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# DEVELOPMENT OF A MICRO-HOTPLATE FOR DIFFERENT METAL OXIDE GAS SENSORS WITH HIGH OPERATING TEMPERATURE

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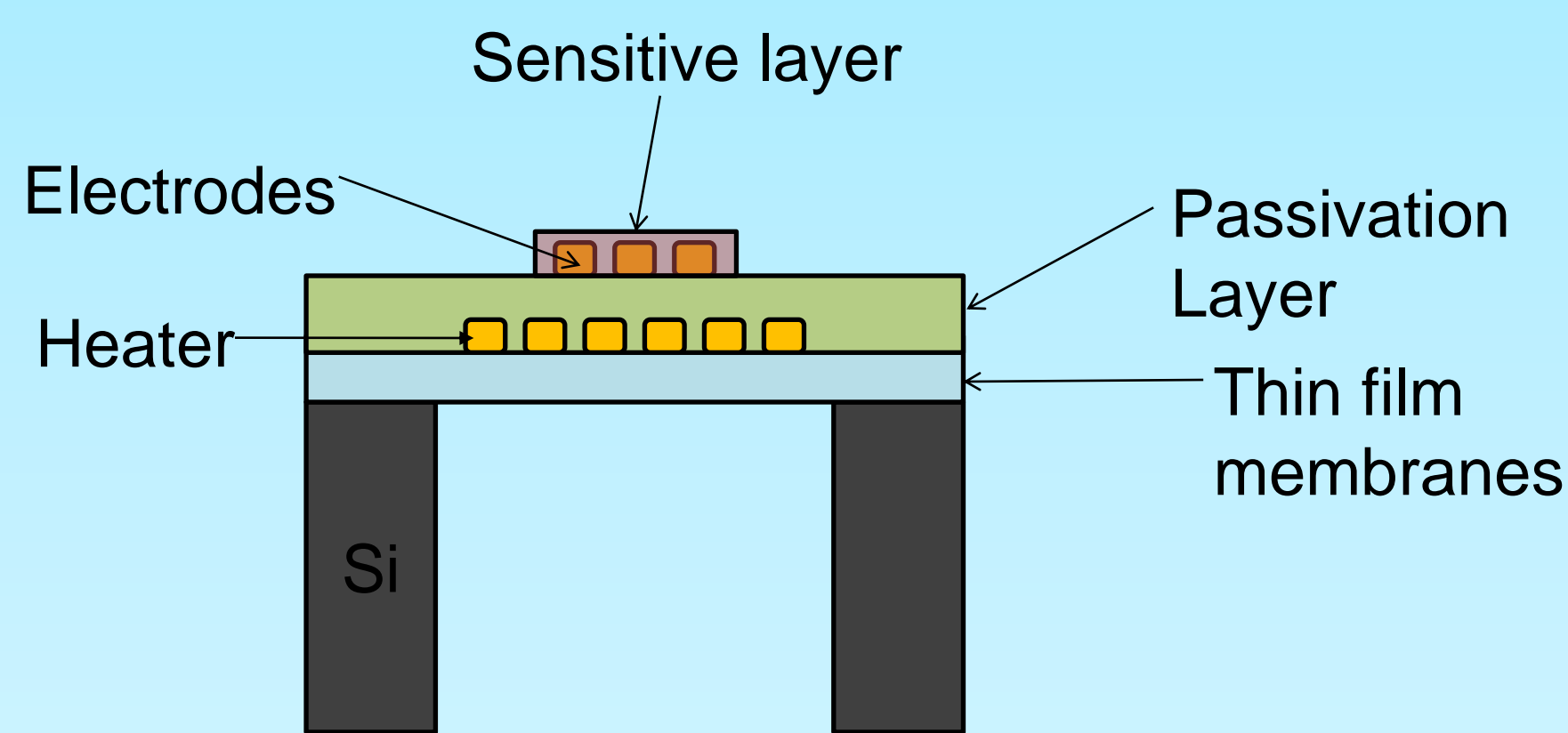
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## ABSTRACT

The main goal of this work is to realize a metal oxide gas sensor with stable operating temperature. This article describes our approach and the technological process used to reach a high and stable operating temperature (650-700°C), with low consumption (100mW) and good thermal homogeneity all over the active area.

## DESCRIPTION OF GAS SENSOR

### Structure of a simple gas sensor



#### Structure with 2 principle parts:

- sensitive layer : metal oxides such SnO<sub>2</sub>
- micro-hotplate (Si-substrate, membranes, heater, Passivation Layer, Electrodes)

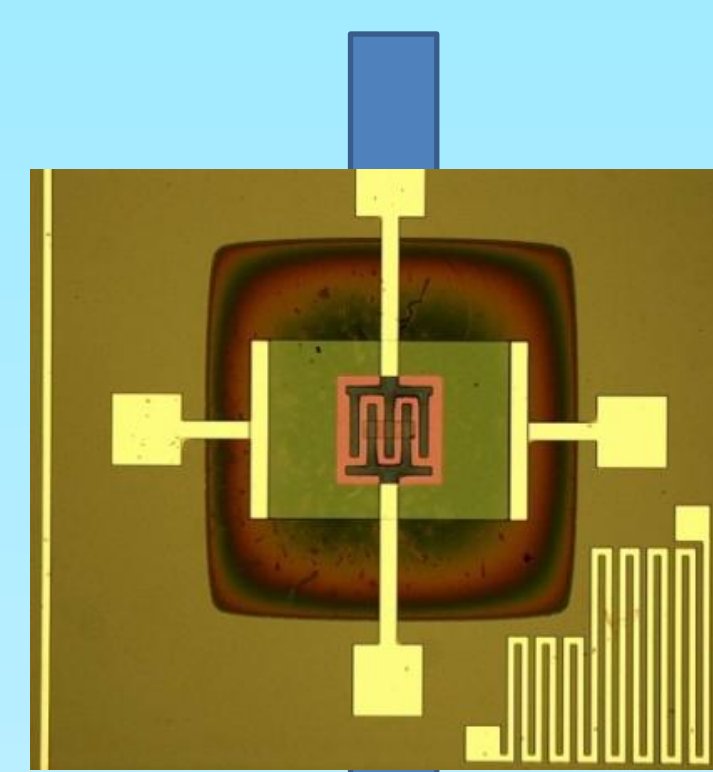
#### Main parameter : Temperature

- Acts on sensor's sensitivity
- Allows reactions between sensitive layer and gases

#### Properties researched:

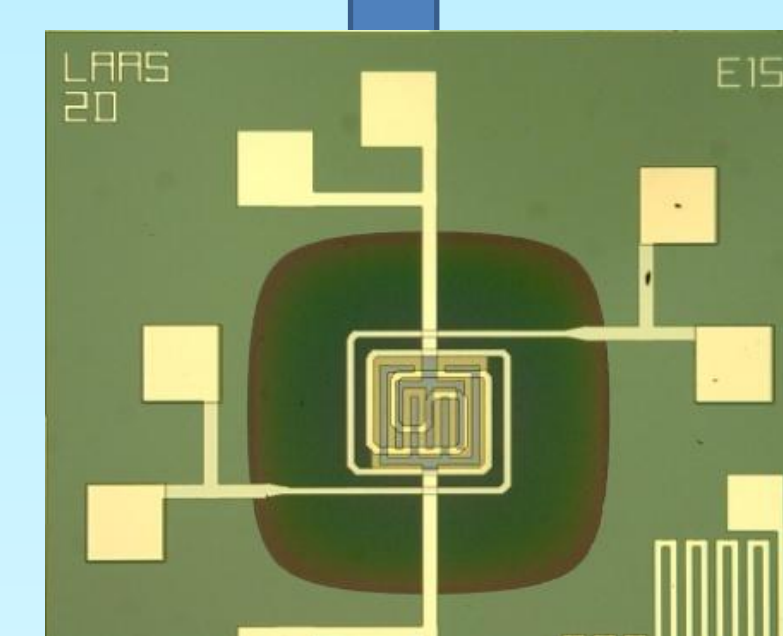


## MOTIVATIONS



#### Poly-Si Heater

- Stable operating temperature is limited to 450°C
- A drift of heater ⇒ bad control of temperature on sensitive layer
- A loss of sensitivity 12% per month



#### Pt-Heater

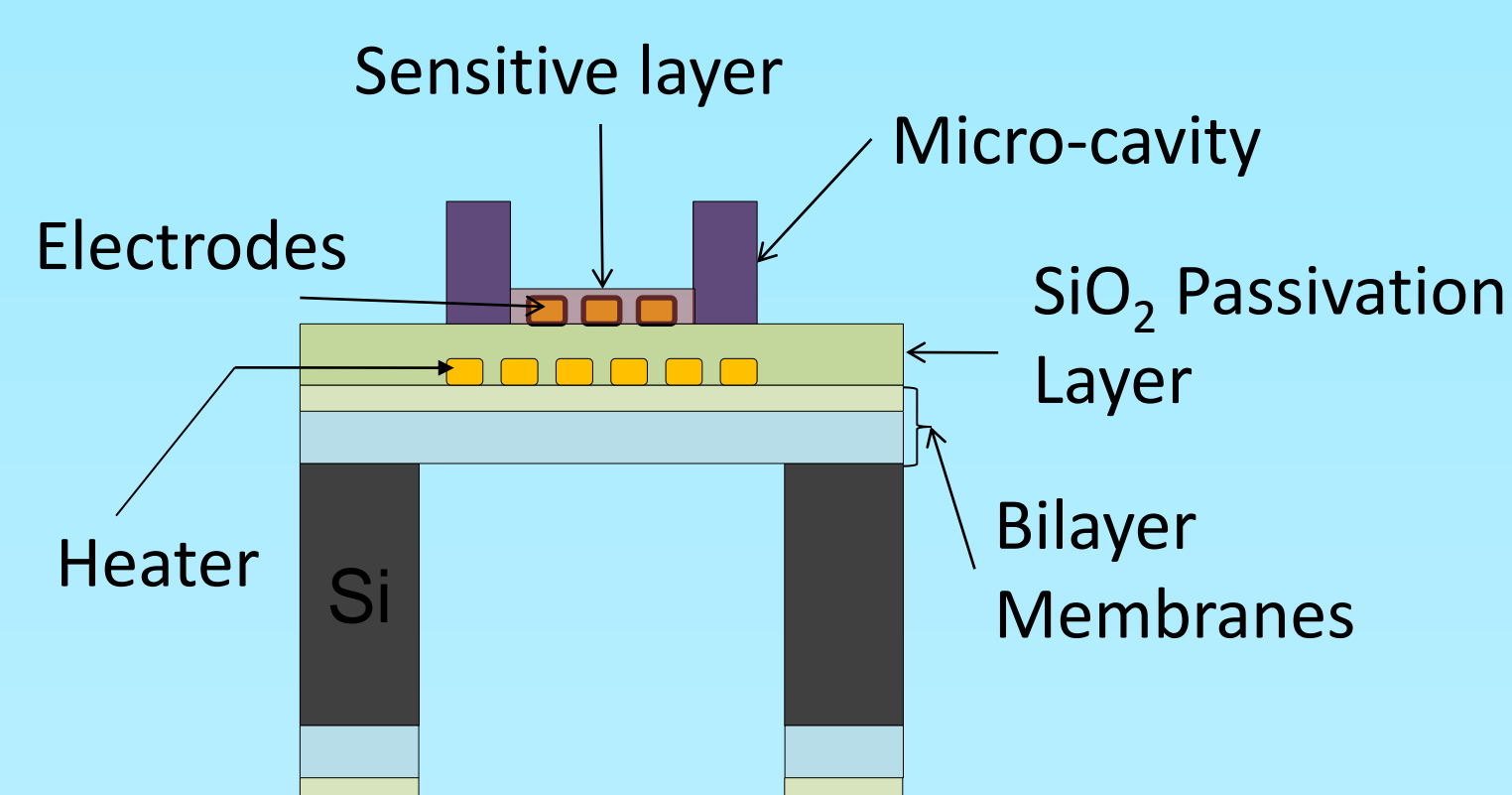
- Temperature reached : 475°C with power less than 100mW
- A good homogeneity of temperature on sensitive area (compare to Poly-Si Heater) : 0.3°C/μm
- A drift of heater resistance for temperature up to 500°C ⇒ not interesting to gas detection with sensitive layers which have an operating temperature up to 500°C

#### Motivation for this work:

- High (>500°C) & Stable operating temperature with a long lifetime
- Control & reproducibility of sensitive layer

## IMPROVEMENTS & TECHNOLOGICAL PROCESS

### The new structure



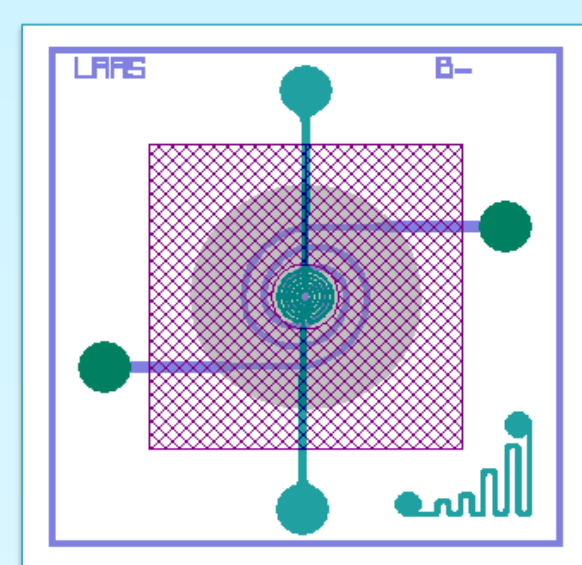
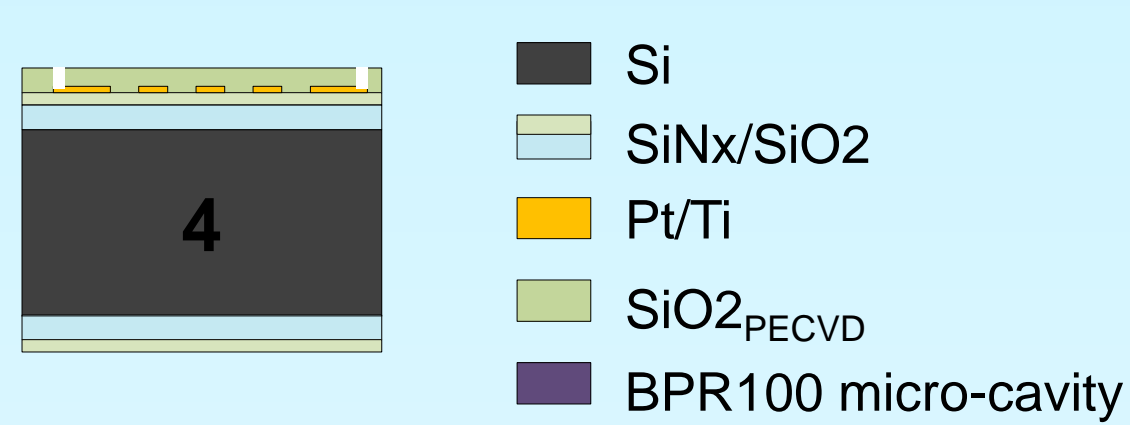
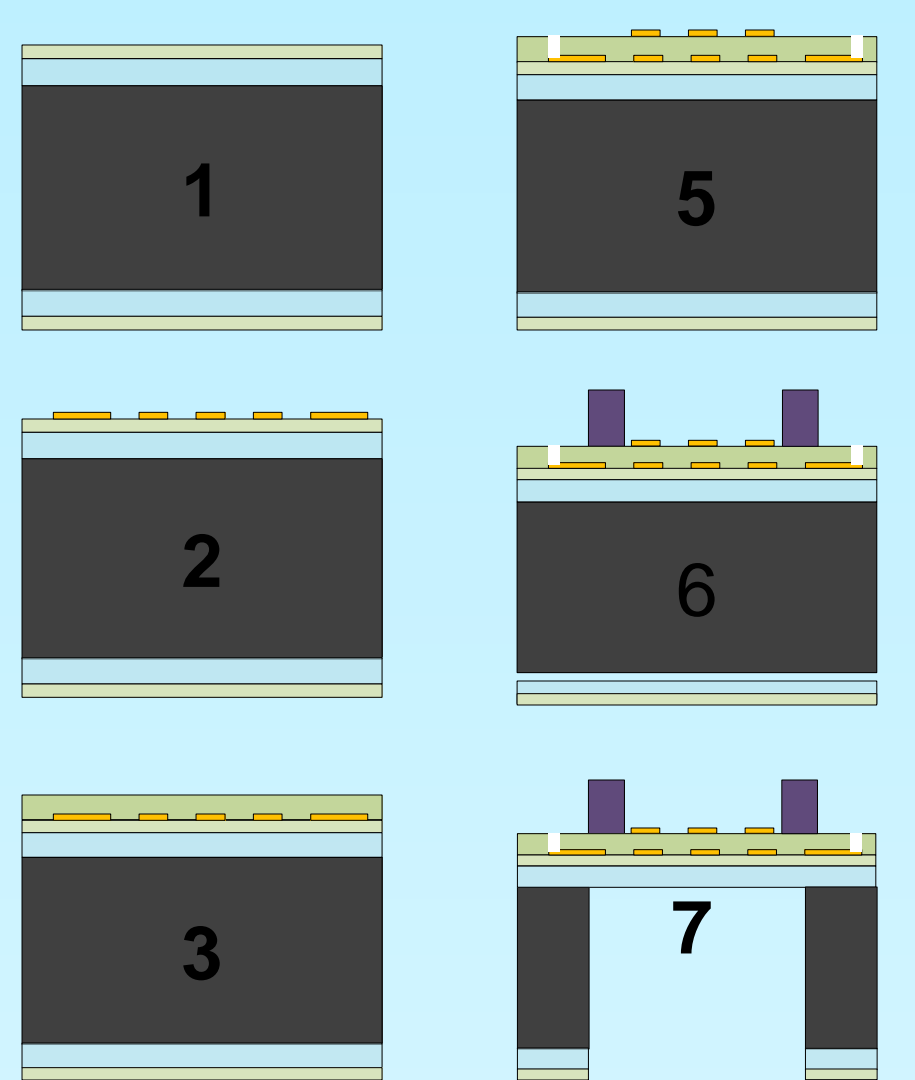
New thickness for heater (Pt/Ti 1500/150Å)  
⇒ stress < 100MPa for an annealing temperature up to 450°C

New design for heater (circular & spiral)  
⇒ to obtain the most homogeneous temperature on the active layer

Integration of micro-hotplate

### Micro-hotplate Technological Process

1. Si-substrate after deposit of bilayer membranes (SiO<sub>2</sub>/SiN<sub>x</sub>) by LPCVD
2. Heater : Pt/Ti (150/1500Å) deposit by lift off process
3. Heater's electrical insulation with SiO<sub>2</sub> deposit by PECVD (0.5μm)
4. Heater's contacts opening by wet etching of SiO<sub>2</sub>
5. Interdigitated sensitive layer's electrodes (idem 2)
6. BPR 100-micro-cavity deposit (height 40μm & active area 260μm)
7. Backside etching of membrane (diameter 900μm)



Cell size: 2\*2mm  
Diameter of Heater : 300μm  
Diameter of membrane etching: 900μm  
Diameter of active area 260μm

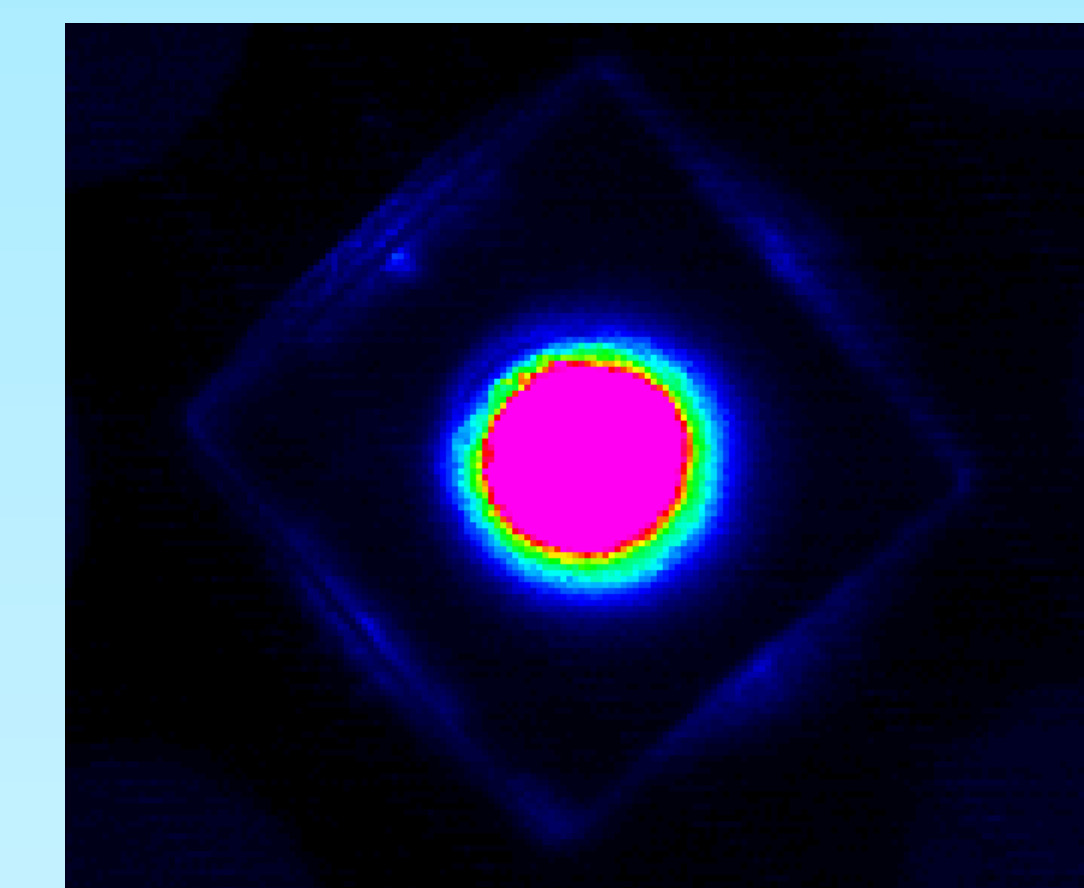
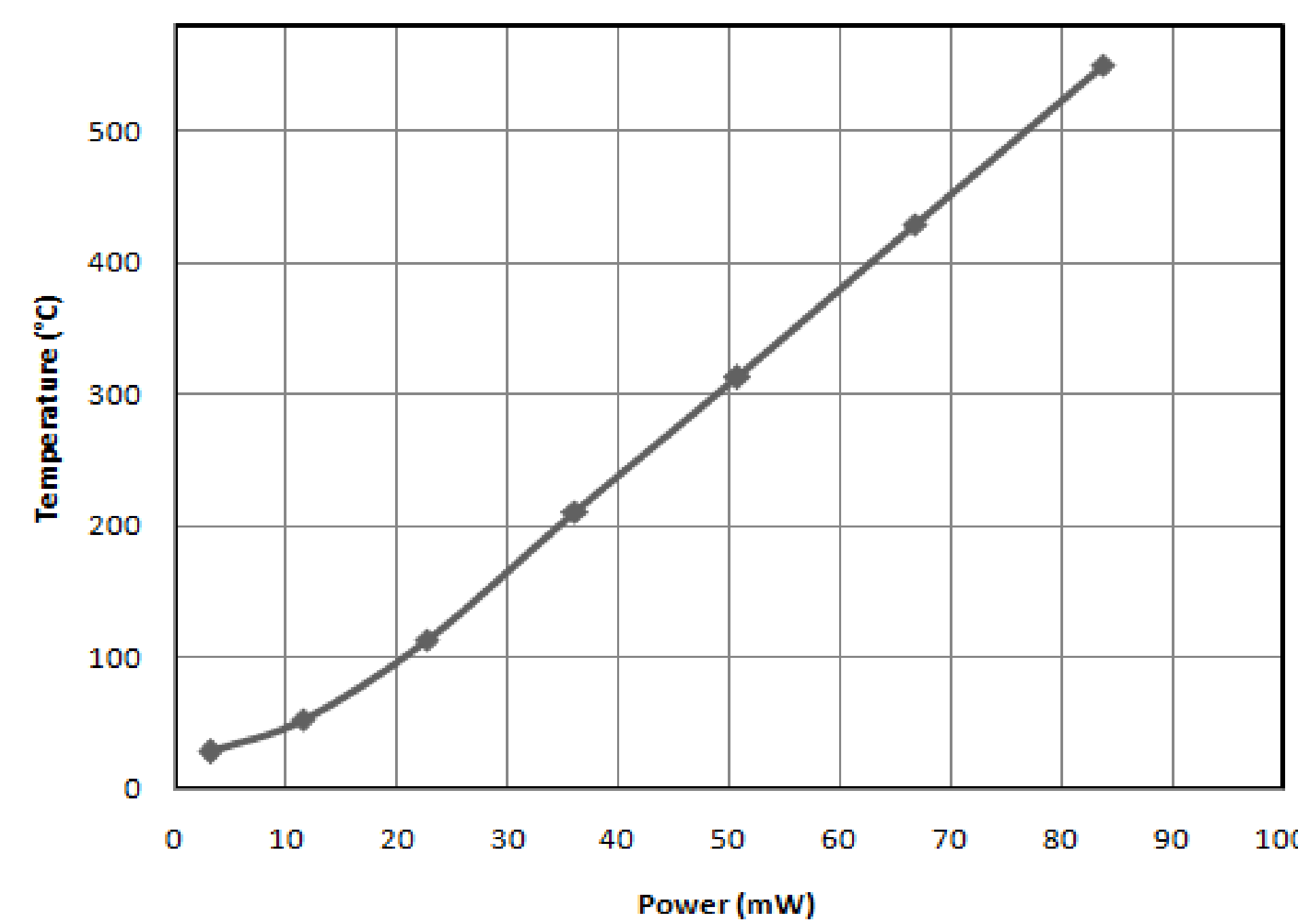
#### BPR 100 Micro-cavity

To delimit and to control reproducibility of the active layer

Removable after a 150°C/1h30 - thermal treatment ⇒ 30min by O<sub>2</sub> plasma .

## ELECTROTHERMAL CHARACTERIZATIONS

### Temperature vs Power



#### IR-profil of Temperature vs. Power

- T<sub>reached</sub> ≈ 550°C for a power less than 100mW
- Stable behavior during several days with a constant power supply
- Good homogeneity on active area :  
⇒ |ΔT|<sub>max</sub> = 45°C.

## Conclusion & Work in Progress

We are able to conceive a new micro-hotplate with a stable operating temperature up to 500°C and low consumption power. We are also proved the feasibility of a platform with circular micro-cavity allowing to a stable and reproducible deposit of sensitive layers for different modes of deposits such micro-injection or screen printing.

We are testing our sensors with a variable power supply in order to observe mechanical behavior of sensors

To reach our targets (stable operating temperature of 650-700°C), we are studying the possibility to work with other adhesion elements for Pt like molybdenum or tantalum because Ti adhesion layer cannot reach 600°C without the destruction of the micro-hotplate.