

# Mesure de Conductivité Thermique de Matériaux par Résistances Electriques Thermosensibles: *application à la micro-électronique*

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**Société Française de Thermique.** Journée Thématique Caractérisation  
Thermophysique et Applications en Microélectronique, Orléans 18 Nov.2011

# 1. Principe

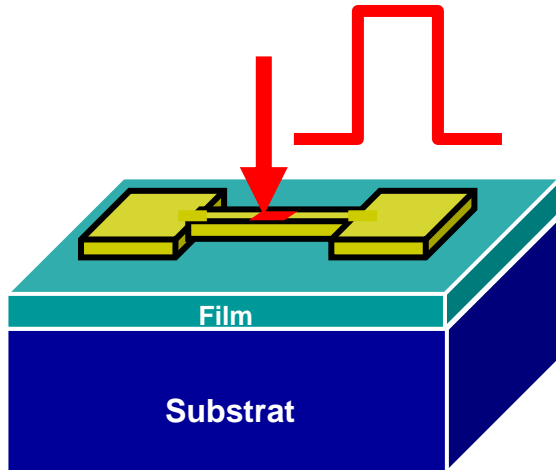
# 2. Réalisations

# 3. Résultats sur films minces

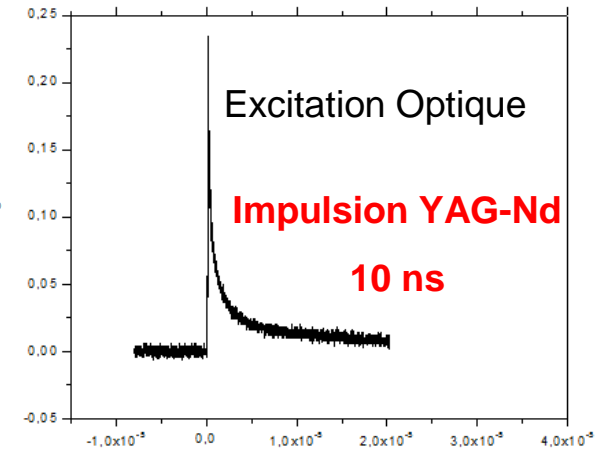
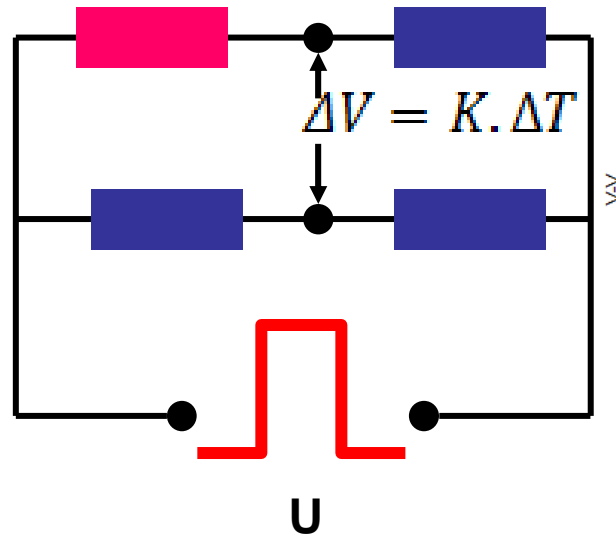
- $SiO_2$
- $AlN$
- *Carbone*

# I-Principe des micro-capteurs

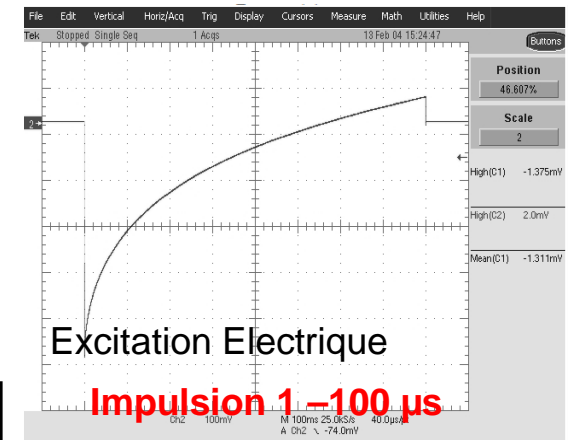
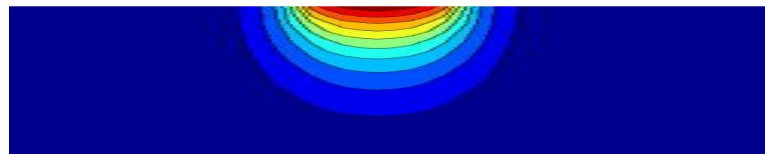
Excitation Electrique ou Optique



Tension de déséquilibre



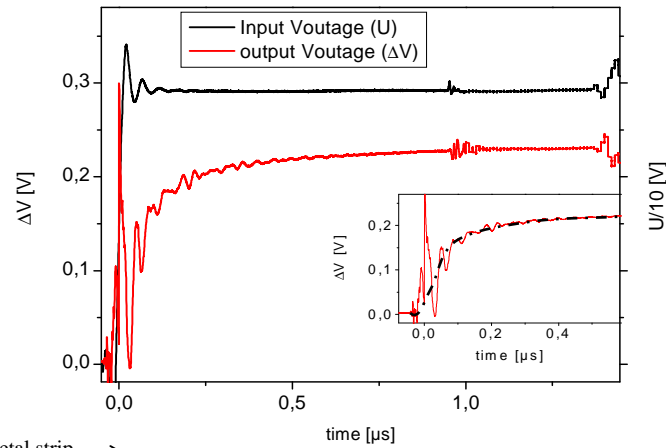
Modèle de diffusion



Estimation de conductivité thermique par méthode inverse

$$\nabla^2 T_i(x, y, z) - \frac{c_i \rho_i}{\lambda_i} \frac{\partial T_i}{\partial t} = 0$$

# II. Réalisations

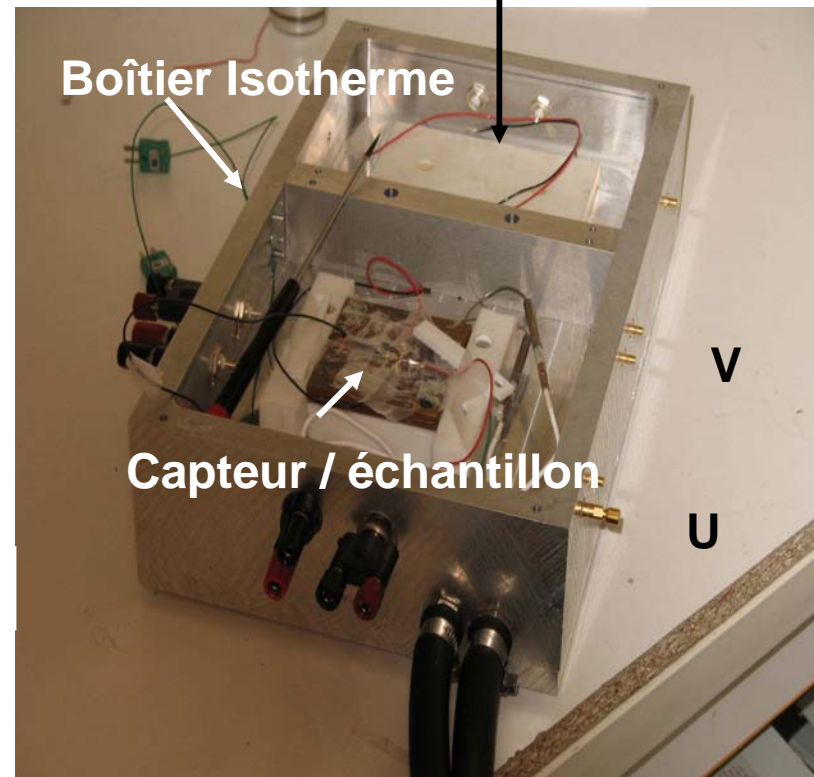
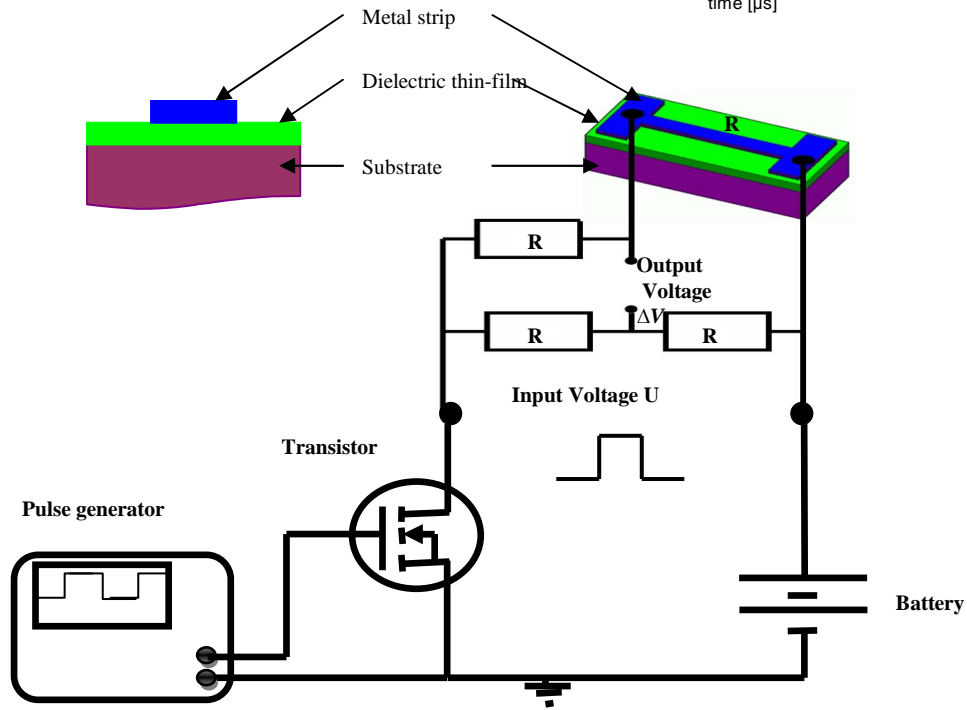


AGENCE NATIONALE DE LA RECHERCHE  
**ANR**

EA 2664  
**LGMPA**  
Laboratoire Génie des Matériaux  
et Procédés Associés

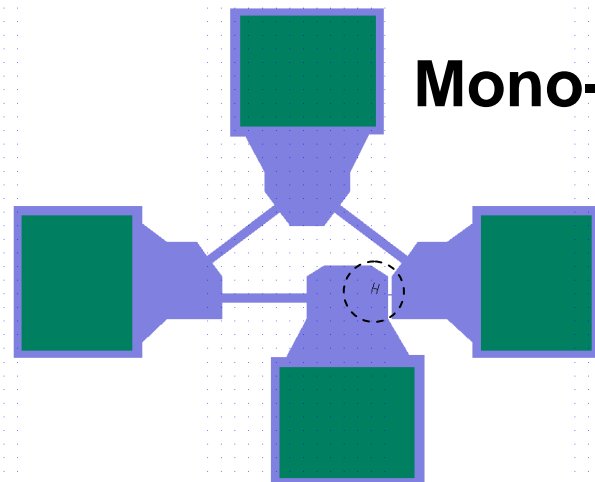
**IMN**

## Carte de Commutation Rapide

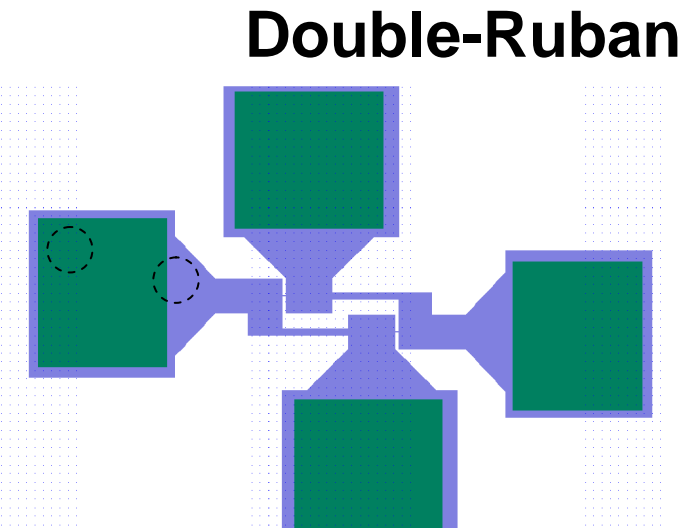
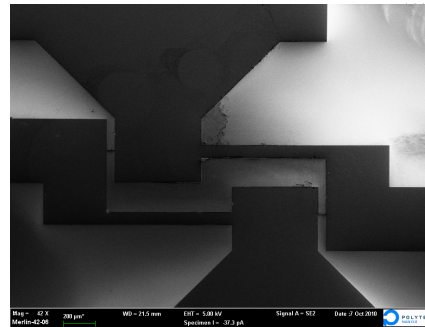


# II- Réalisations

Rubans Thermosensibles :  $20 \times 200 \mu\text{m}^2$  -  $5 \times 50 \mu\text{m}^2$  –  $2 \times 20 \mu\text{m}^2$

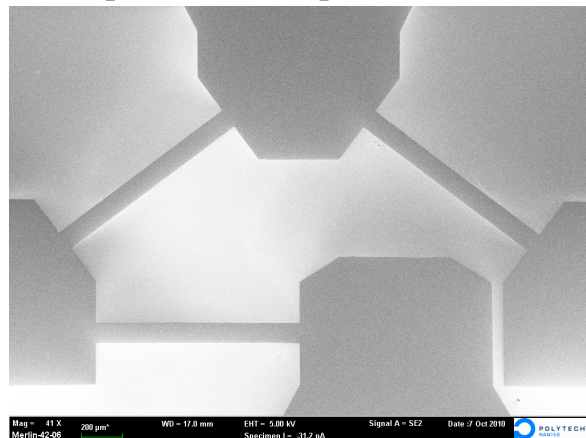


**Mono-Ruban**

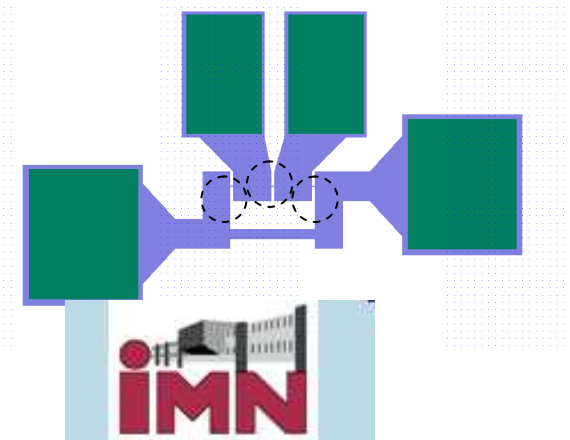


**Double-Ruban**

Capteurs pour mesure de Conductivité Thermique Normale

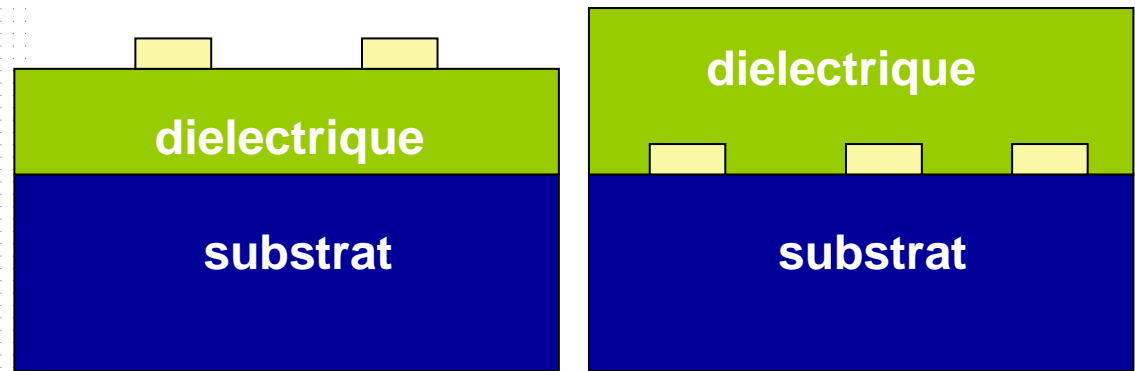
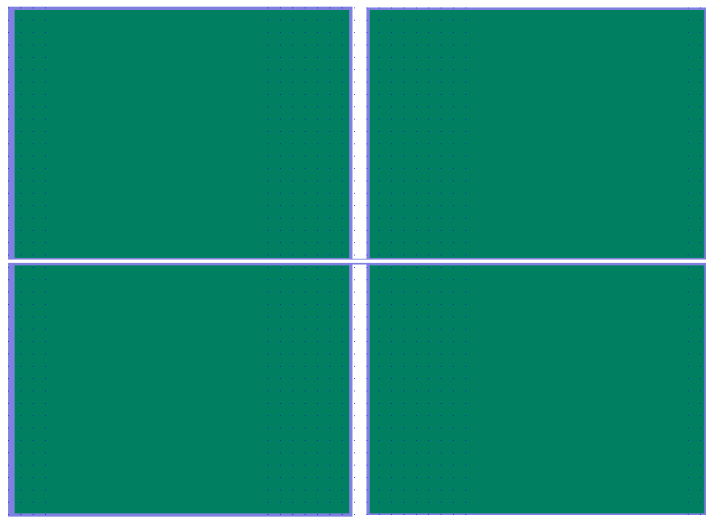


**Triple-Ruban**

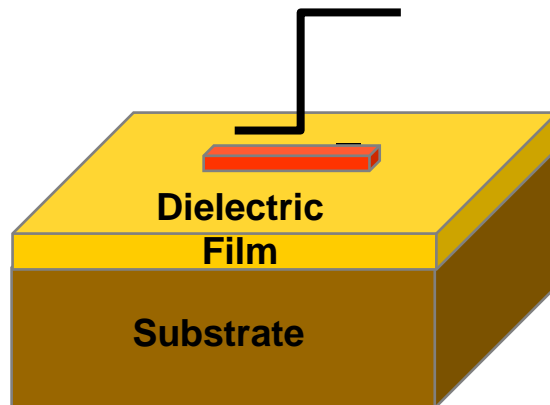
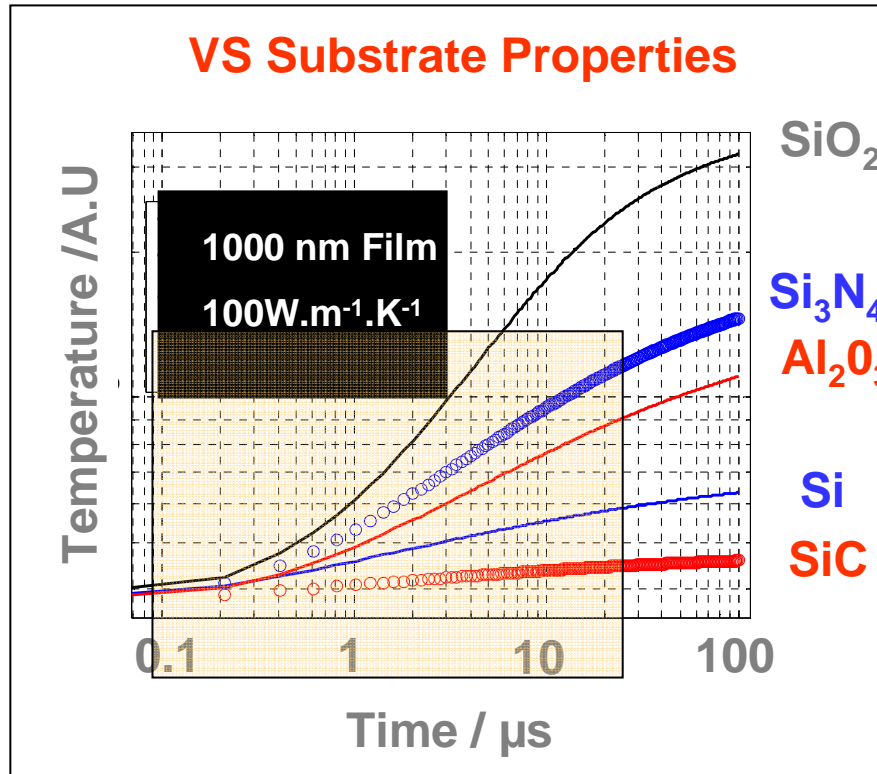


# II. Réalisations

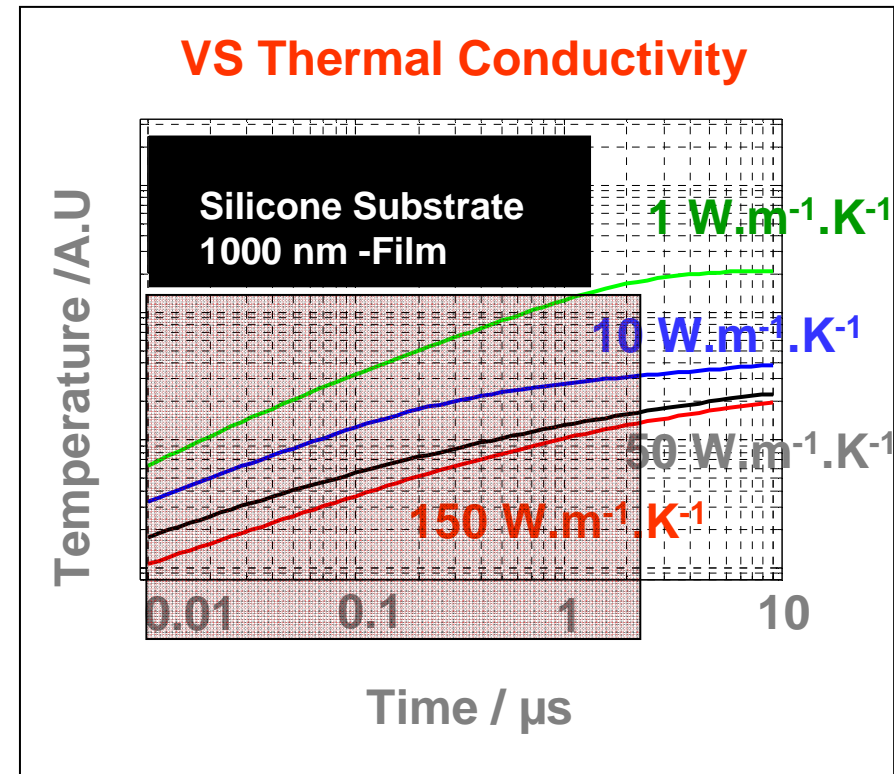
## Mesure de Conductivité Transverse



# III. Résultats

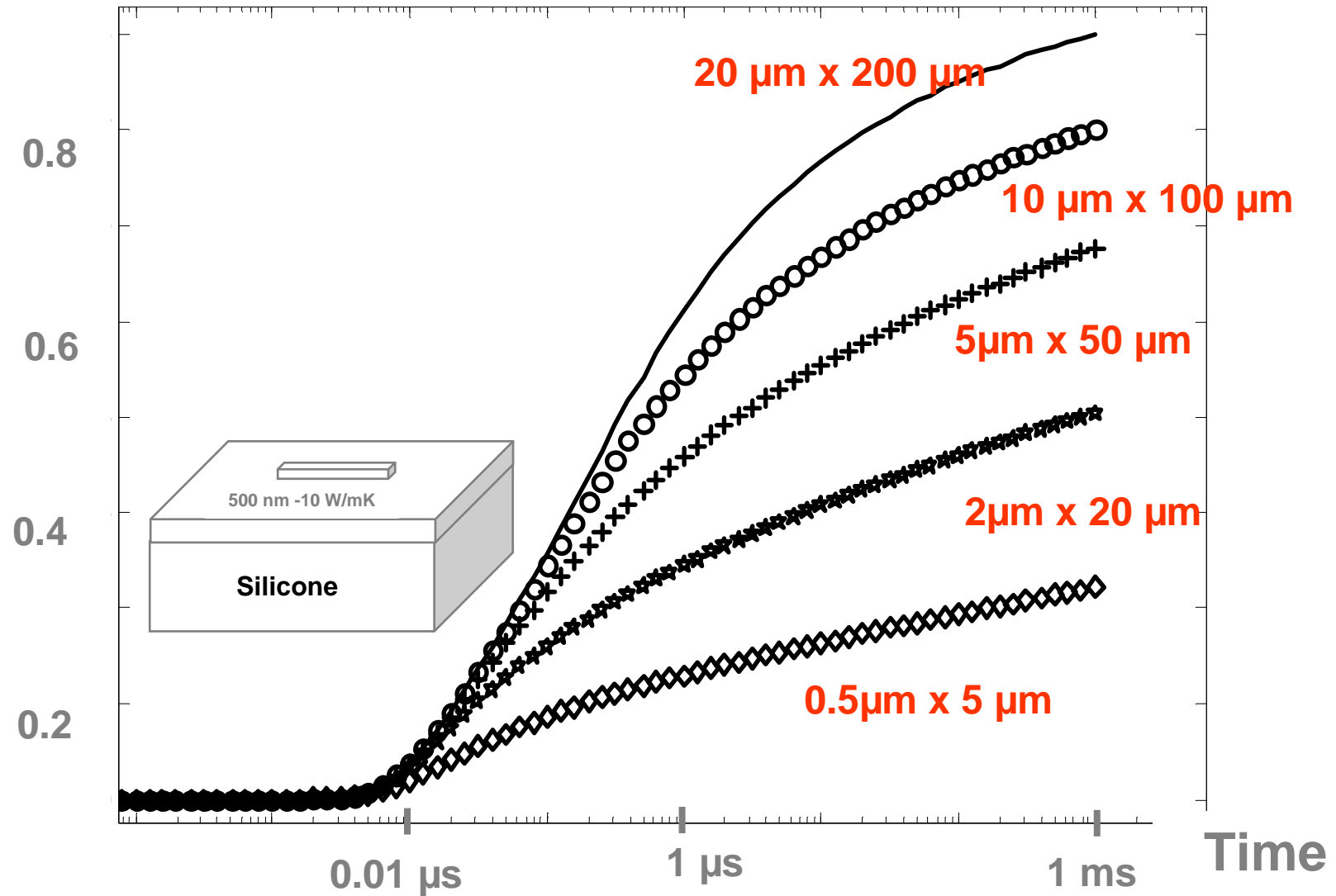


Strip size  $20 \mu\text{m} \times 200 \mu\text{m} \times 50 \text{nm}$



# III. Résultats

Thermal impedance Ratio  $Z_s/Z$



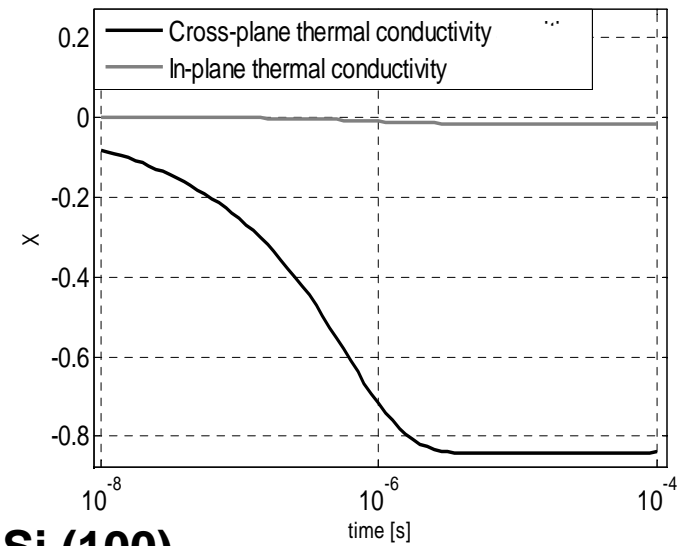
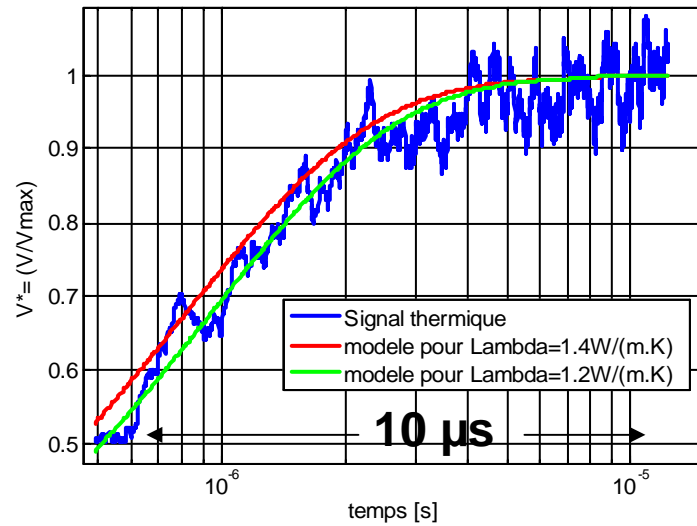


# III. Résultats $\text{SiO}_2$

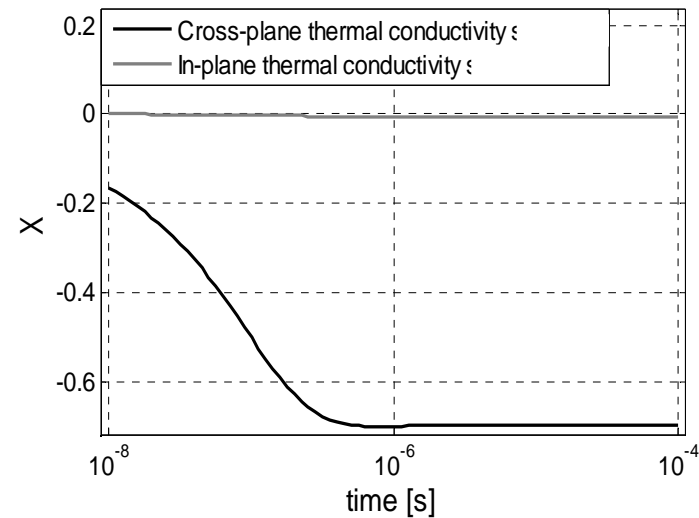
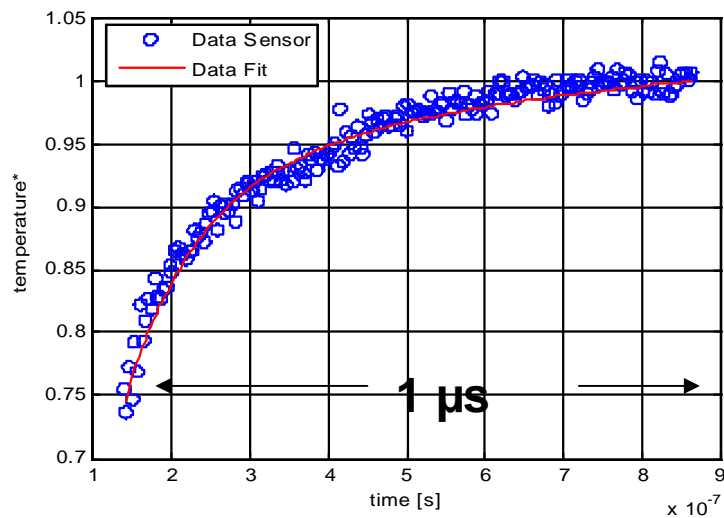
Température normalisée

1.2  $\mu\text{m}$   $\text{SiO}_2$  / Si (100)

Sensibilité



500 nm  $\text{SiO}_2$  / Si (100)

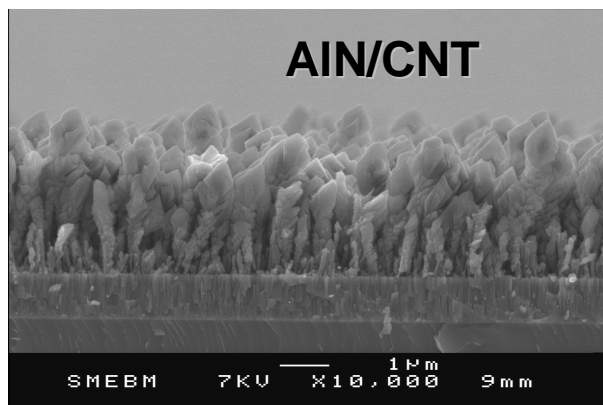
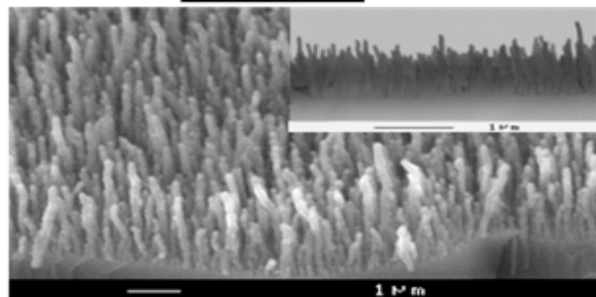
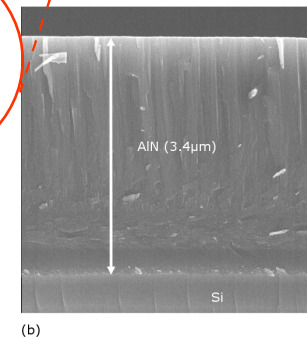
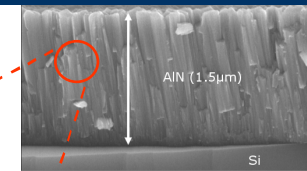
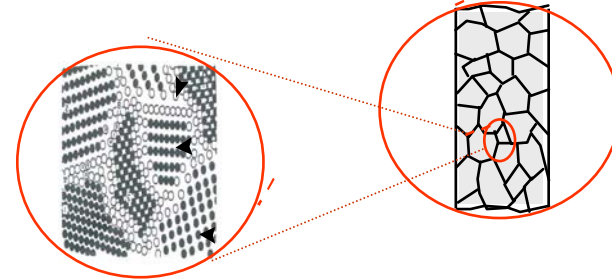


# III. Résultats. Nano-composites

## Plasma-Deposited Dielectrics as Effective Thermal Vias

**SiO<sub>2</sub> Single-cristal~ 1.5 W/m.K**

Film thickness 100nm – 10µm - Grain Size 1nm -  
100 nm - Columnar Structure - Mean Free Path  
Limitation



•Aluminum Nitride AlN

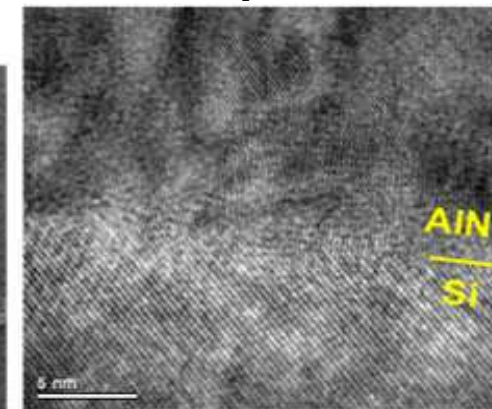
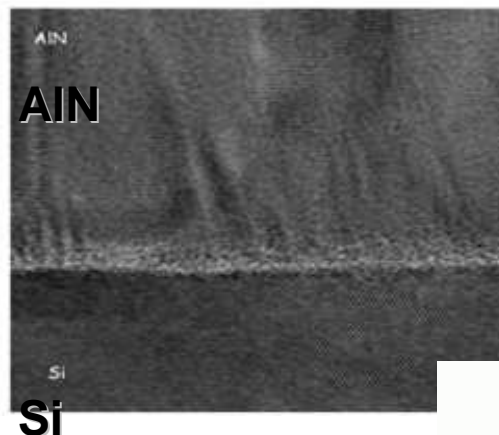
Single-cristal~ 300 W/m.K Poly-cristal~[1- 200] W/m.K

•Boron Nitride BN

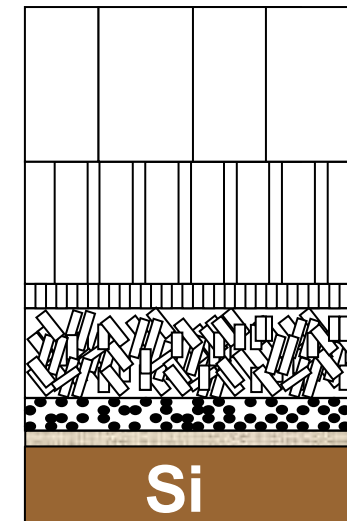
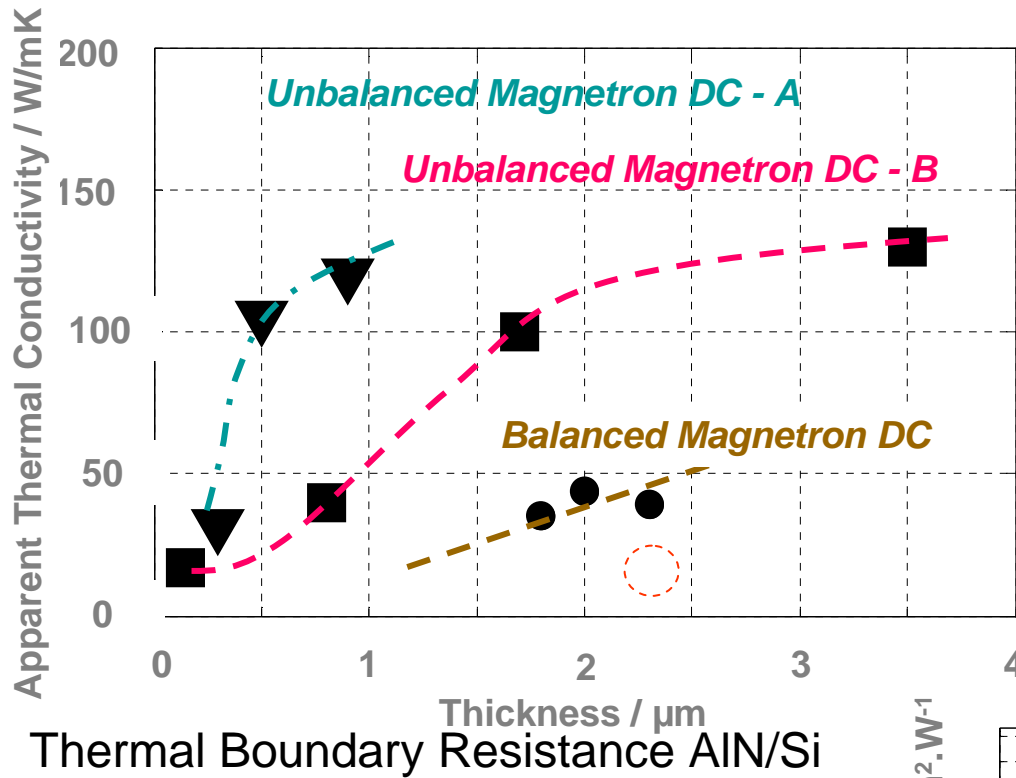
Single-cristal~400 W/mK

•CNT[1000- 2300] W.m-1.K-1

• Nanocomposites AlN/CNT



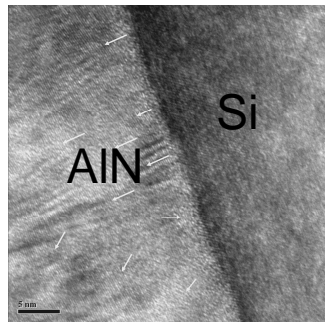
# III. Résultats AlN



**Bulk**

**Intermediate Layer**

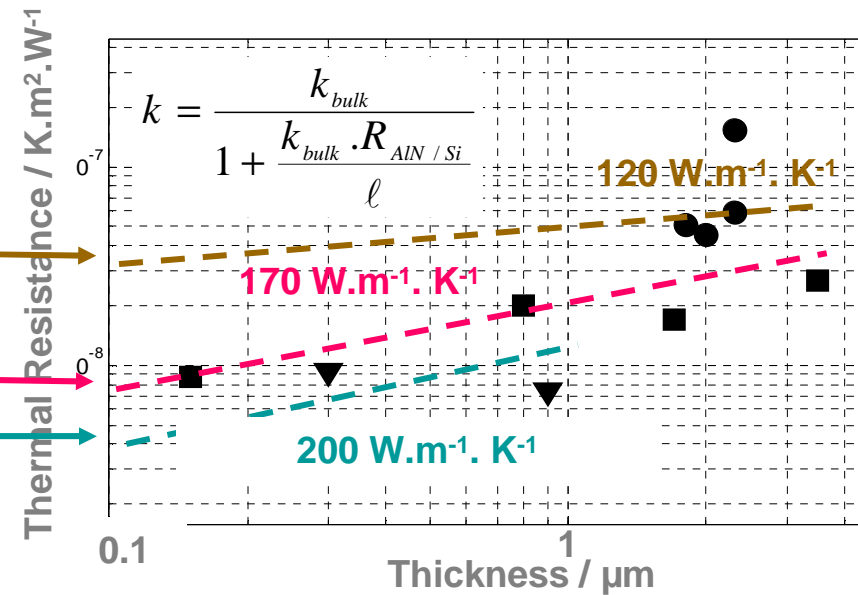
**Amorphous Layer**



$30 \times 10^{-9} \text{ K.m}^2.\text{W}^{-1}$

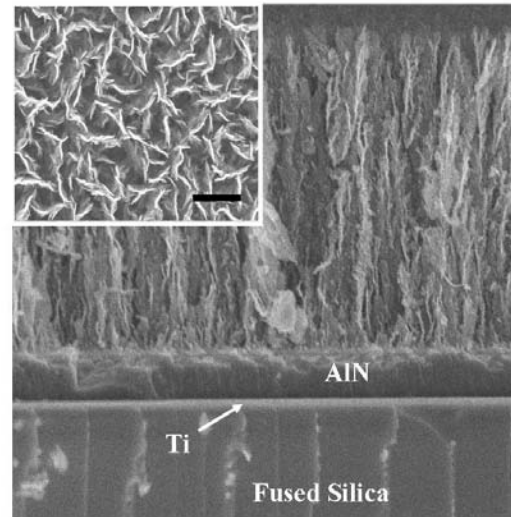
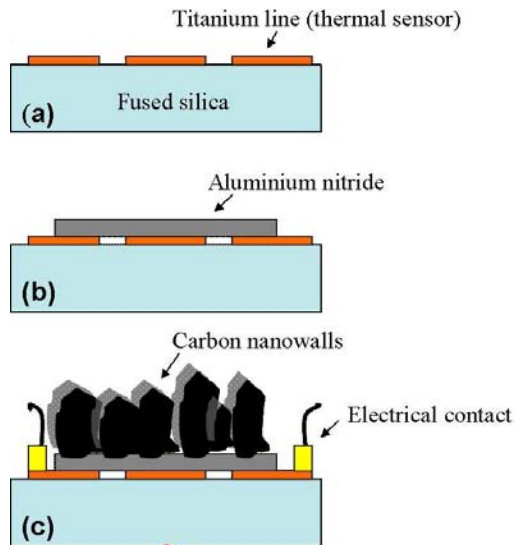
$9 \times 10^{-9} \text{ K.m}^2.\text{W}^{-1}$

$3 \times 10^{-9} \text{ K.m}^2.\text{W}^{-1}$



# III-Résultats Carbon Nanowalls

microwave plasma chemical vapour deposition



IR  YAG-Nd 10 ns

