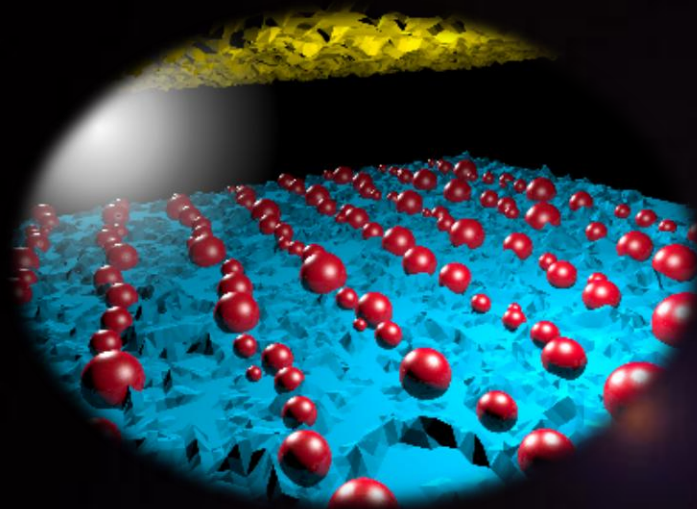




Towards the industrialisation of a laser-colouring process for random plasmonic metasurfaces

NATHALIE DESTOUCHES & MANUEL ALEJANDRO FLORES FIGUEROA

Laboratoire Hubert Curien, Saint-Etienne & Toppan Security

TOPPAN SECURITY: FORMING SYNERGIES

TOPPAN Security is the *international security branch* of the TOPPAN GROUP.



800+

CUSTOMERS



1000+

EMPLOYEES



100+

COUNTRIES SERVED

IDENTITY & ELECTIONS

PAYMENT



ADVANCED ID SOLUTIONS TO KEEP YOU SECURE

From what ?

DOCUMENT FRAUD

- Immigration Abuse
- Illegal Working
- Hide True Identity
- Financial Fraud - Theft based

How is it made ?

- **-Counterfeits:** A reproduction of a genuine document
- **Forgeries:** A genuine document that has been altered in some way by substitution of the page(s), photograph and/or personal details (*New! Use of AI*)
- **Impersonation:** An imposter posing as the genuine individual

6000-9000 detected fraud on ID documents in Europe per year

FRONTEx				Share of	Highest Share
Type of Document	2021	2022	Total		Doc. Type
Other	4601	2248		27	Counterfeit (96%)
Passport	1294	1822		22	Impostor (28%)
Visa	700	1422		17	Fraudulently obtained (51%)
Border Stamp	963	1242		15	Counterfeit (94%)
Residence Permit	668	1014		12	Counterfeit (78%)
ID Card	477	514		6.2	Counterfeit (67%)
Total	8703	6622		100	

ADVANCED ID SOLUTIONS TO KEEP YOU SECURE

But how ?

SECURITY FEATURES

Digital Watermarking

Level 3

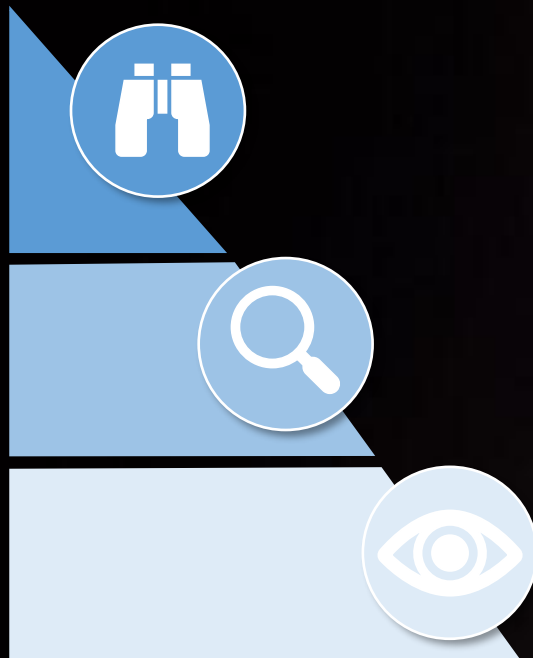
Microprint
UV
Chip

Level 2

Hologram
Guilloche
Laser engraving

Tactile
Second portrait
Clear Window

Level 1



Clear windows

Microtext

UV

Laser engraving

Second portrait

Embossing

Hologram

Guilloche



- LASER MARKING USED TO COMBINE MANY SECURITY FEATURES
- DIFFICULT TO COUNTERFEIT DUE TO STRONG AND UNIQUE LINK!

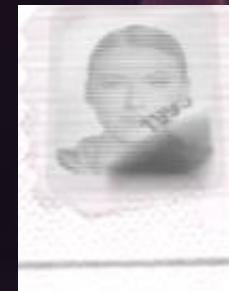
Laser technologies are the future for the ID industry

Strong interest in developing complex features that are difficult to manufacture BUT easy to check

=> Apply additional holder's image for a second level of verification



THALES



Develop new laser technology for color portrait





Joint laboratory 2022-2029: Laser Materials and Colors for citizen ID documents



Objectives:

- Strengthen long-term collaboration
- Promote joint research and innovation on topics with high potential for application and transfer
- Encourage knowledge and skill transfer, through the joint supervision of PhD students, postdoctoral fellows, and engineers
- Bring technologies to TRL 4-5 and then scaled up by the industrial partner

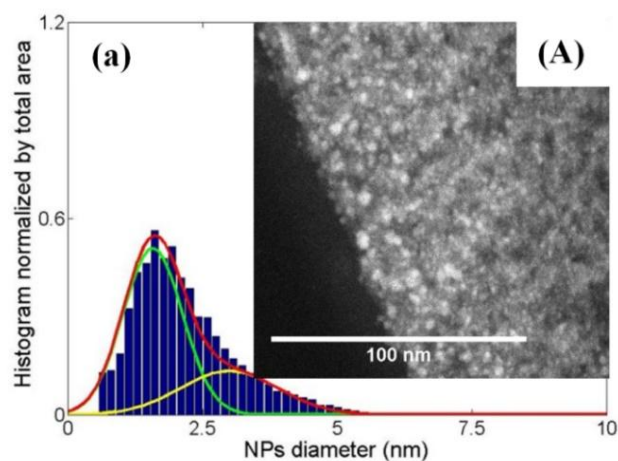
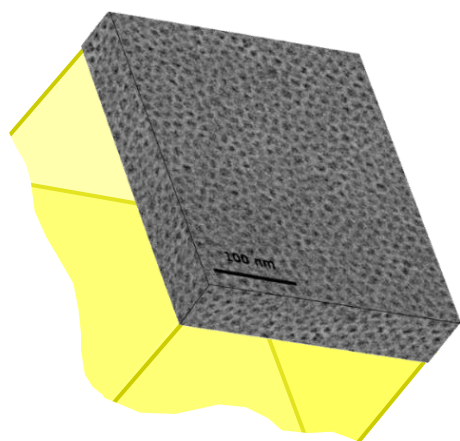


Agreement (4 years):

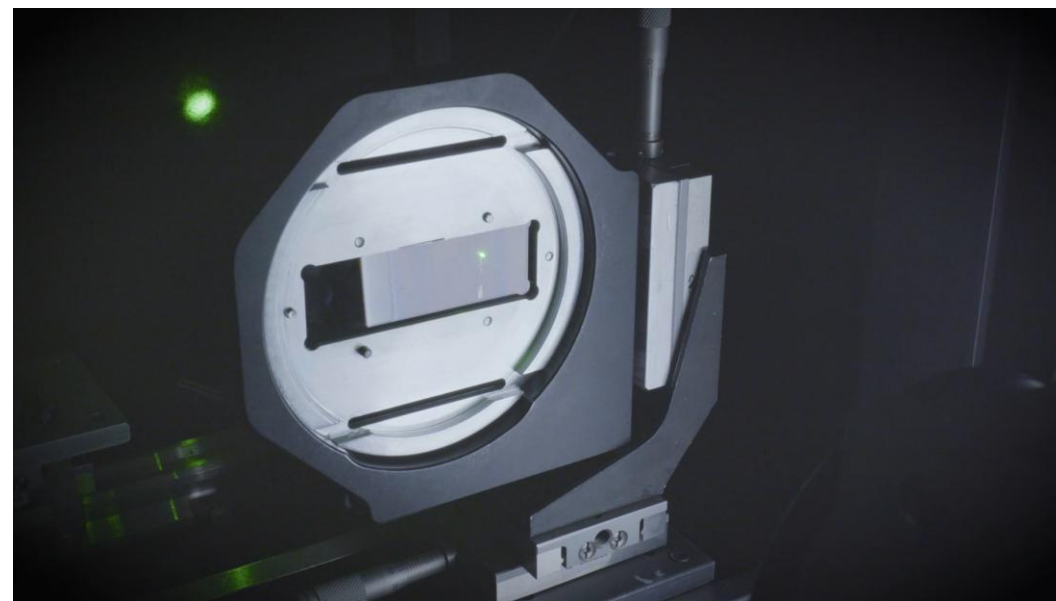
- Background knowledge and research topics
- TS commits to funding for interns, PhD, post-doc and/or engineers) + annual contribution
- Resources: location, equipment, personnel
- IP, confidentiality and publications

Print personalized color images by nanosecond laser on plasmonic nanomaterials

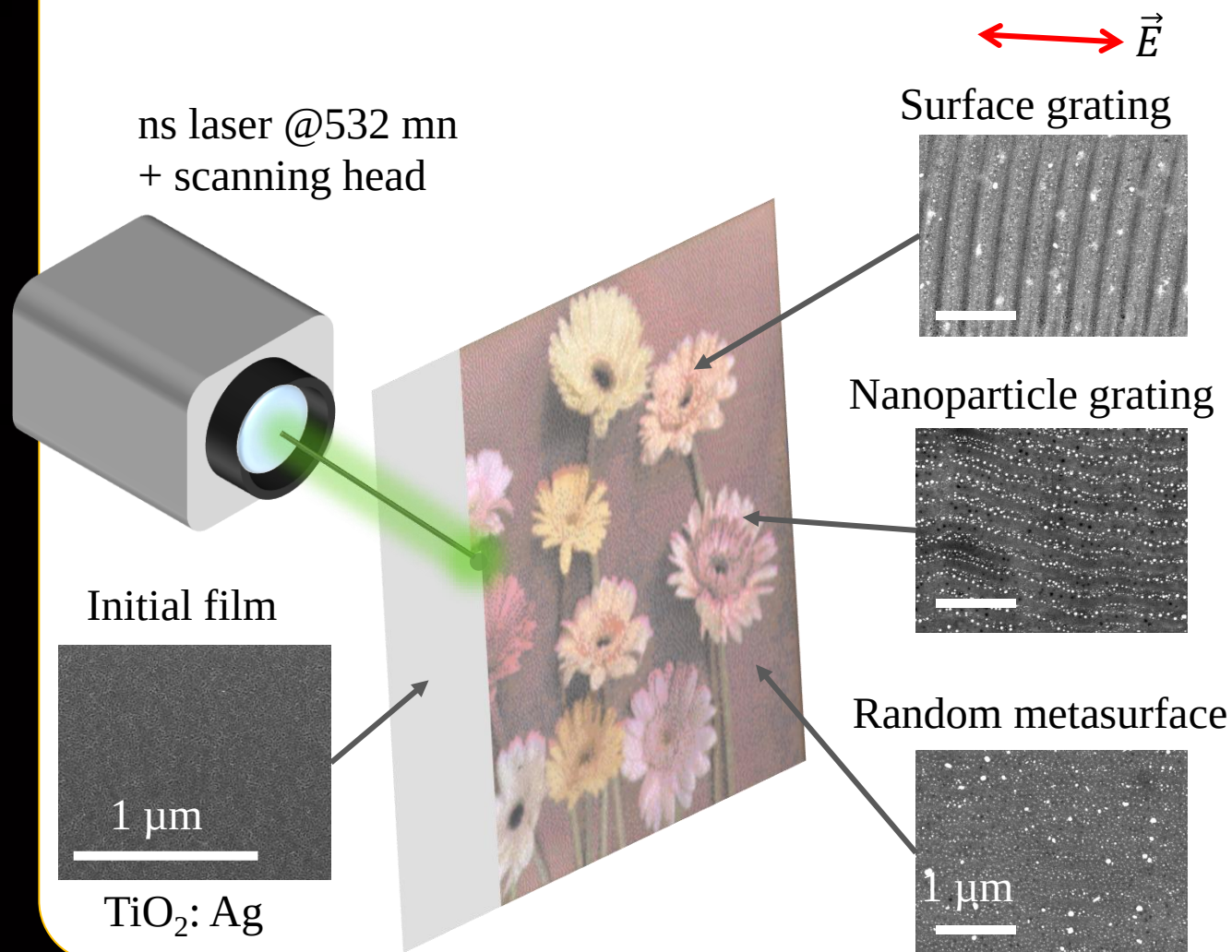
Thin film of mesoporous TiO_2 + Ag^+ + Ag NPs



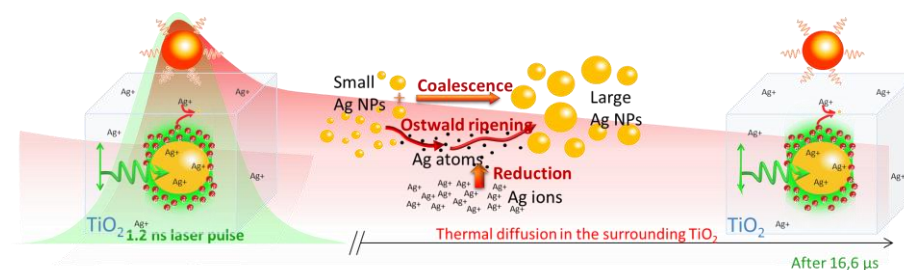
Direct laser processing @ 532 nm, 1.2 ns



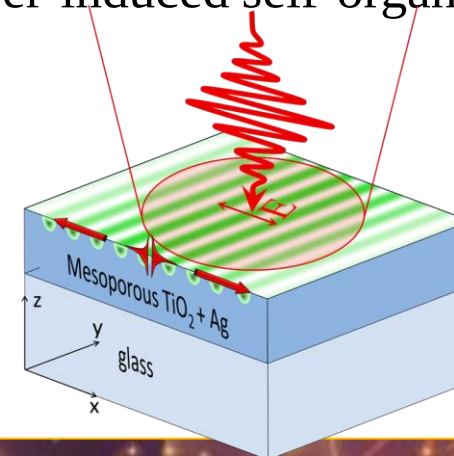
Laser-induced structural colors



NP growth triggered by laser-induced temperature rise



Laser-induced self-organization

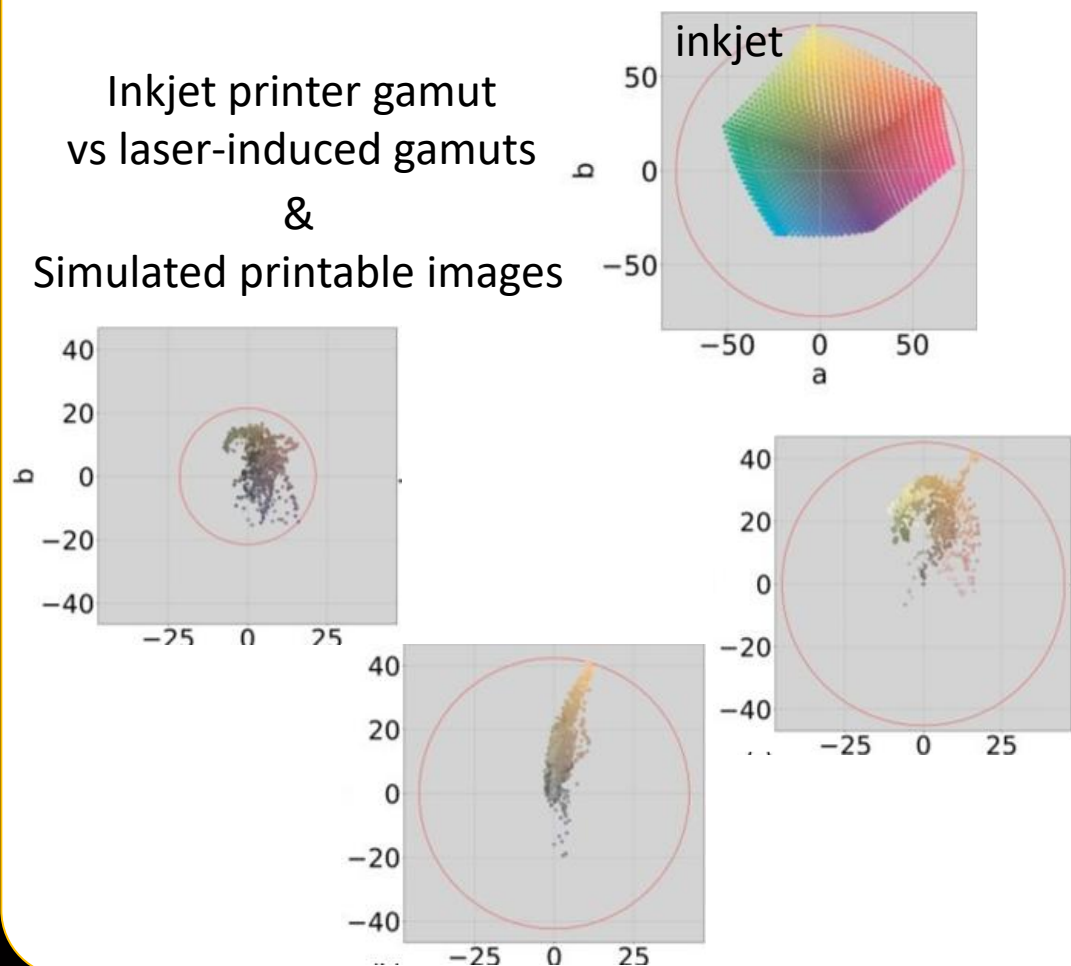


Gamut limitation and solutions

Inkjet printer gamut
vs laser-induced gamuts

&

Simulated printable images



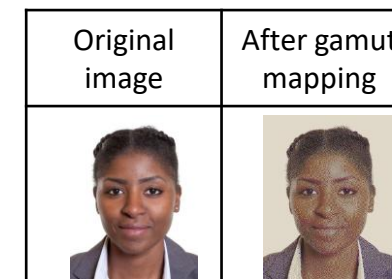
1- Bayesian optimization of laser processes to maximize structural color gamut

R. Mermillod-Blondin et al., **JEOS-RP**, 22, 45, 18 (2026)

2- Gamut mapping

Use only the laser-induced colors

Vector error diffusion



3- Definition of quality image metrics to select automatically the best gamut



4.1



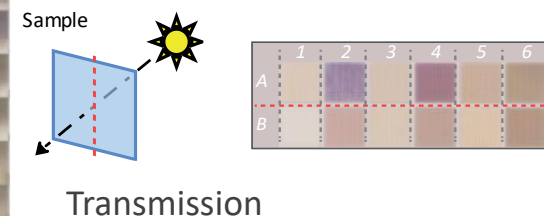
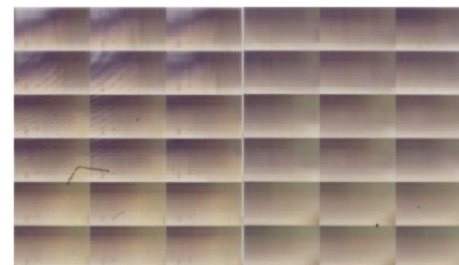
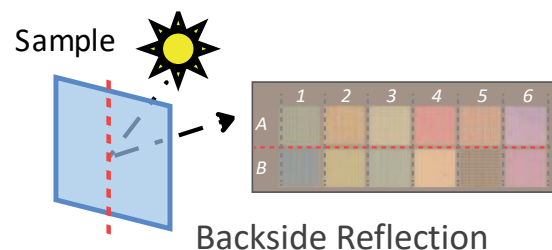
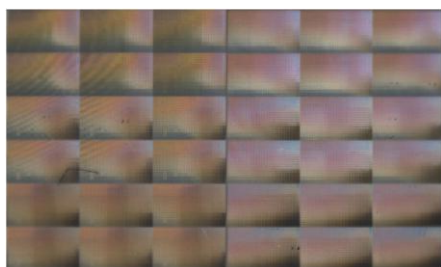
4.2



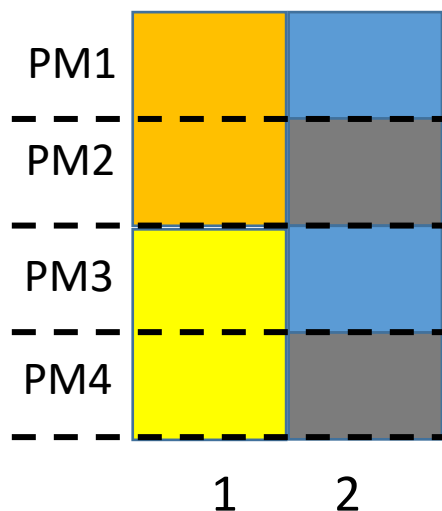
3.5

R. Mermillot-Blondin, et al. **JEOS-RP**, 21, 36 (2025)

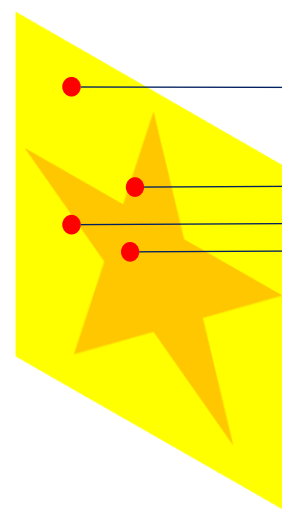
Image multiplexing for visual authentication



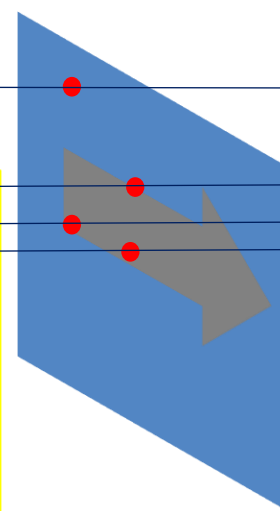
4 laser-
induced
plasmonic
metasurfaces



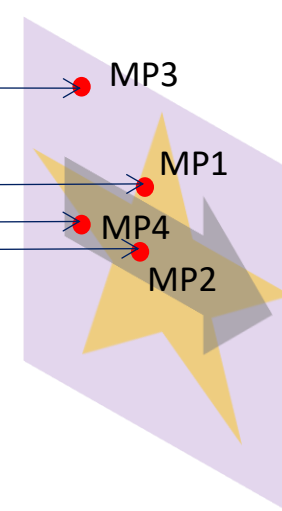
Observation Modes



Observation
Mode 1

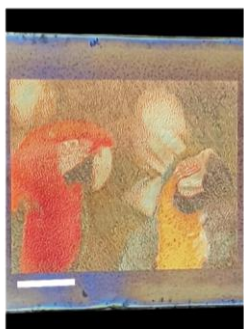


Observation
Mode 2



Laser-printed
image

Image multiplexing for visual authentication



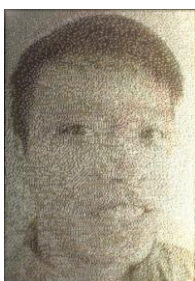
Backside
reflection



Diffraction



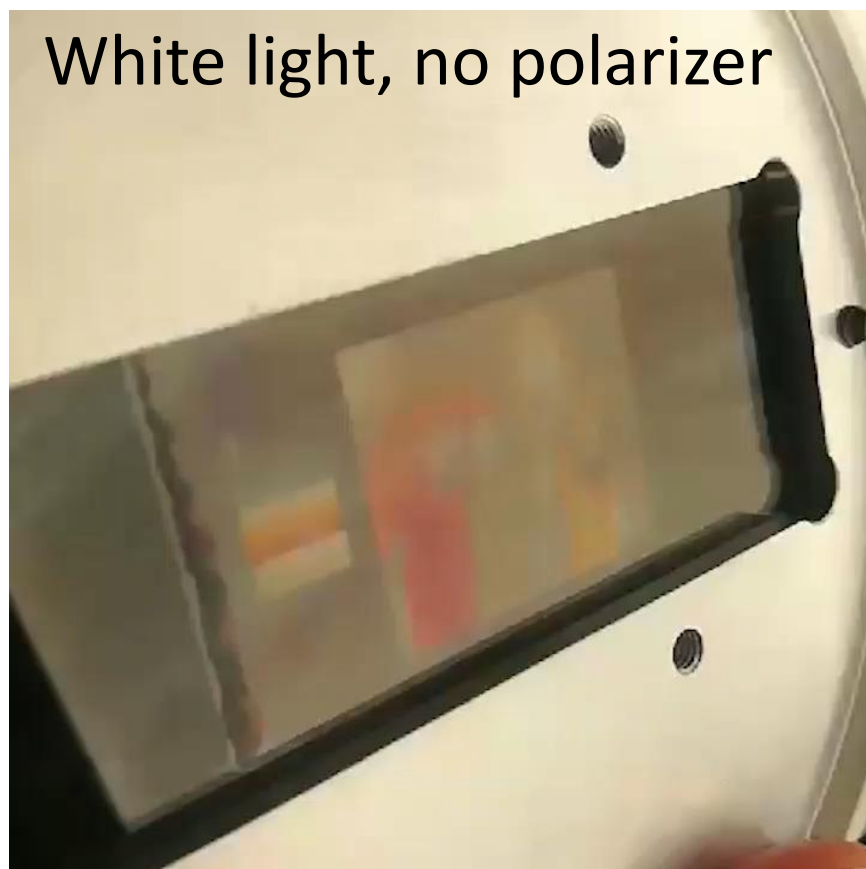
Transmission



Scattering



Diffraction



White light, no polarizer



White light, no polarizer

Technology developed in plastic card

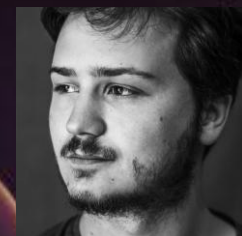
From prototype to a real product



Acknowledgements



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Blondin



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ANR-23-
CE39-0006



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Hébert



Marc
Sebban



Christophe
Hubert



Francis
Vocanson



Van Doan
Le



Hongfeng
Ma



Amaury
Habrard



Rémi
Emonet