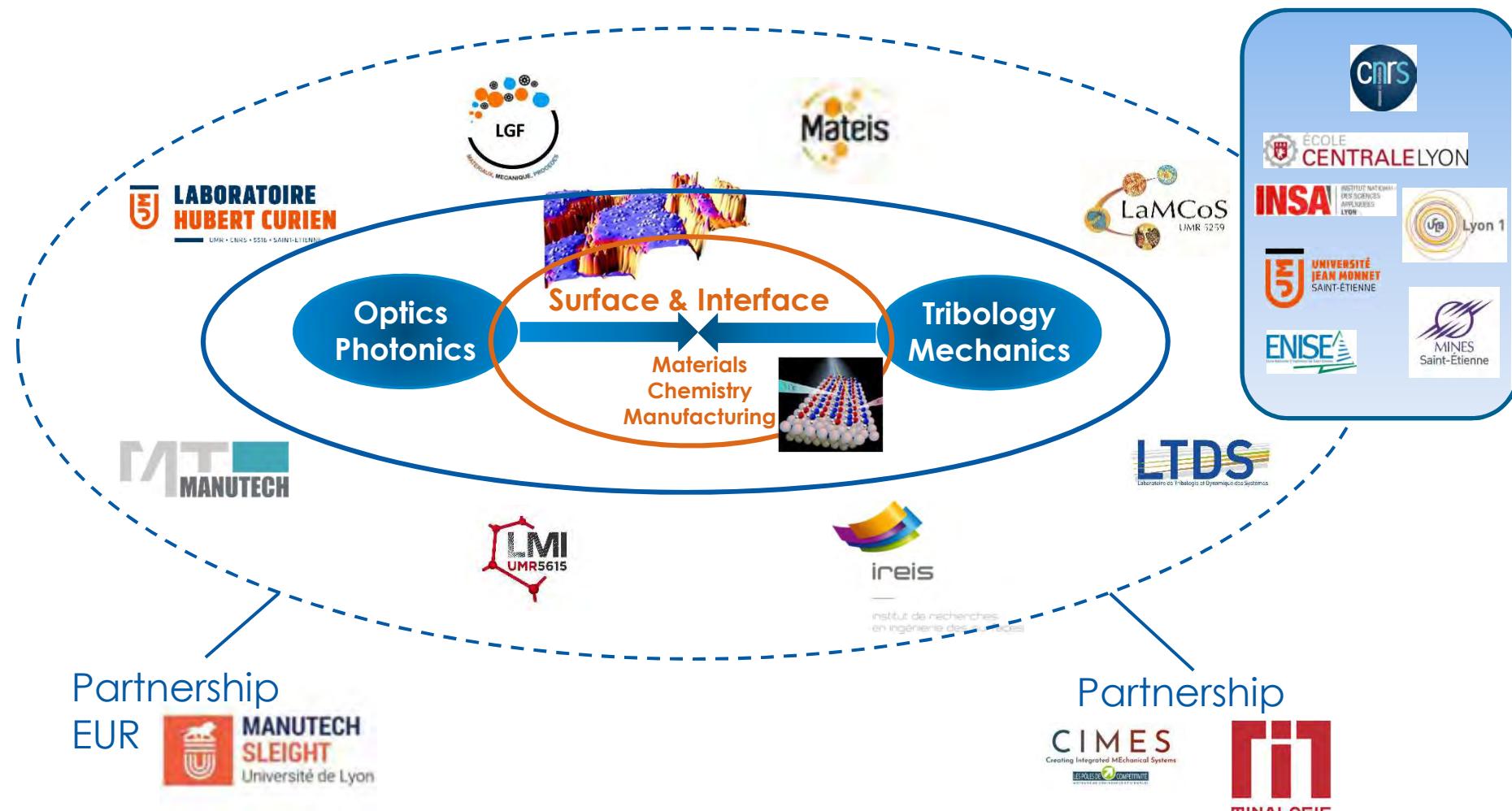
LABEX 20-24

- 4 new scientific Axes
- 3 new partners
- Towards prototypes
- Label “MANUTECH”





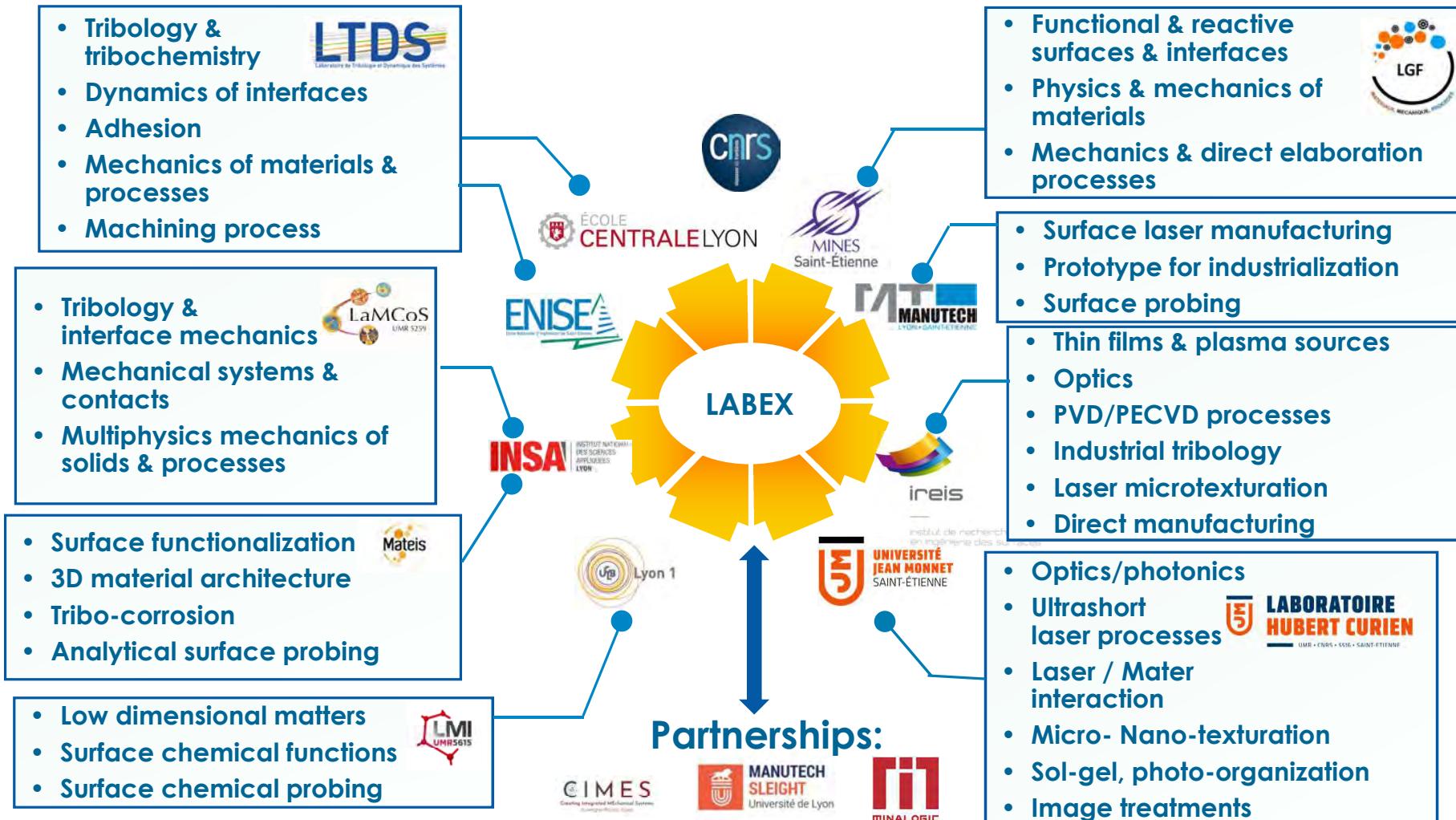
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Introduction to Labex Manutech SISE

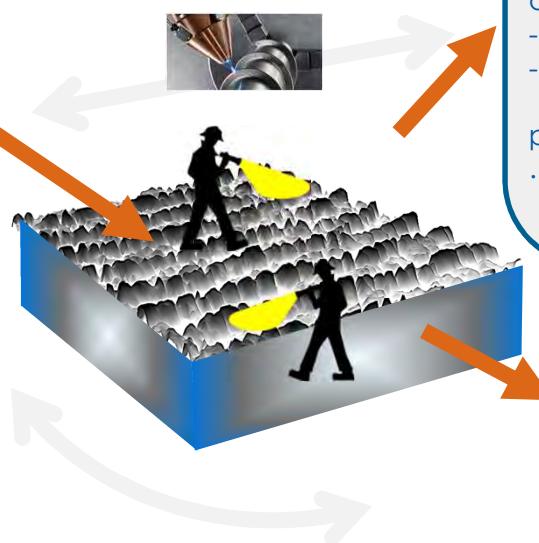
Skills and know-hows of the LABEX MANUTECH-SISE 2020-2024 partners





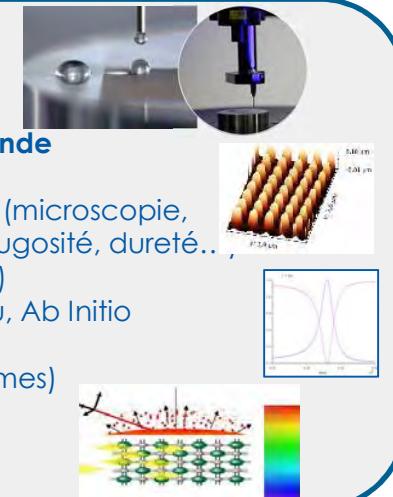
Introduction to Labex Manutech SISE

Scientific objectives



Caractérisation / sonde

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



Propriétés / fonctions

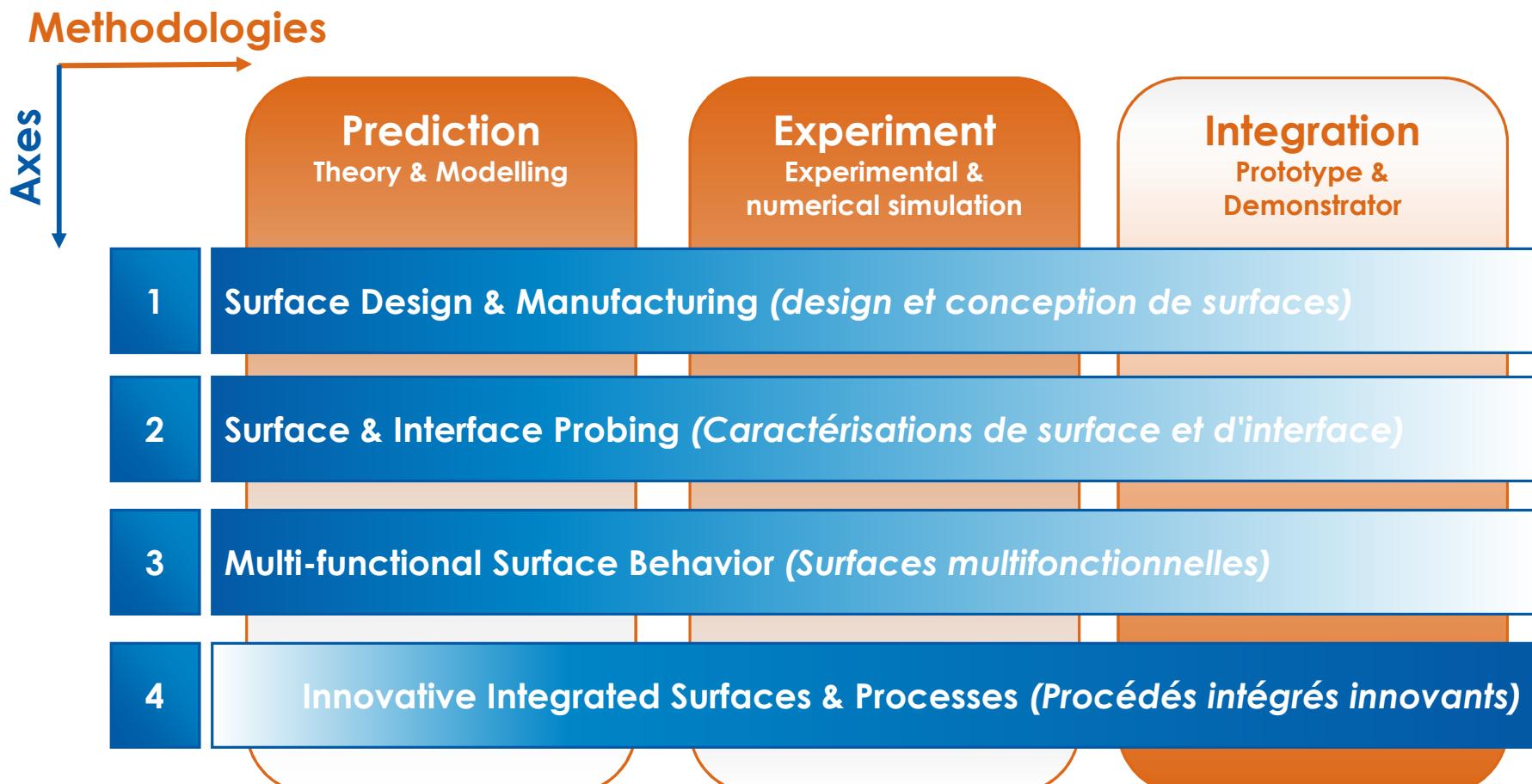
- Mécaniques (tribologie, frottement, usure, dureté...)
- Optique (couleur, capteur, transparence, absorption...)
- Chimiques / Physiques / physico chimiques (mouillabilité, adhésion, sensoriel...)
- ...



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



Axes





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GIE Manutech facilities and projects

Examples of Labex's projects (ongoing and completed)



GIE MANUTECH USD
FEMTO-SECOND LASER EUROPEAN PLATFORM

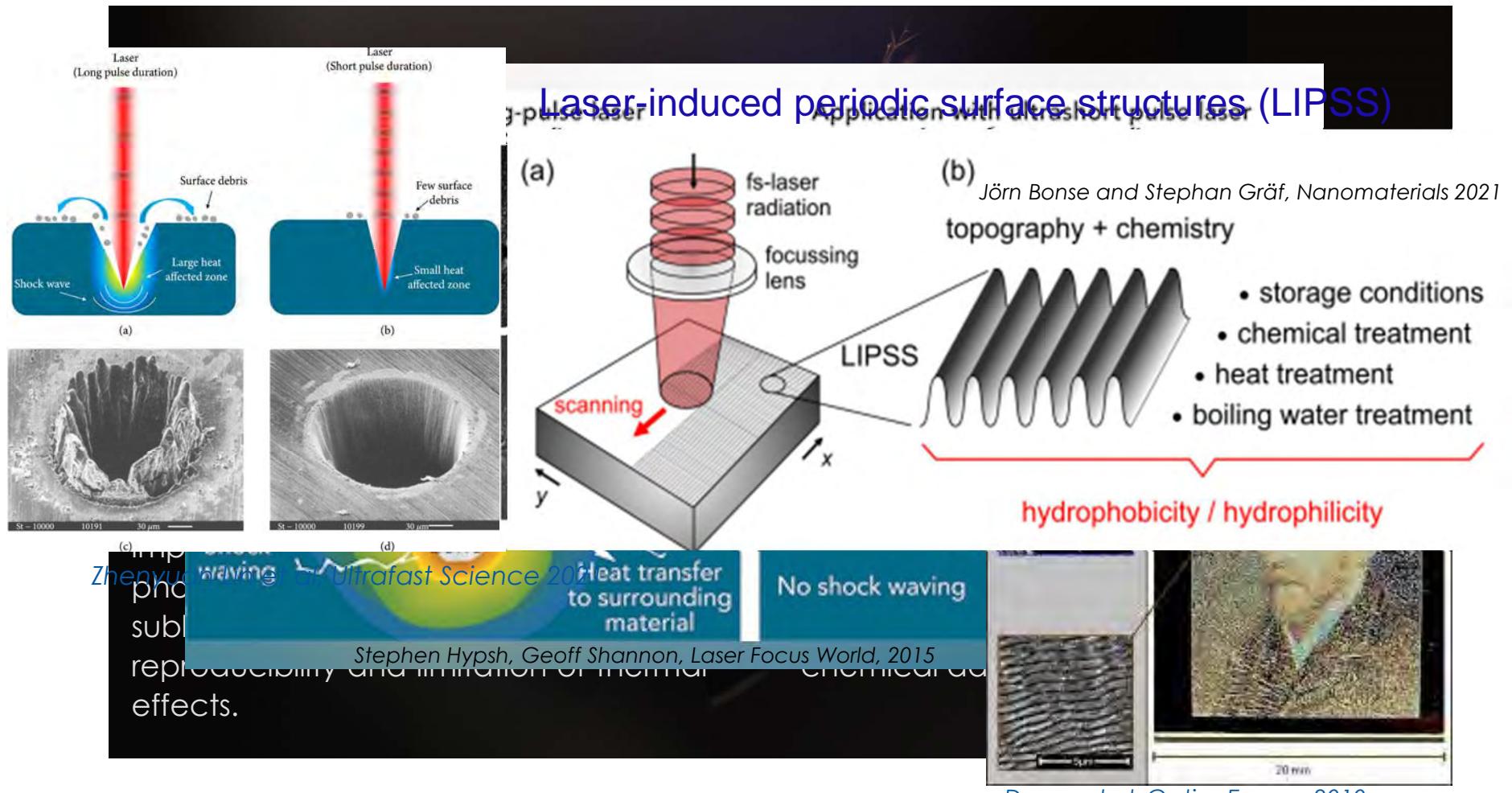
**Which tool is able to sublime all kind of materials
with micrometric precision?**

Nicolas Compère Vice-Président

nicolas.compere@manutech-usd.fr



GIE Manutech facilities and projects





GIE Manutech facilities and projects

...in an ecosystem promoting scientific transfer to industry



ECONOMICAL CONTEXT





GIE Manutech facilities and projects



EQUIPMENTS AND CAPACITIES

10 Femtosecond laser ($\leq 300\text{ W}$)

12 Laser platforms

6 XYZθ stages ($0.1\mu\text{m}$ to 0.8m)

2 Robot arms

4 Optical microscopes

3 Topographic probes (Confocal & interferometric)

4 Characterization platforms

1 AFM

1 SEM / FIB

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



ISSUES

Complex parts

Quality Repeatability

Time processes



GIE Manutech facilities and projects

UNIQUE TOOL FOR LIMITLESS APPLICATIONS



Etanchéité

Piège à photons

Antibactérien

Anticalcaire

Antigivre

Esthétique

Hydrophobie

Autonettoyant

Conservation alimentaire

Anti-moisissure

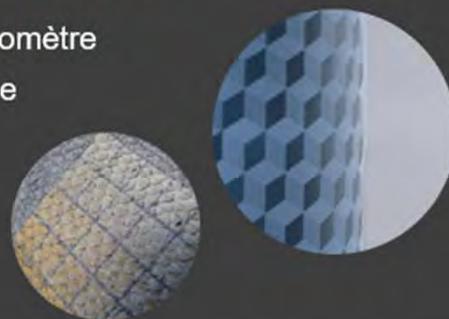
Anti arc EM ...

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
- ...





GIE Manutech facilities and projects

MT MANUTECH

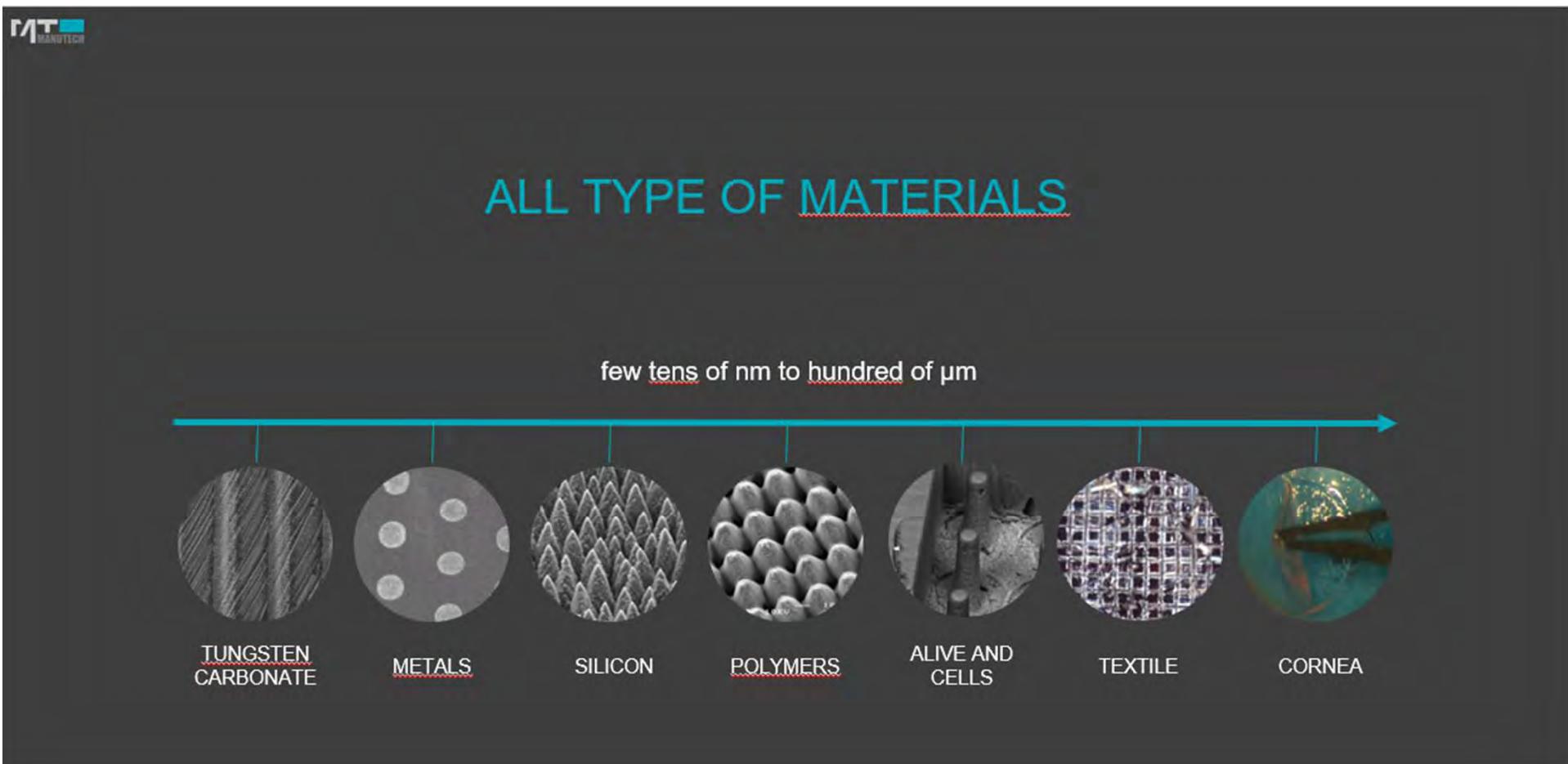
UNIQUE TOOL FOR LIMITLESS APPLICATIONS

The figure displays nine scanning electron micrographs (SEM) illustrating various surface topographies, arranged in two rows of four and one row of three. The top row includes scale bars of 25µm, 50µm, 50µm, and 5µm. The bottom row includes scale bars of 20µm, 3µm, and 10µm. The surfaces shown range from large-scale periodic structures to small-scale nanoscale textures.

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

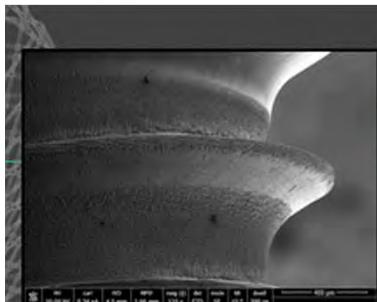


GIE Manutech facilities and projects



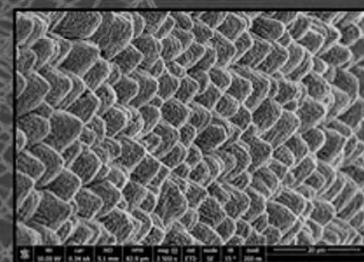
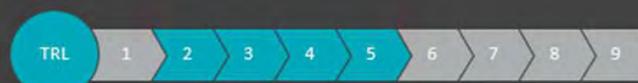


GIE Manutech facilities and projects



EUROPEAN PROJECT

LASER IMPLANT



6 partners



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JYU
JOHANNES KEPLER
UNIVERSITÄT LINZ



hofer
MEDICAL SOLUTIONS



Budget

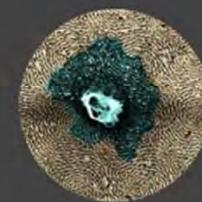
European Commission | Horizon 2020
European Union funding for Research & Innovation
Grant Agreement no: 951730

1.94M€

Budget over 2 years



Objectives



- Surface Design on TA6V
- Biological characterization
- Production demonstrator



MT MANUTECH

1 – RECHERCHE DE TEXTURATIONS ADAPTÉES ⇒ COLLABORATIONS AVEC LES CHERCHEURS

BACTÉRIES

Textured Mirror polished

Textured GR LIPSS $\lambda=515\text{nm}$
IR LIPSS $\Lambda=400\text{ nm}$

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

20 μm

20 μm

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

Implant sain Mucosite péri-implantaire Péri-implantite

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CENTRALELYON ENISE

LMI UMR5615

LABORATOIRE HUBERT CURIEN
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MT MANUTECH

1 – RECHERCHE DE TEXTURATIONS ADAPTÉES ⇒ COLLABORATIONS AVEC LES CHERCHEURS

CELLULES

Poli LIPSS IR LIPSS Radial

50 µm 50 µm 50 µm

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

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Fibronectin area (%)

Surface	Fibronectin area (%)
Polished	~15.5
Linear LIPSS	~13.5
Radial LIPSS	~17.5

0.045
0.016



MT MANUTECH

1 – RECHERCHE DE TEXTURATIONS ADAPTÉES ⇒ COLLABORATIONS AVEC LES CHERCHEURS

CELLULES

200 μm
50 μm
micro
5 μm
nano

Surface microstructurée

Surface polie

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UNIQUE TOOL FOR LIMITLESS APPLICATIONS

Anti-moisture



T₀ without texturing



Cleaning after 7 weeks



Without texturing

Cleaning after 7 weeks

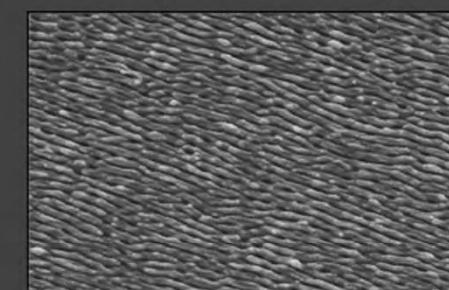


Texturation laser
n°1

5µm



Texturation laser n°2



- Easy cleaning
- Enhance lifetime



GIE Manutech facilities and projects

UNIQUE TOOL FOR LIMITLESS APPLICATIONS

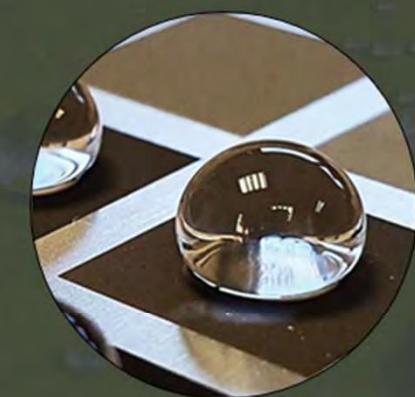
wettability : Hydrophobia / Hydrophilic / repealance

Raw aluminium



Aluminium with laser texturing

Super-Hydrophobic



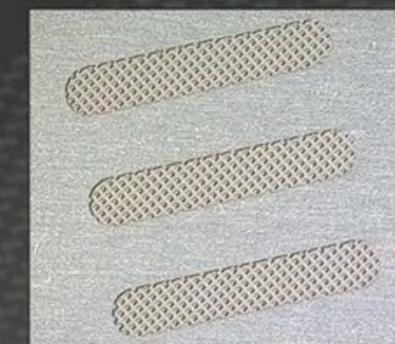
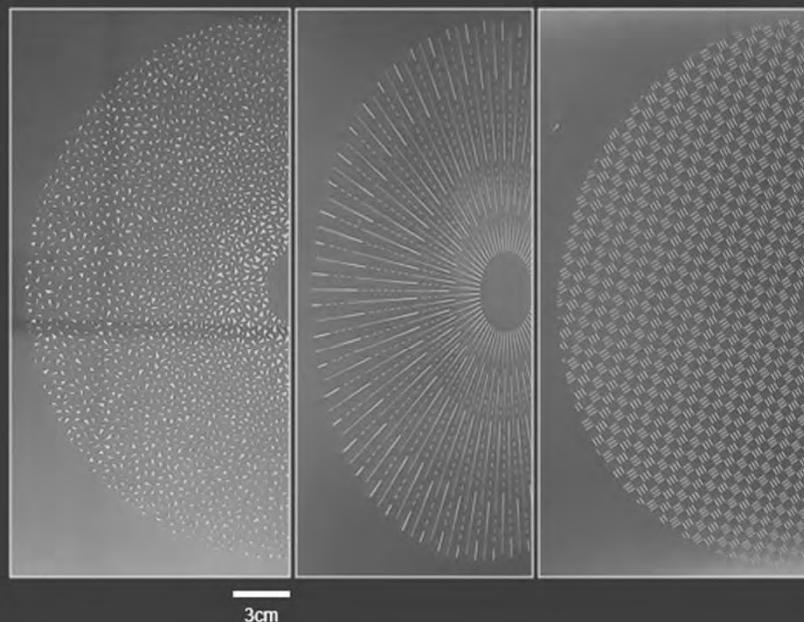
- Self cleaning surface
- Dry process(chemistry less)



GIE Manutech facilities and projects

UNIQUE TOOL FOR LIMITLESS APPLICATIONS

aesthetic



➤ Customizing



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Examples of Labex's projects (ongoing and completed)

SODYRACT

SODYRACT

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



J. Scheibert



C. Ducottet



Laboratoire de Tribologie et Dynamique des Systèmes

Contacts:

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



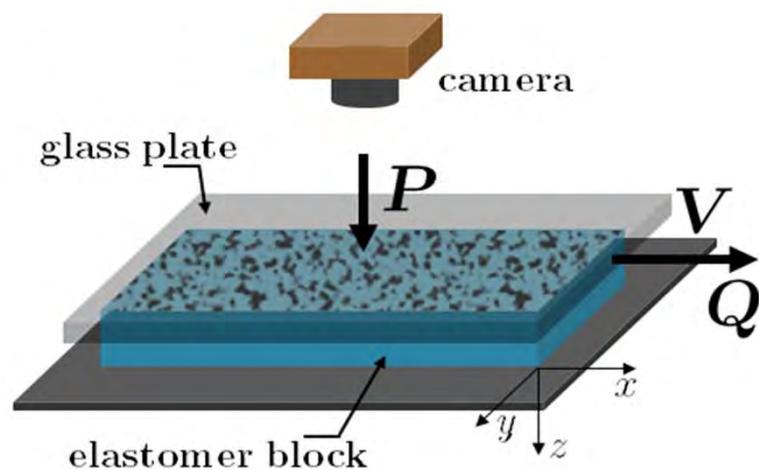
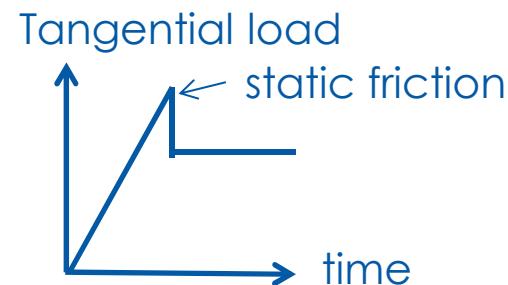
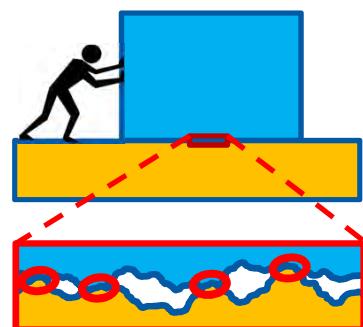
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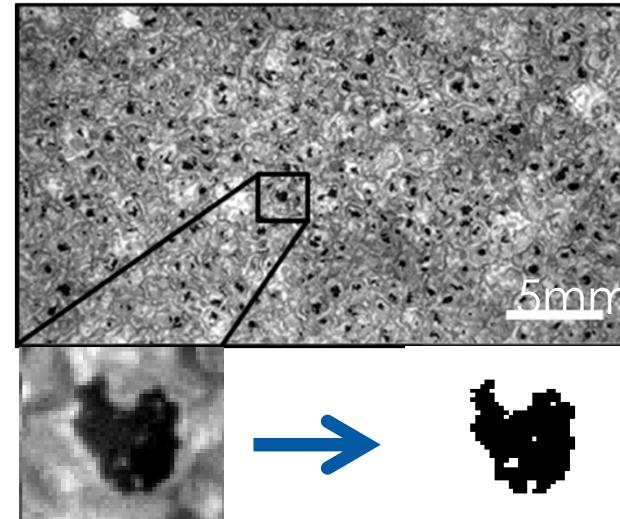
Examples of Labex's projects (ongoing and completed)

Understanding the onset of sliding

SODYRACT



Strategy:
in situ observations of the phenomena preceding static friction



→ Develop and use quantitative analysis of contact images



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)

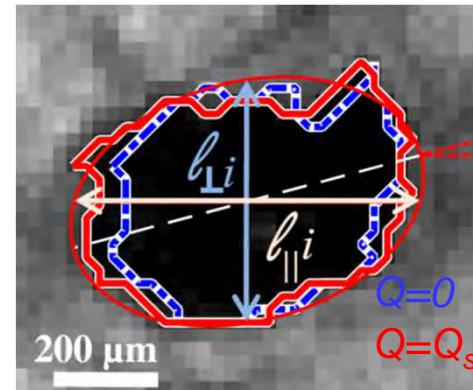
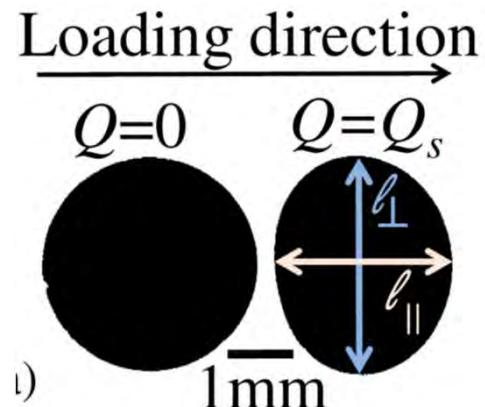




Examples of Labex's projects (ongoing and completed)

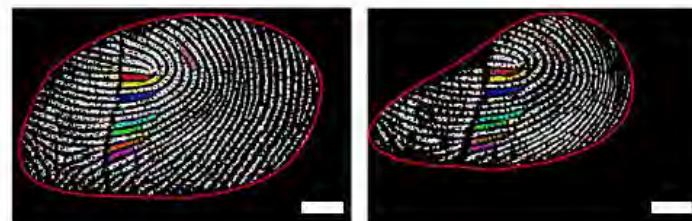
Main results

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,...)



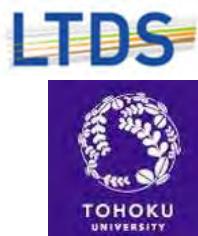


Examples of Labex's projects (ongoing and completed)

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)



Doctorante : Laura Jay ^{1,2}
Superviseurs : Pr. Hassan Zahouani ¹ & Pr. Koshi Adachi ²
Co-superviseur : Pr. Philippe Kapsa ¹

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

² Mechanical engineering department, Adachi . Kanda Laboratory
Tohoku University

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



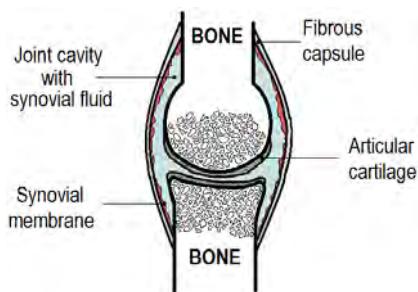
Examples of Labex's projects (ongoing and completed)

Introduction sur le cartilage hyalin

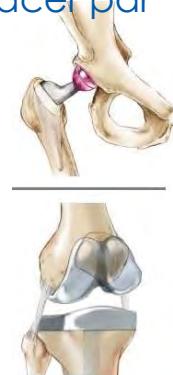
- Au niveau des articulations



- 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



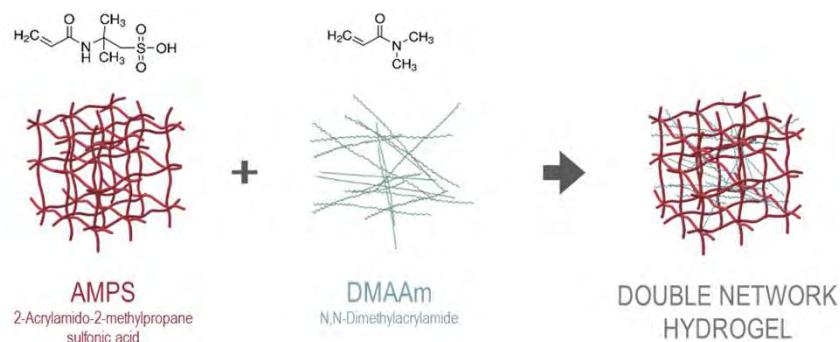
Il y a de grands progrès dans la domaine des biomatériaux



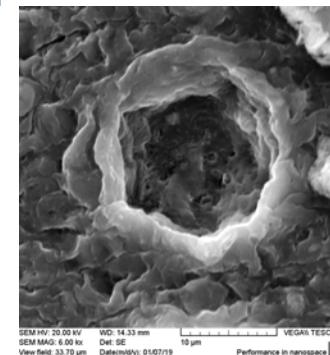
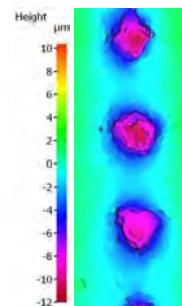
Examples of Labex's projects (ongoing and completed)

Dispositifs utilisés

- DN gel fabriqué au LTDS et au Japon



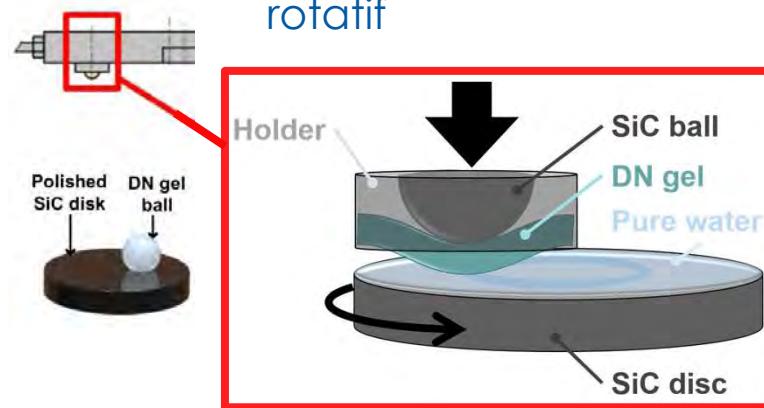
- Texturation laser du DN gel par Manutech Sise
- Observation au MEB et microscope optique



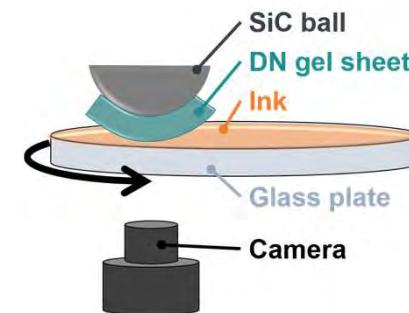
L'influence de la texture sur le frottement, l'usure et la repousse cellulaire a été étudié

TACMUST

- Utilisation d'un tribomètre rotatif



- Observation directe de l'interface





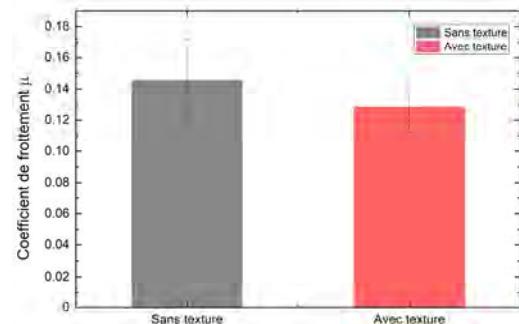
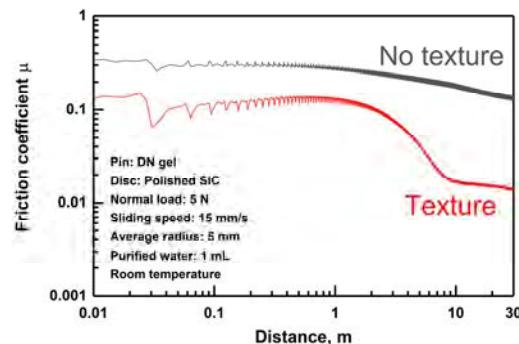
Examples of Labex's projects (ongoing and completed)

TRIBOLOGIE

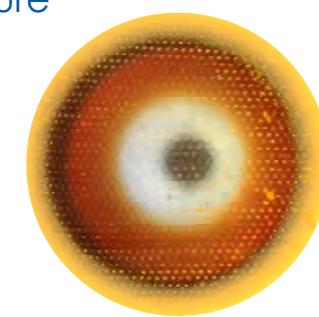
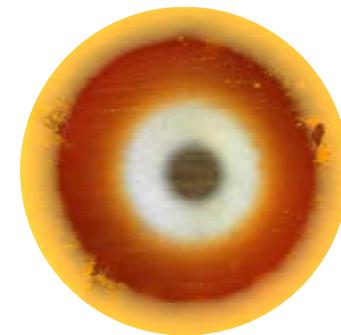
Résultats influence texture sur les propriétés tribologique du DN gel

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)



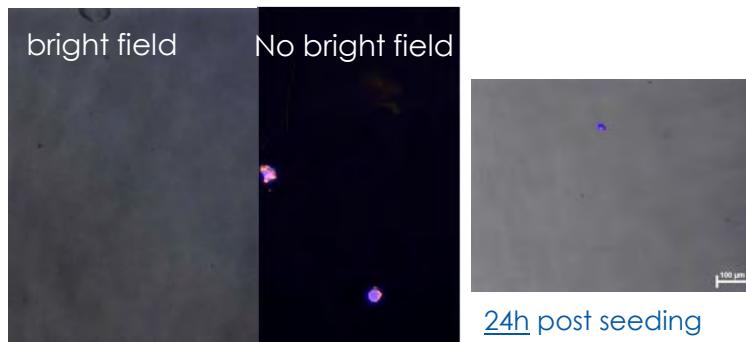
Examples of Labex's projects (ongoing and completed)

BIOLOGIE

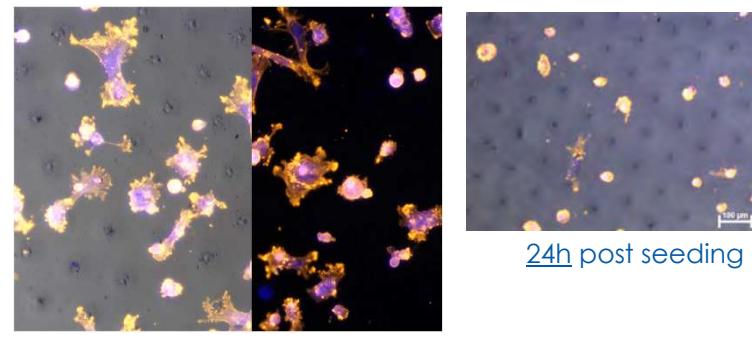
Résultat influence texture sur les propriétés biologiques du DN gel

TACMUST

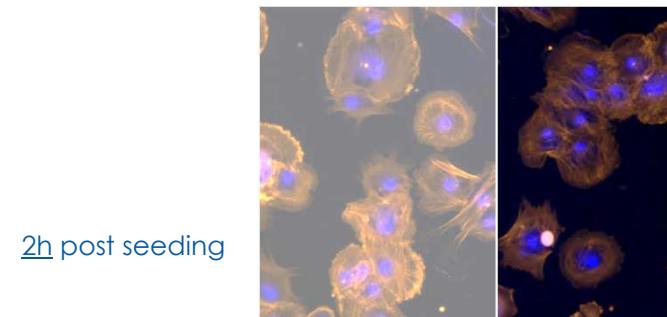
- Sur la repousse cellulaire



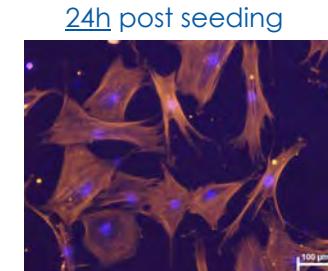
DN gel non texturé



DN gel texturé



Boîte de Petri
en plastique



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



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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
VO₂ Thin Films for the Protection of Electronic and Optical
Devices



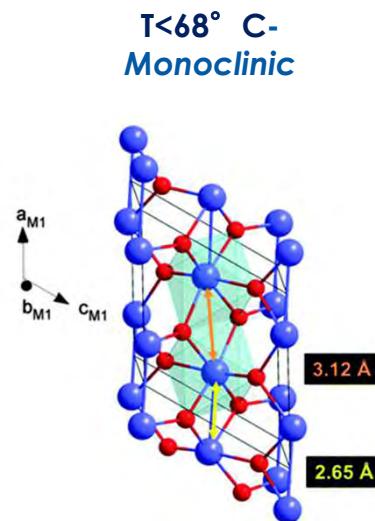
Contacts:
Christophe Donnet (Christophe.Donnet@univ-st-etienne.fr)



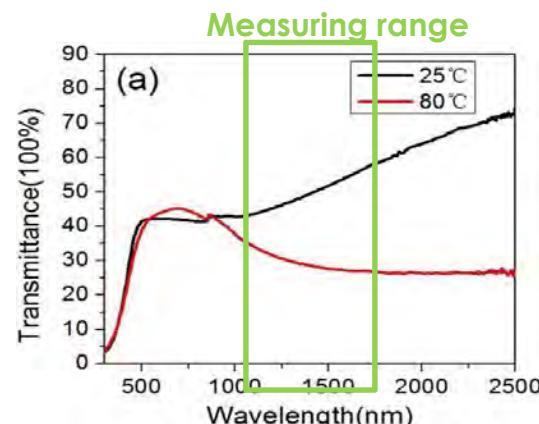
Examples of Labex's projects (ongoing and completed)

R2EX

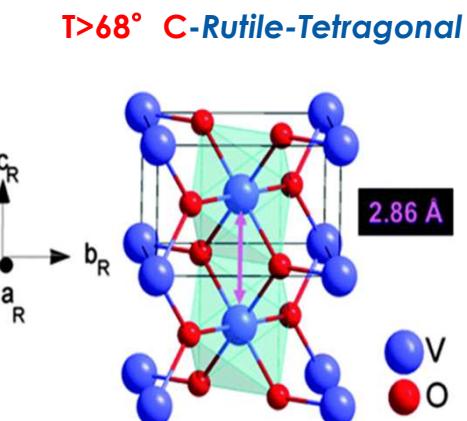
VO₂ Material : metal–insulator transition



Dielectric material
**Transparent in the IR
region**



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



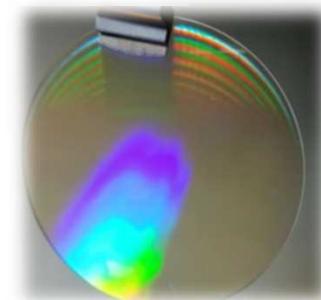
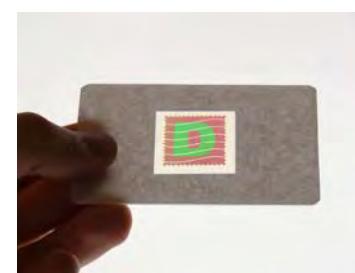
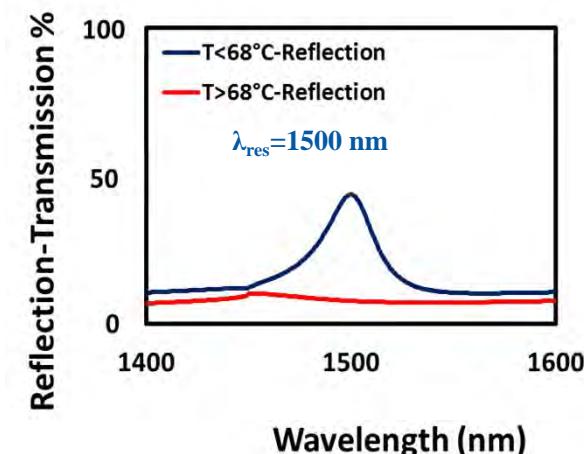
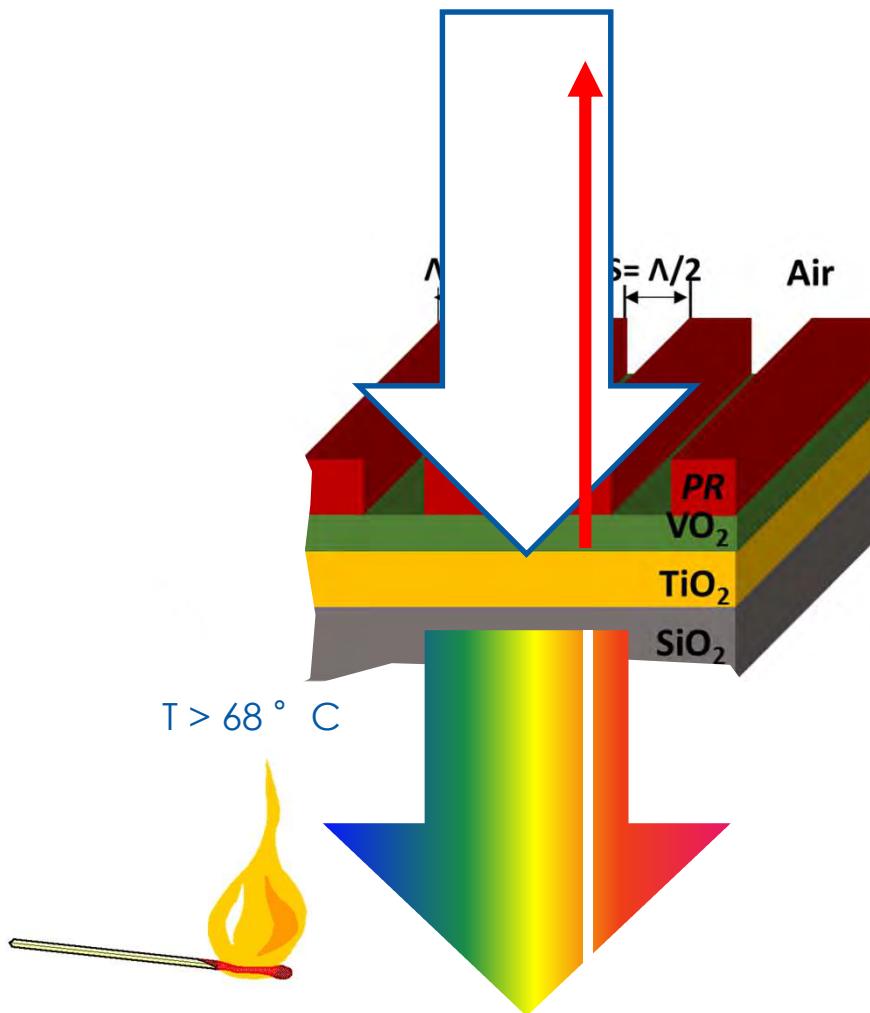
Metallic material
**Opaque in the IR
region**



Examples of Labex's projects (ongoing and completed)

Thermally Activated Waveguide Resonant Grating (VO₂ thin layer)

R2EX



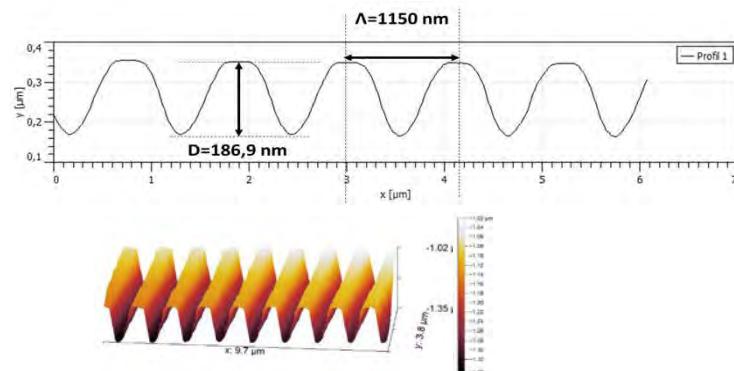


Examples of Labex's projects (ongoing and completed)

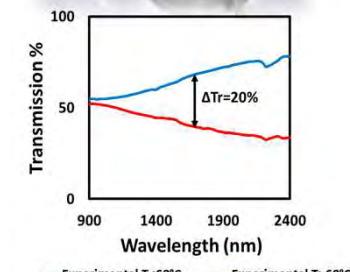
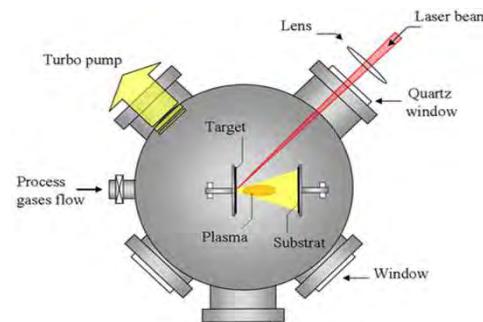
Fabrication and optical measurements

TiO₂ sol-gel deposition
VO₂ layer deposition (PLD)

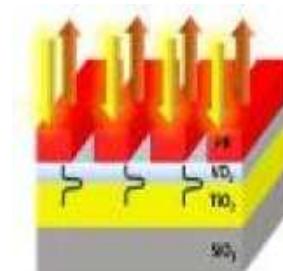
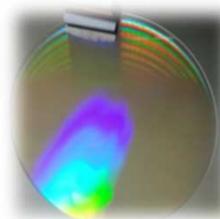
Grating writing (LIL)



PLD (Pulsed Laser Deposition)



R2EX

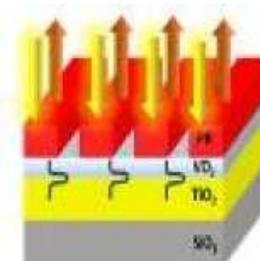
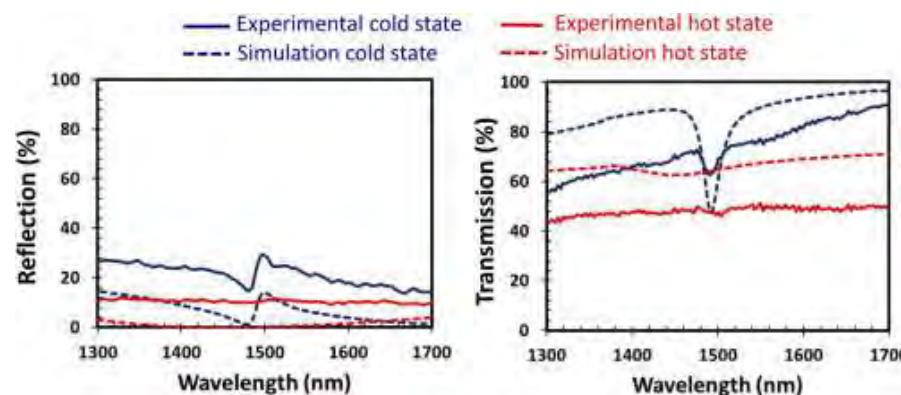
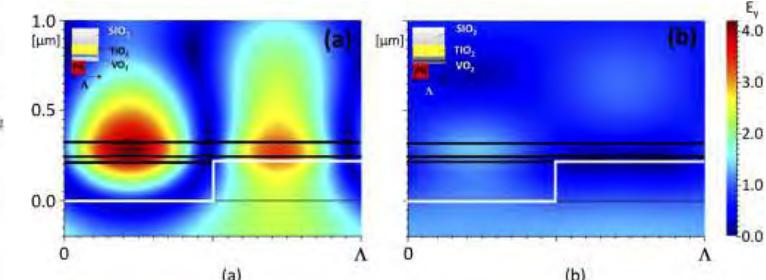
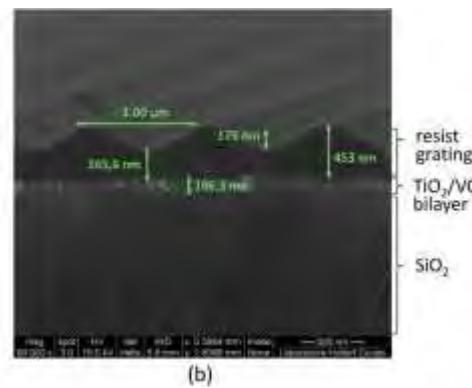
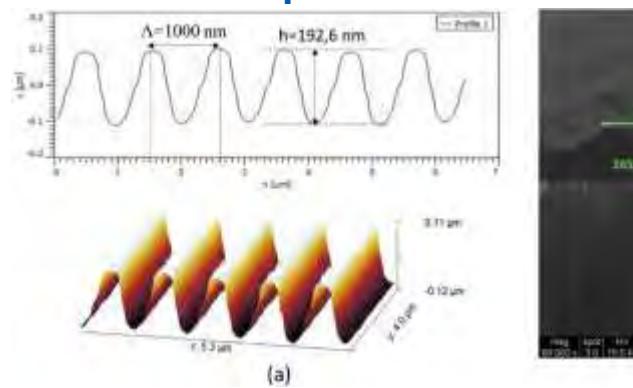




Examples of Labex's projects (ongoing and completed)

Fabrication and optical measurements

R2EX

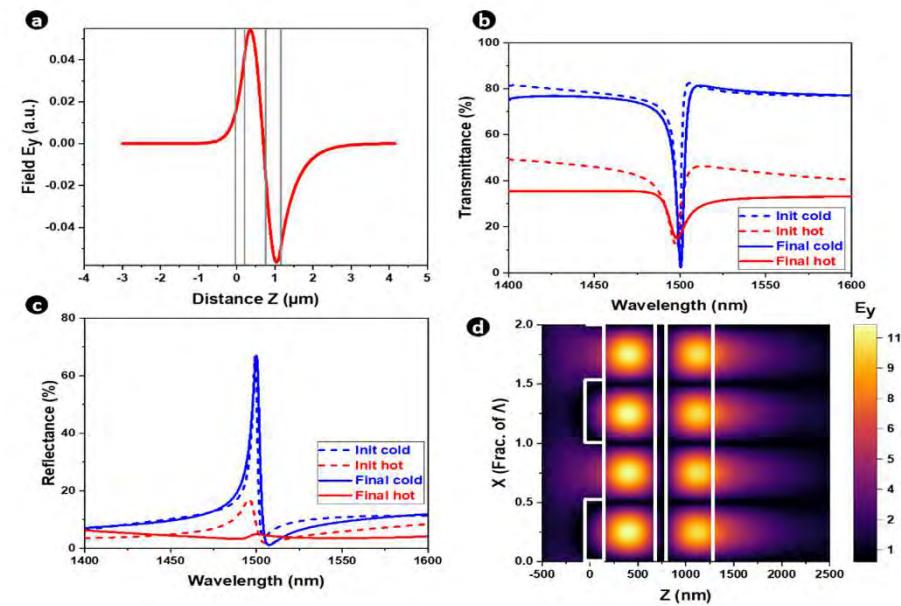
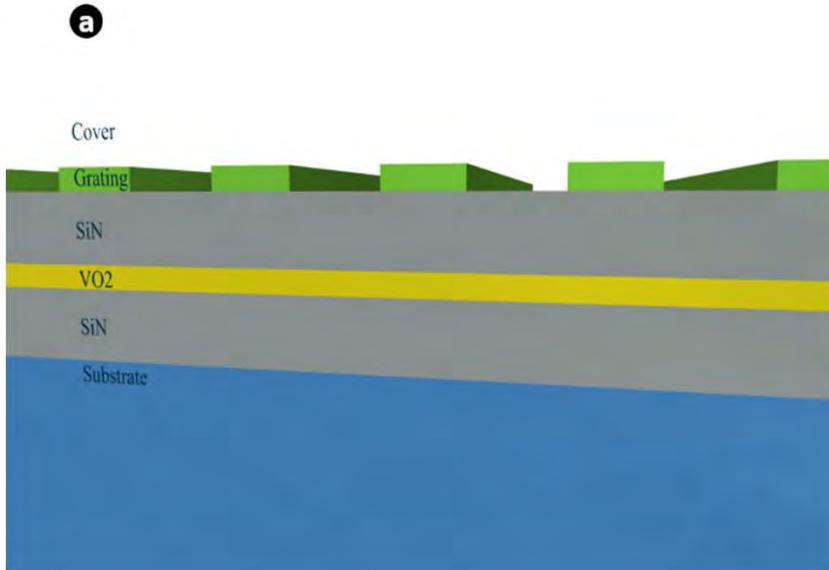


Koussi et al, "Thermally activated resonant grating using a vanadium dioxide waveguide" *Opt. Mat. Express* 11(4), 2021



Examples of Labex's projects (ongoing and completed)

New design (PROTECT)

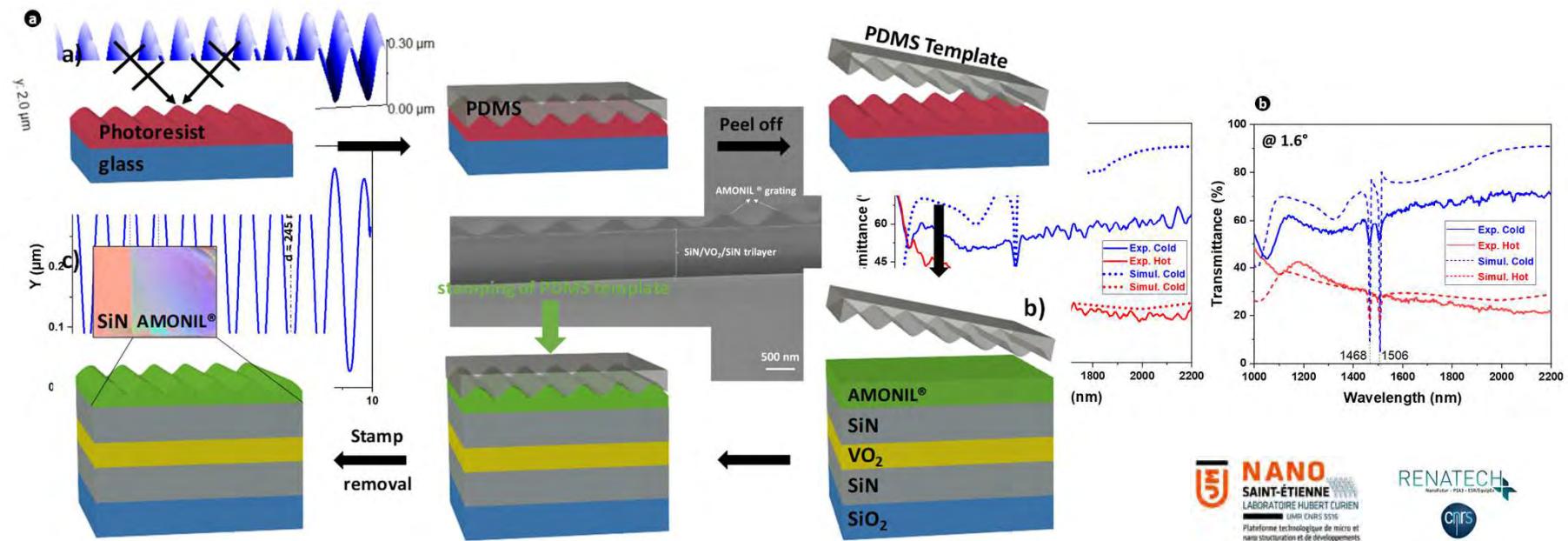




Examples of Labex's projects (ongoing and completed)

PROTECT

Fabrication and optical measurements



Bleu et al., "SiN/VO₂/SiN sandwich-based resonant waveguide grating to produce thermally activated optical components", *Advanced Optical Materials*, May 2023, DOI: 10.1002/adom.202300126



CONCLUSION

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)

Nicolas COMPERE (nicolas.compere@manutech-usd.fr)

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

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