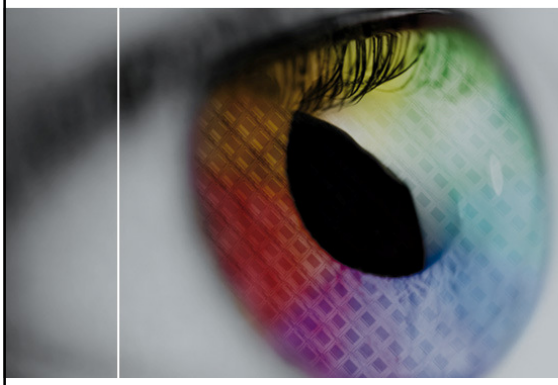
# AMAA 2012

## Far Infrared Imaging Sensor for mass Production of Night Vision & Pedestrian Detection Systems




*Dr JL Tissot, E Bercier, P Robert, D Pochic, A. Arnaud*, JJ Yon**

***ULIS*** *BP27 - 38113 Veurey-Voroize France*

****CEA/LETI*** *- 38054 Grenoble France*


Silicon infrared imaging sensors



## Outline

- **Automotive applications**
- **FIR imaging sensor**
- **Thermal imaging for automotive applications**
- **Non imaging applications**
- **Conclusion**

## FIR imaging sensors for automotive applications

Far infrared (λ = 10 µm) is well adapted to pedestrian detection because of:

- High contrast based on object thermal detection
- Completely passive imaging system

**Two types of applications:**

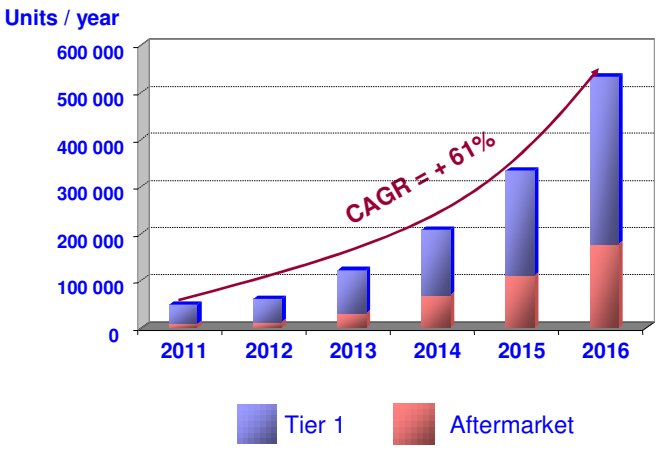
- Imaging applications
  - *Enhanced Driver Vision (EDV)*
  - *Pedestrian Detection System (PDS)*

- Short distance Detection applications
  - *Front & Back viewer*
  - *Occupancy detection*



## Imaging application – Market forecasts

**Enhanced Driver Vision**
**& Pedestrian Detection System**

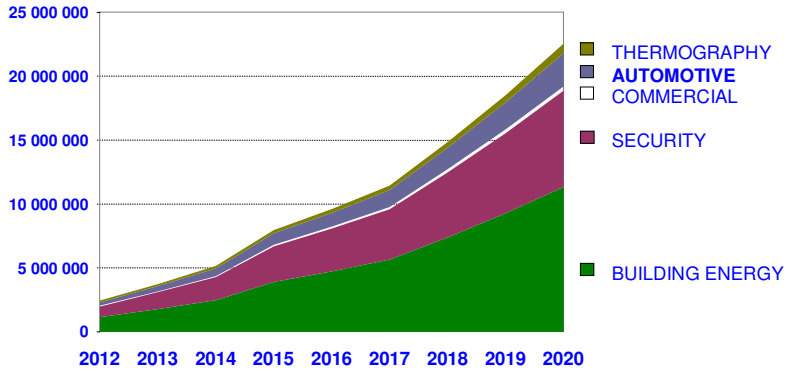



Forecasts from Yole Développement

## Detection applications - Market forecasts

It exists an important need of 2D arrays (# 64 x 64) which will be addressed mainly by microbolometer arrays and Thermopile arrays

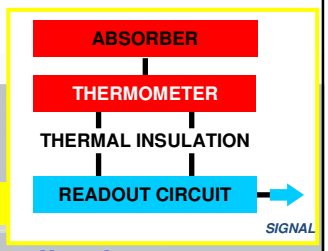
Units / year




Forecasts from Yole Développement



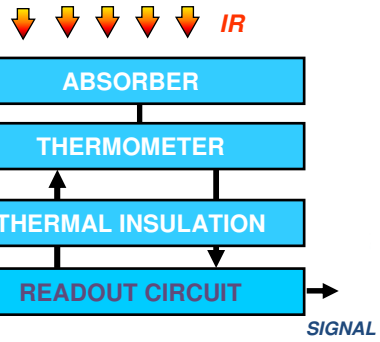
## Outline




- Automotive applications
- FIR imaging sensor
- Thermal imaging for automotive applications
- Non imaging applications
- Conclusion

## FIR imaging sensor background

Microbolometer
- Amorphous silicon *(aSi)*
- Vanadium oxides *(VOx)*




Vacuum Packaging

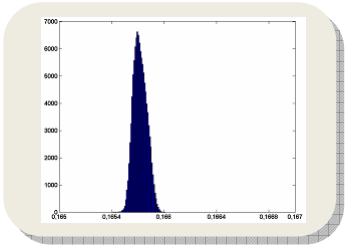
**Thermal detector**
**⇨ Uncooled detector**



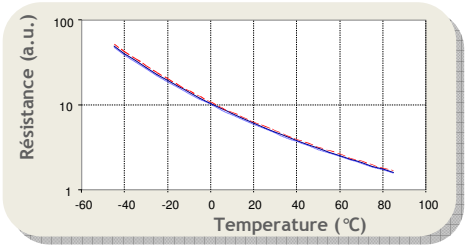
## Amorphous silicon background

aSi microbolometer: simple and uniform behavior

$$R_{bolo}=R_0.\exp(E_a/kT)$$



$E_a$ distribution histogram
aSi 384 x 288 / 17µm array

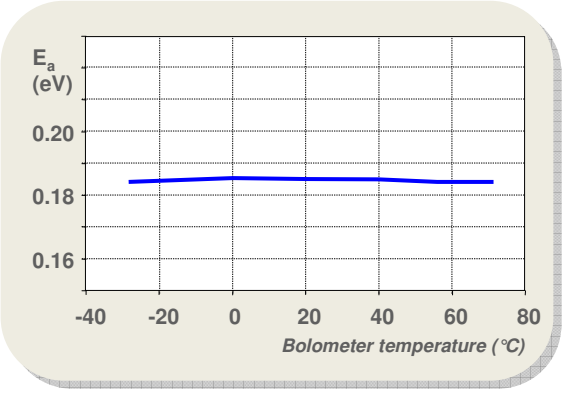



Uniform pixel behavior

**$E_a$ σ/m = 0.034%**

## Amorphous silicon background

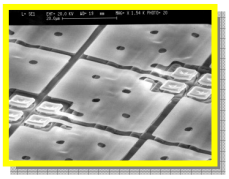
aSi microbolometer: Predictable over large range
-40 °to +85℃ operating temperature



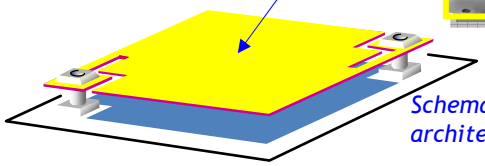

In addition to being very uniform over an array, $E_a$ is extremely stable with FPA temperature. ➡ **Easier TEC-less operation**
**Easier Shutter-less operation**



## Amorphous silicon technology



Only active layers in pixel structure



*Schematic pixel architecture*

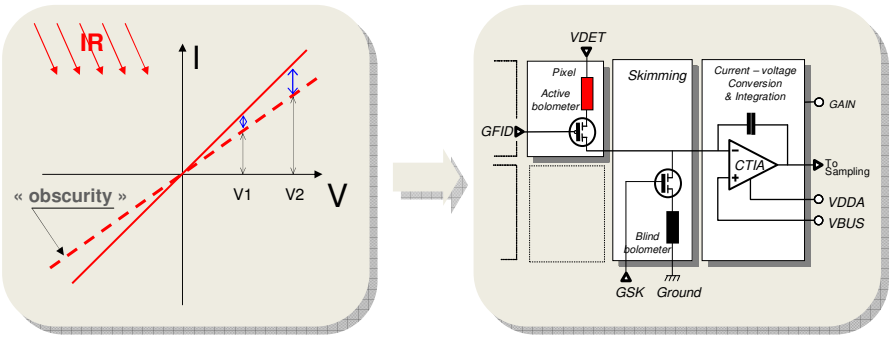
☑ **Smaller suspended mass = Smaller thermal time constant**

⇨ **Thermal time constant ≤ 10 ms**

+ High thermal insulation (shorter leg length ⇨ higher Fill Factor)

+ Low defect density & high uniformity

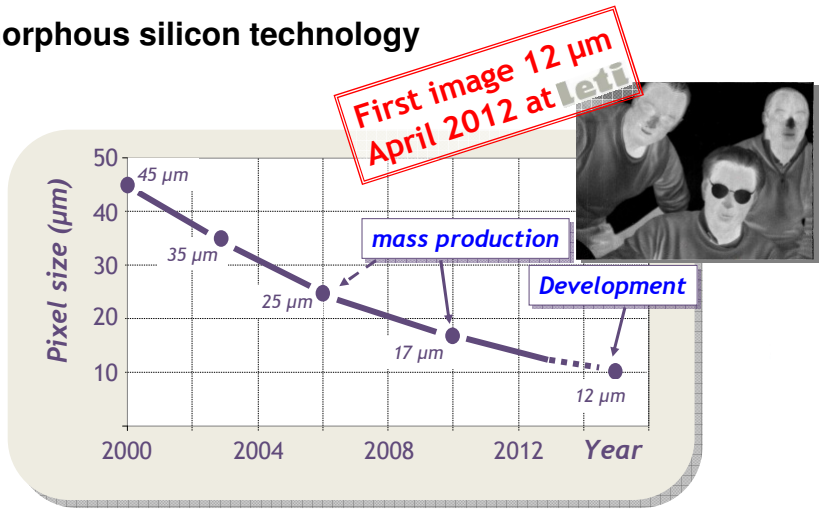
## Microbolometer Readout IC Design




***Signal = f(IR & bias) ⇨ necessity to introduce a skimming function***



## Amorphous silicon technology




***Development of amorphous silicon technology at ULIS in cooperation with CEA / LETI***

# Outline

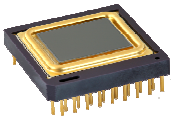
- Automotive applications
- FIR imaging sensor
- Thermal imaging for automotive applications
- Non imaging application
- Conclusion



## Imaging application

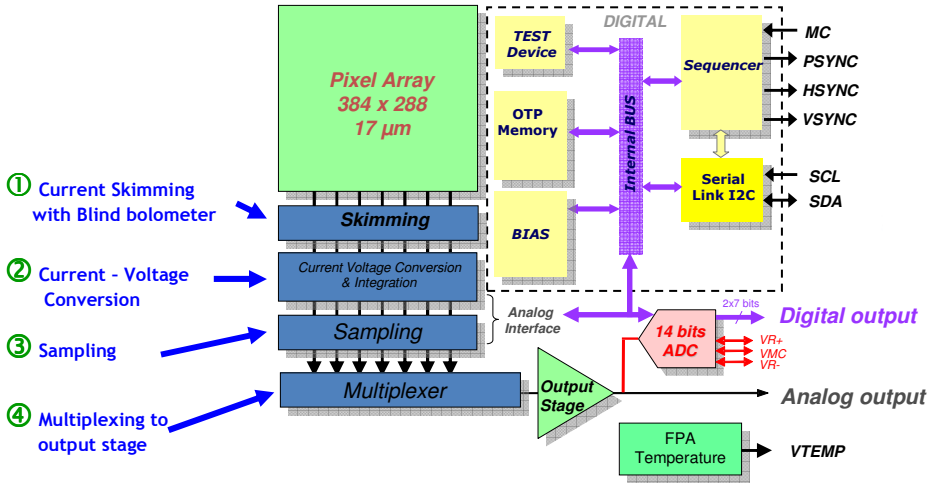
Needs for a ¼ VGA imaging sensor currently tested by Tiers 1 and Equipment manufacturers

⇨ Development of a new detector
¼ VGA / 17 µm pixel pitch



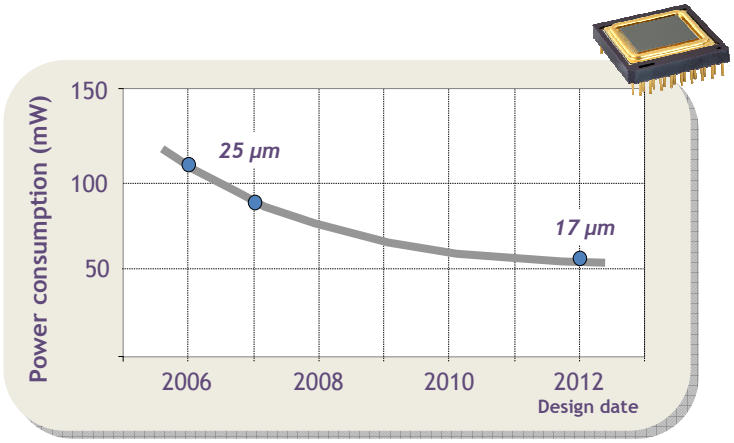
## Imaging application

⇨ Development of a new detector ¼ VGA / 17 µm pixel pitch





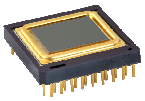

## Imaging application with 384 x288 / 17 µm IRFPA

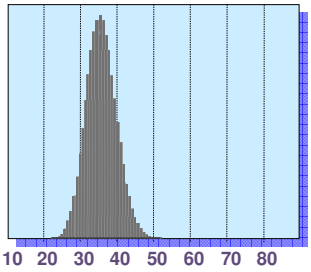



***Improvement of ¼ VGA power consumption (analog output)***

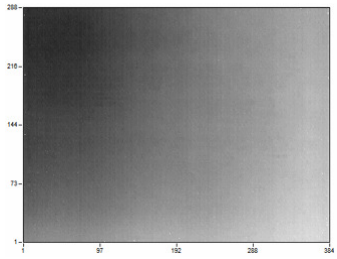
## Imaging application with 384 x288 / 17 µm IRFPA

### Device performance






NETD (mK)



**RFPN** = 250 µV
= *75% of rms noise*

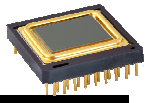
**Mean NETD* : 35 mK** (f/1, 300 K, 30 Hz)
**Thermal time constant : ≤ 10 ms**

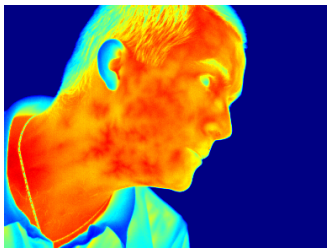
* NETD: Noise Equivalent Temperature Difference # detector sensitivity



## Imaging application with 384 x288 / 17 µm IRFPA

### Device performance





Groupe SOFRADIR
UNCLASSIFIED
ULIS

# Outline

- Automotive applications
- FIR imaging sensor
- Thermal imaging for automotive
- Non imaging application
- Conclusion

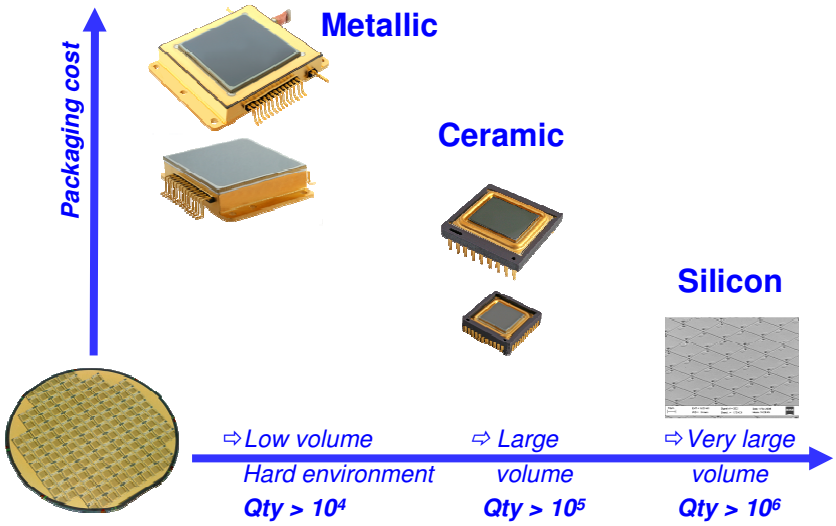


## Non Imaging application with microbolometer

| | Thermopile/ Pyroelectric | µbolometer | Comments |
|---|---|---|---|
| NETD | --<br>0.15°C @1Hz, 100°C | ++<br>0.05°C @50Hz, 20°C | |
| Size / pixel pitch | --<br>100 to 250 µm | ++<br>17 to 25 µm | |
| Frame rate | -- | ++ | |
| Uniformity | + | + | Both require calibration process |
| Vacuum | -<br>Chip Level Package | +<br>Pixel Level Package | Both require vacuum package |
| Operating range | + | ++<br>-40°C to +85°C | Performance stability over the operating temperature |
| Manufacturability | + | + | |

PIR detectors versus Microbolometer detectors Comparison

## Microbolometer Packaging technology

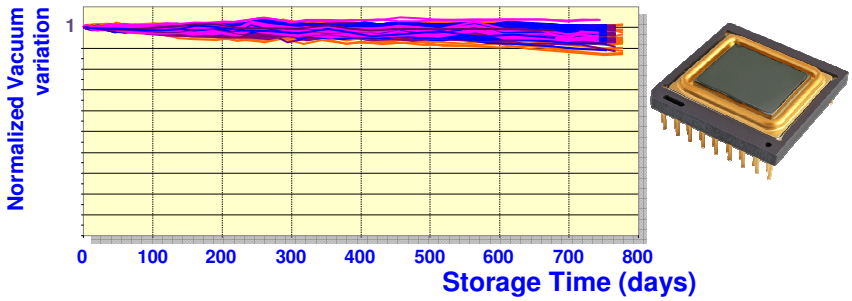





## Ceramics packaging technology

### Vacuum Life time evaluation

**Storage temperature — 90°C, —110°C, —130°C and —170°C**




***Vacuum Life time > 15 years***

***Compliant with Automotive Standards AEC-Q-100 Grade 3 (TC, HTSL)***

***No getter activation = no maintenance***

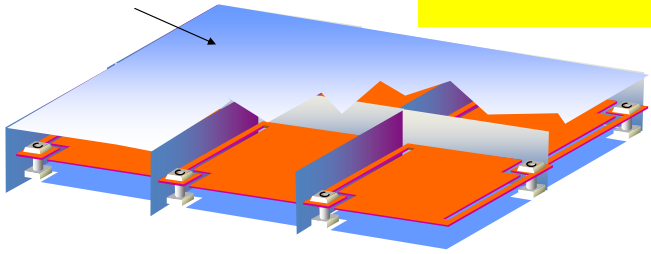
## Silicon packaging technology: Pixel Level Packaging

***For small sensor generation***

leti **Advanced vacuum Pixel Level Packaging**

Single-pixel micro-capsule

*Front end manufacturing process*





## Silicon packaging technology: Pixel Level Packaging

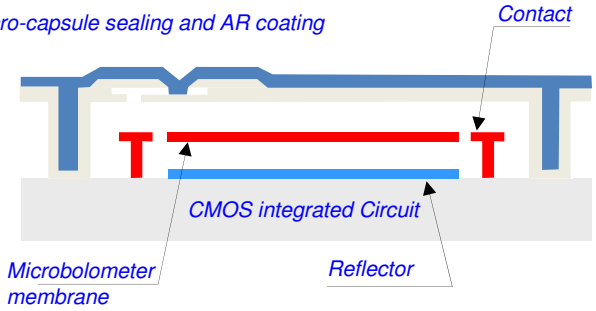
① *Sacrificial layer*

② *Sacrificial layer etching*

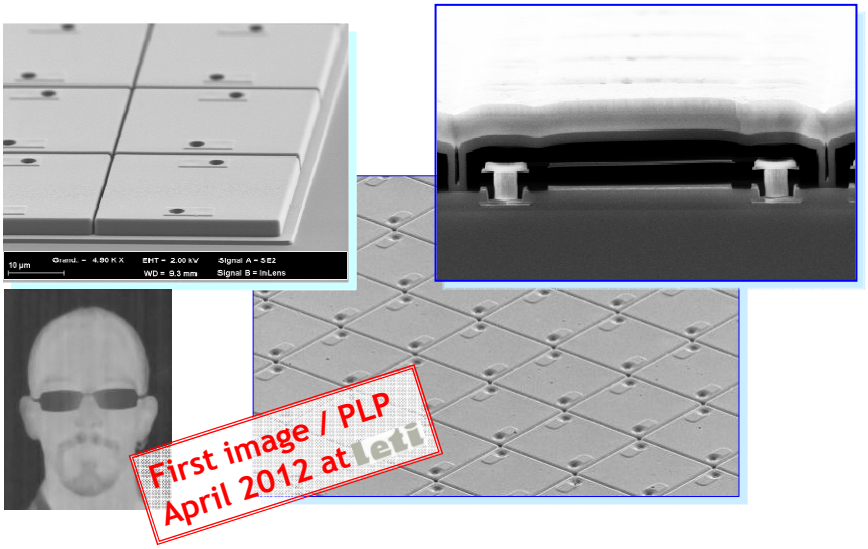
③ *Micro-capsule build up*

④ *Micro-capsule evacuation*

⑤ *Micro-capsule sealing and AR coating*



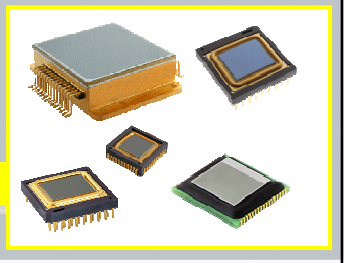
## Silicon packaging technology: Pixel Level Packaging






## Outline

- Automotive applications
- Uncooled IR Focal Plane Array
- Imaging automotive application
- Non imaging application
- Conclusion



## Conclusion

**Key benefits of a-Si are extensive**

**a-Si** physical properties

*Thin microbridge architecture / fast sensor*
*Enhanced thermal insulation / fast & sensitive sensor*
*Easy downscaling for small pixel*

**a-Si** thin film uniformity

**a-Si** is Compatible with silicon technology for advanced packaging techniques



## Conclusion

**Key benefits of a-Si imaging sensor for automotive**

**a-Si** paves the way to very large volume applications required by automotive security enhancement like:

- ✓ Long distance pedestrian detection (DVE)
- ✓ Short distance pedestrian detection (small arrays)
- ✓ Blind spot detection
- ✓ HVAC management & seat occupancy

Contact: Dr Jean-Luc Tissot
Tel: +33 476 53 74 70
Email: jl.tissot@ulis-ir.com

ULIS
ZI les iles cordées
BP 27
38113 Veurey-Voroize - France

INNOVATION

INTEGRITY

PERFORMANCE

SOLIDARITY

Groupe SOFRADIR

ULIS
Infrared for you