



Infrared coating filter obtained in large industrial equipment



Workshop Infrared Detection for Space Applications

CNES COMET - TOULOUSE - June, 7-9th, 2023

[Dragan Stojcevski](#), R&D Project Manager

Contents

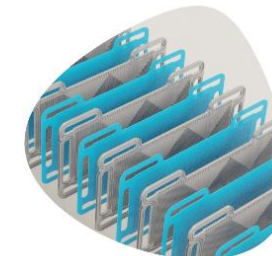
1. HEF Groupe and KERDRY's activities
2. Anti-reflective coatings for IR applications
3. Example of IR filter
4. R&D on new material and designs
5. DLC coatings for high durability
6. Conclusions

HEF Groupe \ the Photonics Unit

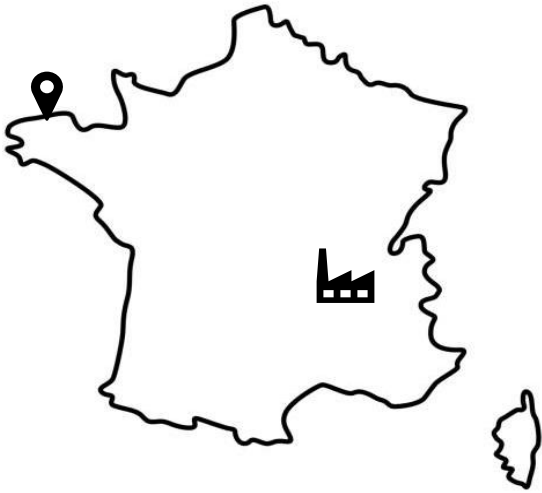
Since 2021



Since 1953



KERDRY Thin Film Coatings

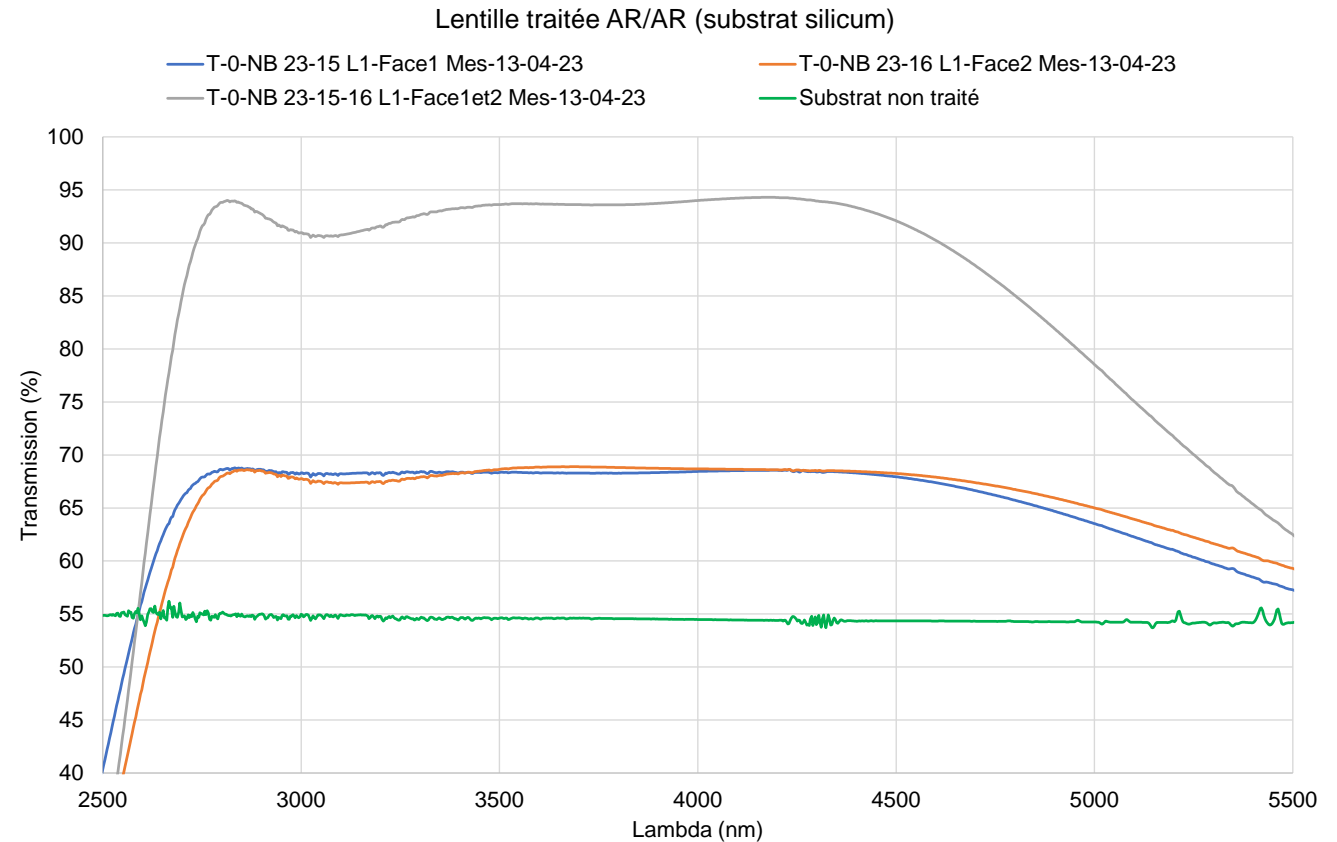
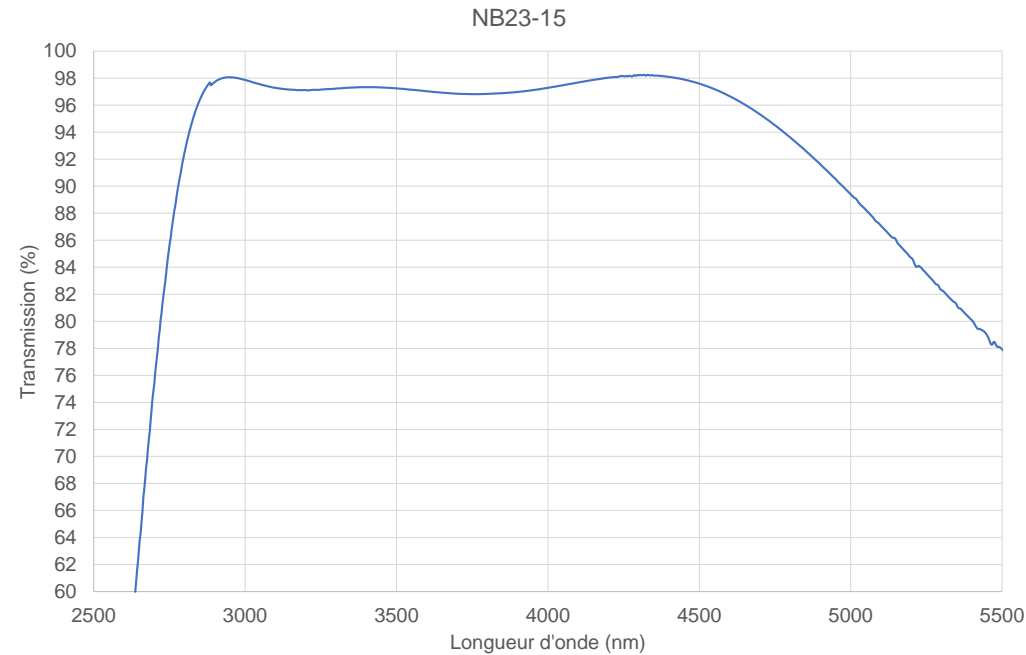


- Custom thin film coatings for advanced technologies
- Applications : Defence, Space, Metrology, Photonics...
- From R&D to Production
- 15 PVD machines installed in 1000 m² of clean room
- Magnetron sputtering and e-beam IAD deposition technologies
- Optical coatings from **UV to IR** : AR, metallic mirrors & HR mirrors, black coatings, dichroic filters...
- Large scale substrates up-to 1.40 m
- ISO 9001 and ISO 14001 certifications

Coating highlights

- **Coating technology**
 - E-beam with ions assisted deposition
 - Thermal evaporation (Joule effect)
- **Coating optical functions**
 - Anti-reflective over 3-5 μ m and 8-12 μ m
 - Selective filter on 2-14 μ m spectral range
- **Adapted coating tools**
 - Planar windows
 - Concave/Convexe lenses
 - Diameter up to 400mm
- **Various type of substrate materials**
 - Si, ZnSe, Ge, IG-6 / IRG-26, GaAs
- **Environnemental conditions**
 - Temperature : -40°C ; +80°C
 - Adhesion resistance : MIL-C-48497A (section 4.5.3.1)
 - Humidity : MIL-C-48497A (section 4.5.3.2) → +50°C; RH 95-100%; 24h
 - Abrasion resistance : MIL-C-48497A (section 4.5.3.3)

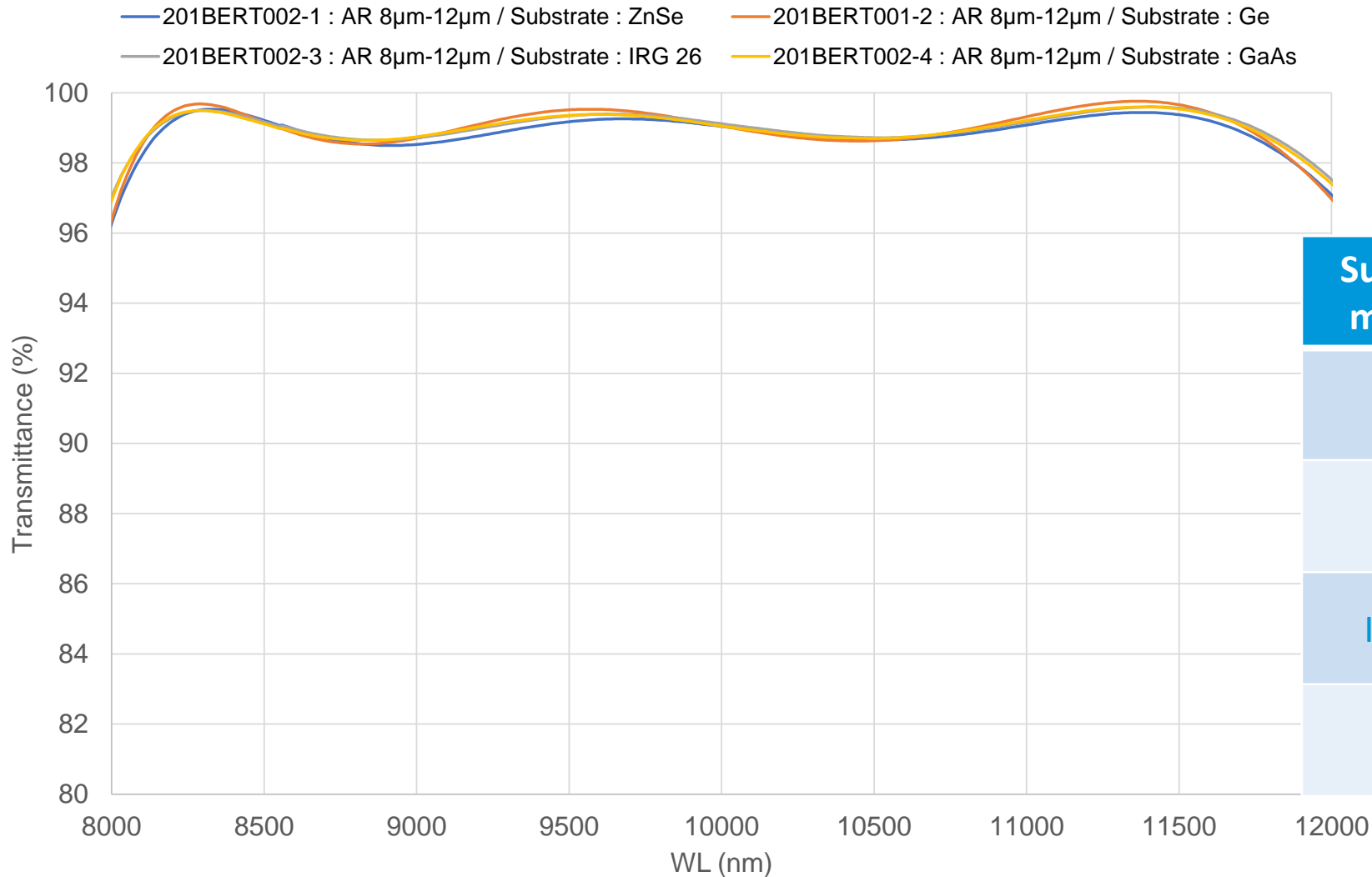
Anti-reflection coating IR 3-5 μ m range



- **Performances by reverse engineering**
 - Performance of the AR without contribution of the backside
 - T mean > 96,5% per face on 3-5 μ m
- **Substrats**
 - Ge and Si
 - Diameter 370 mm, CX/CC lens

- **Coating realizations on Si substrate**
 - Measurement on 1 side coated sample
 - Measurement on 2 sides coated samples

Enhanced AR coatings 8-12 μ m range

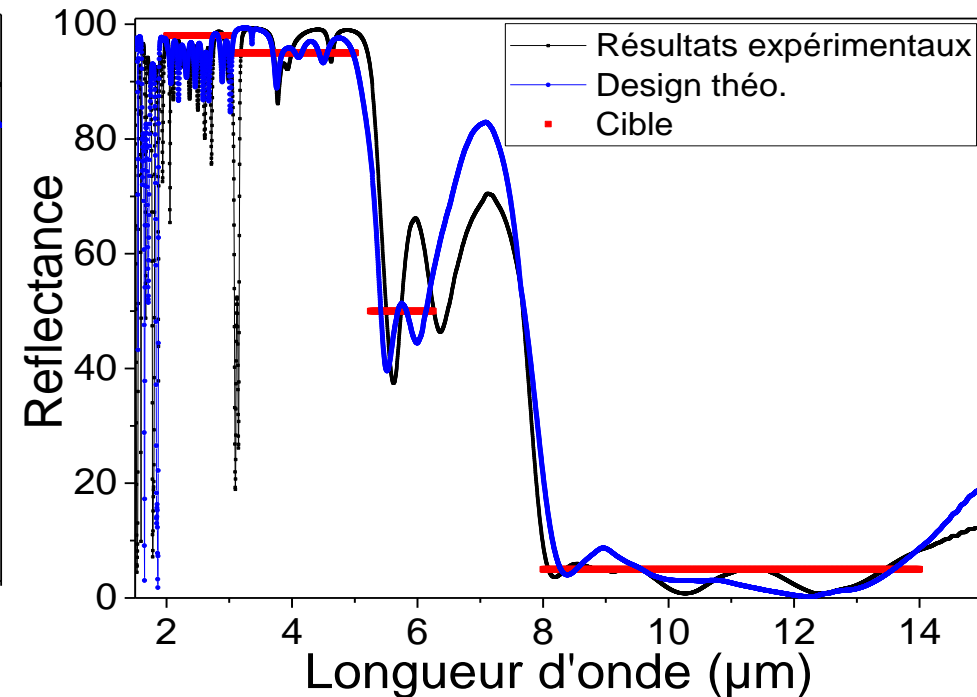
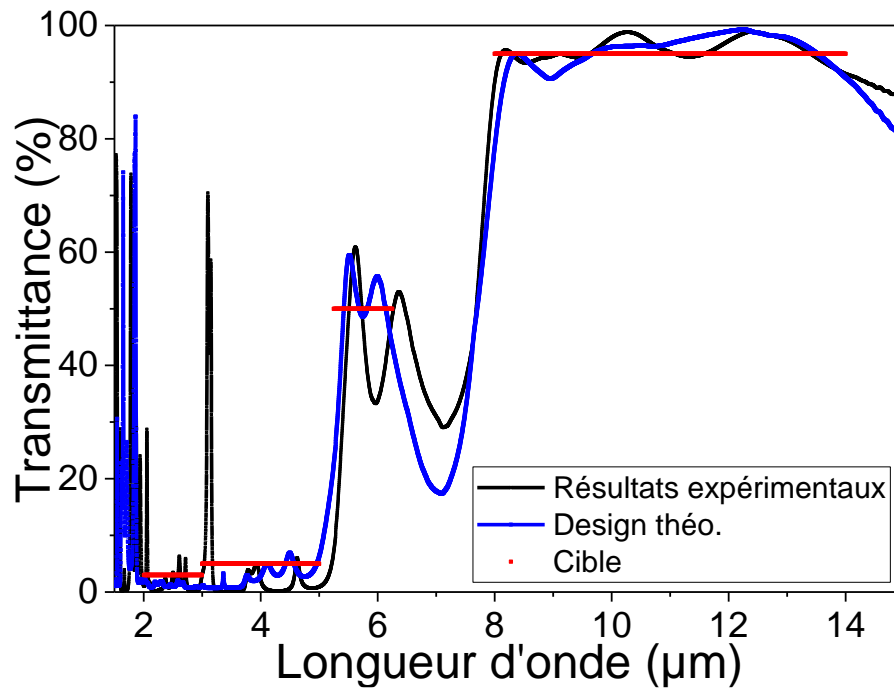
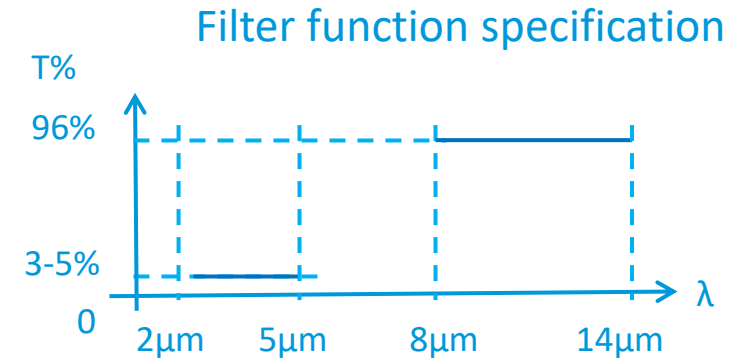


Improvement of the design for enhanced transmittance performances

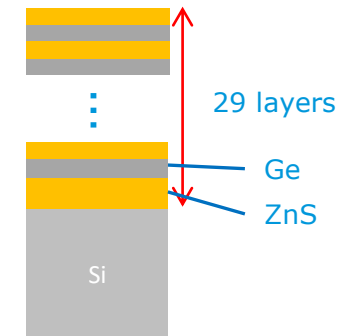
Substrate material	Transmittance performances
ZnSe	T_min > 96% T_average > 98,5%
Ge	T_min > 96% T_average > 98,5%
IRG-26	T_min > 96,5% T_average > 98.5%
GaAs	T_min > 96,5% T_average > 98.5%

Infrared dichroic filter 2-14 μm

- Si substrate thickness 625 μm
- Dichroic filter design of 29 layers Ge/ZnS
 - One side coating
 - AR function on 8-14 μm
 - Mirror function on 2-5 μm

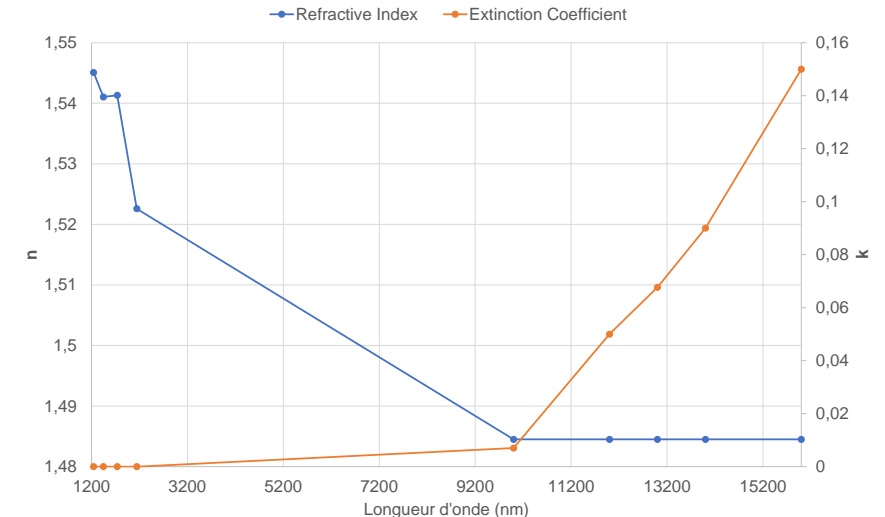
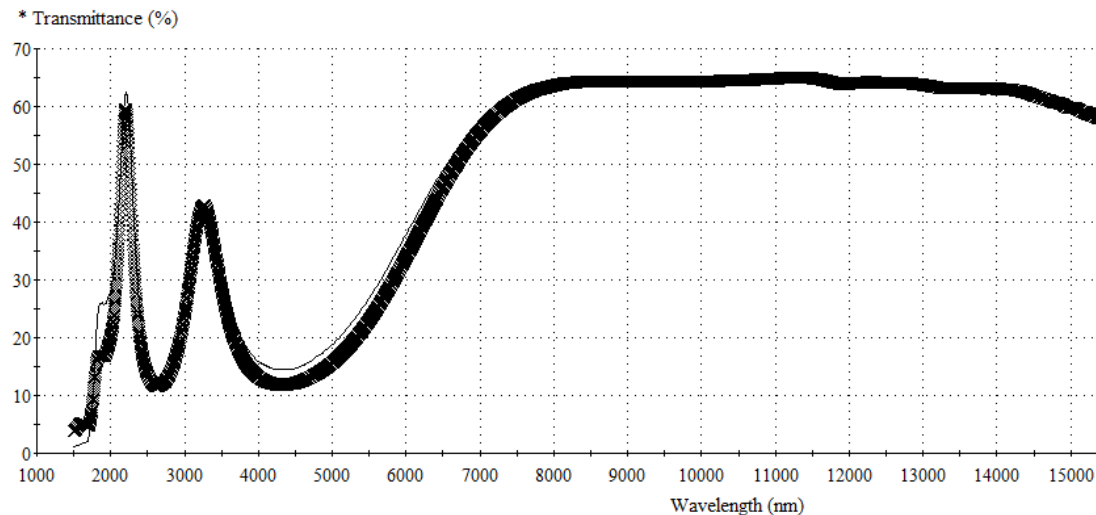


Multilayer design



Developments for new solutions

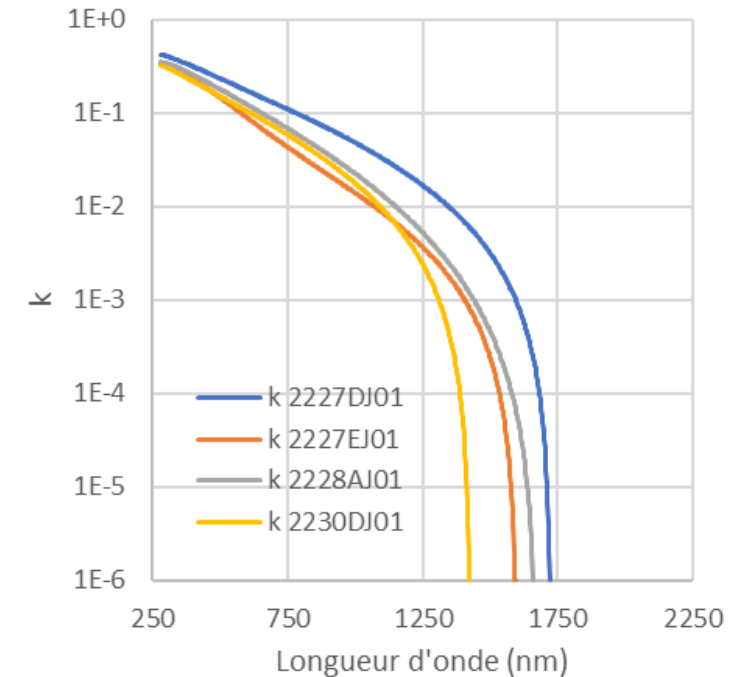
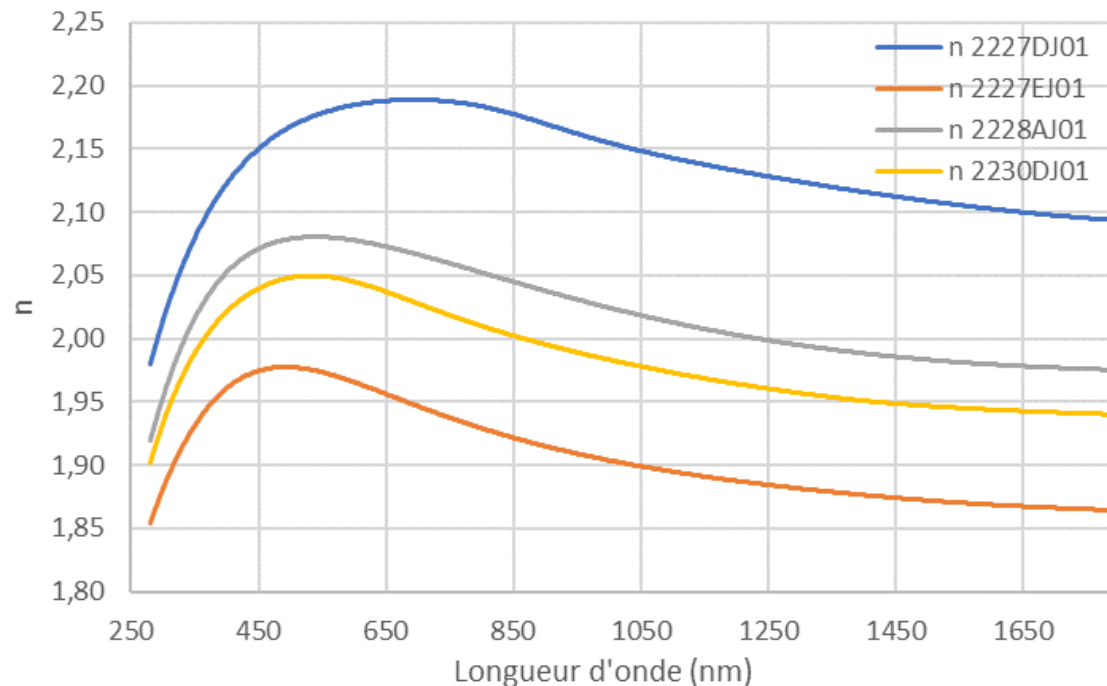
- Solution with new material for IR applications
 - Extend the spectral range
 - Process parameters setup and optical characterizations (n & k) in progress
 - The objective is to improve the level of transmittance on 3-5 μ m/7-14 μ m spectral range



- First results of AR coatings achieves on Ge substrate
- Theoretical study of design configuration : AR coating with 3 materials

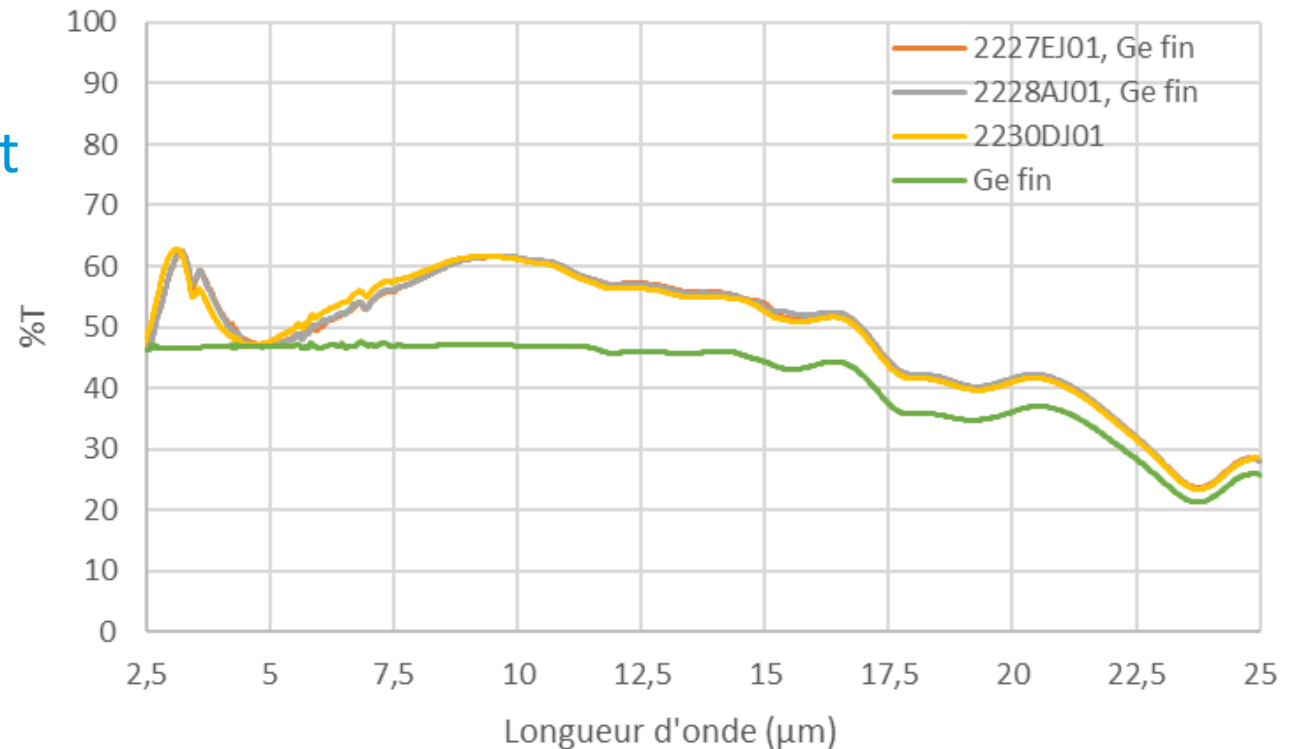
High durability coating

- DLC coating by HEF CVD plasma assisted technology
- Coating on large size optics with HEF machines for IR applications
- Characterization of the optical property of the DLC layer
 - Modulation on the $n(\lambda)$ & $k(\lambda)$ constants in function of the process parameters

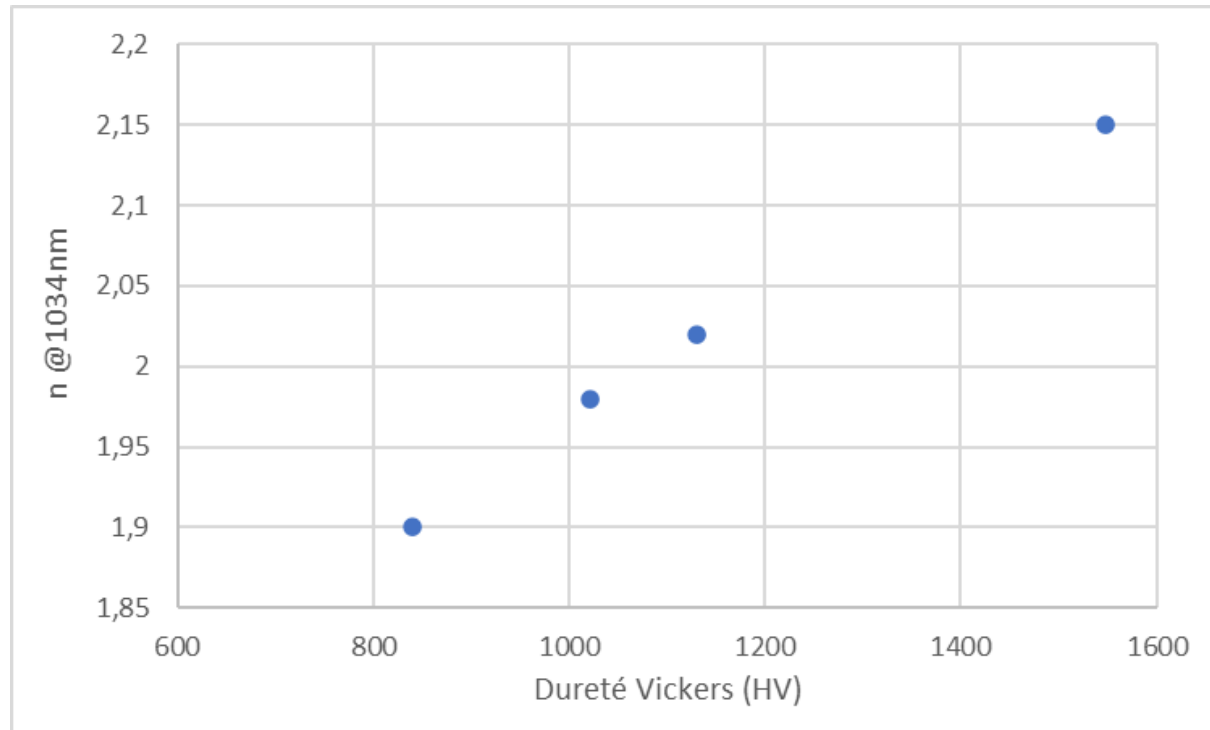


DLC performances

- Spectrophotometric AR performances (measured by FTIR method)
 - Enhanced transmittance performances : 35% over spectral range 8-12 μ m
- Environmental durability
 - Abrasion & adhesion resistance
 - Solubility test in water and solvent
- Next step :
 - Test matrix to complete the environmental tests for Space qualification
 - ✓ Thermal cycling
 - ✓ Humidity test
 - ✓ Radiation test
 - ✓ Vacuum thermic test



DLC mechanical properties



- Correlation between the refractive index and the layer hardness $HV=f(n)$
- Passed tests
 - Adhesion
 - Water and solvent solubility

Coating ID	Refractive index at 1034nm	Physical thickness	Vickers Hardness (HV)
2227EJ01	1,90	1333	840
2230DJ01	1,98	1218	1021
2228AJ01	2,02	1259	1130
2227DJ01	2,15	1314	1548

Conclusions & perspectives

- AR coating for spectral range 3-5 μ m & 8-12 μ m
- Various substrates material and geometry
- Customize filtering functions (*i.e.* dichroic,...)
- Qualified for environmental conditions
- Developments in progress for processing new material and improving designs
- Adapted coating performances :
 - High efficiency AR/AR coatings
 - High durability coatings with the DLC hard layer
 - Combining AR and DLC coatings for application in severe environmental conditions

Thank you for your attention



KERDRY HEF Photonics

Espace Louis de Broglie

5 rue Louis de Broglie

22300 LANNION

FRANCE



dstojcevski.kerdry@hef.group



hef.fr

kerdry.com