# Study of vanadium dioxide based relaxation oscillators for neuromorphic applications

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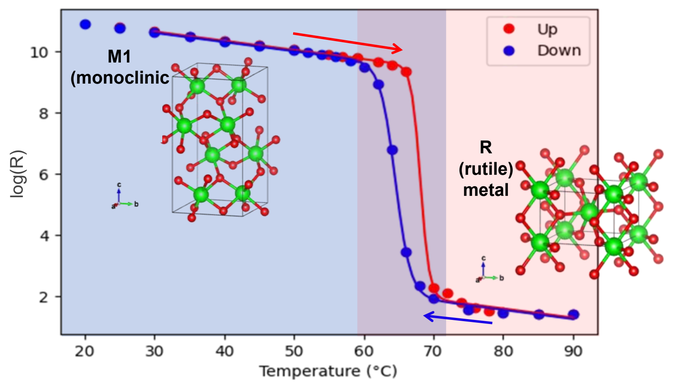
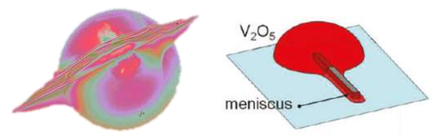
## Introduction

- $VO_2$ -reversible insulator to metal transition (IMT) at 68C°
- Transition triggered optically thermally or **electrically**
- Applications in memristors, sensors and electrical **oscillators**
- **Structural characterization of $VO_2$ µ-structures**
- **Fabrication of 2 terminal devices**



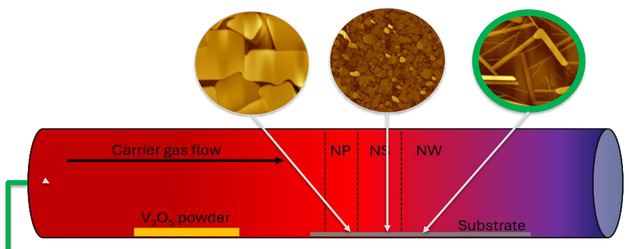

**Formation of a $VO_2$ wire**




100µm

[1] Soo Kim et al: doi.org/10.1021/cg201

## Methods



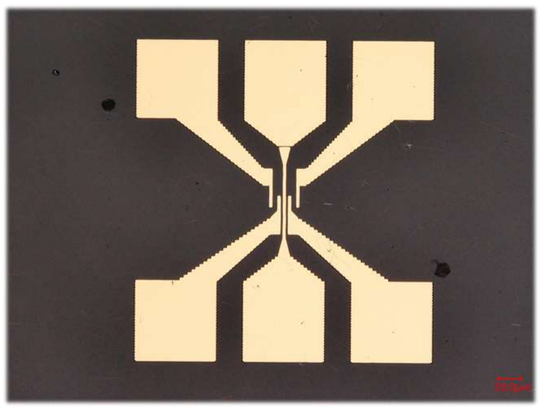

*Schematic of the furnace, probability of nucleation*

$$P_N = B.\exp\left(-\frac{\sigma^2.\pi}{k_B^2.T^2.ln\,\alpha}\right)$$

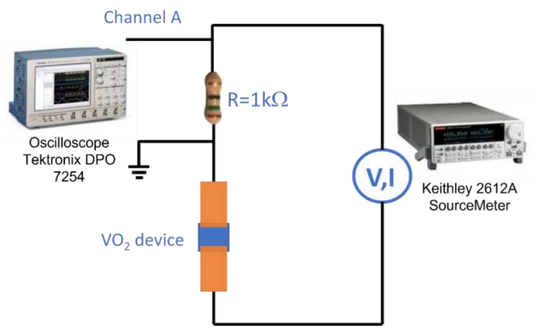
[1] Soo Kim et al: doi.org/10.1021/cg201488w

- Modified vapor-liquid-solid method using **$V_2O_5$ powder**
- **$VO_2$** wire growth on silica substrates
- Electrical and structural charcterisations

## Device fabrication



- 2 terminal devices **20/500** nm Ti/Au
- **5**,**10** and **15-**µm gaps

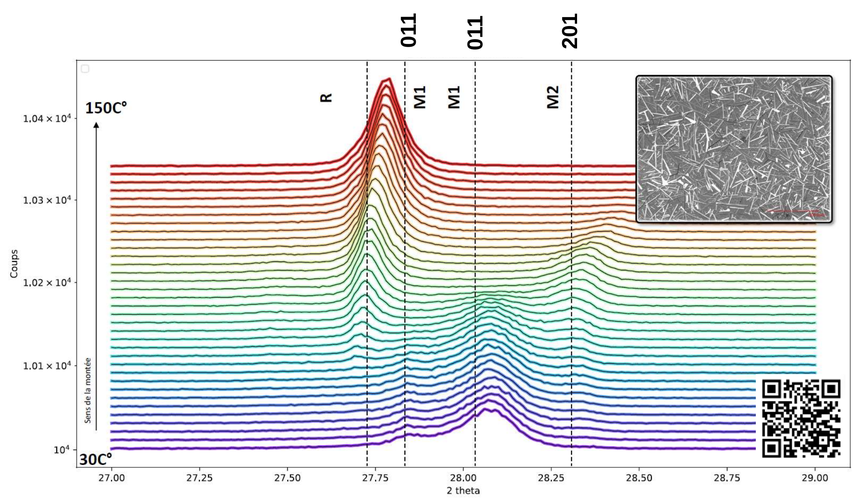



## Structural and microstructural properties

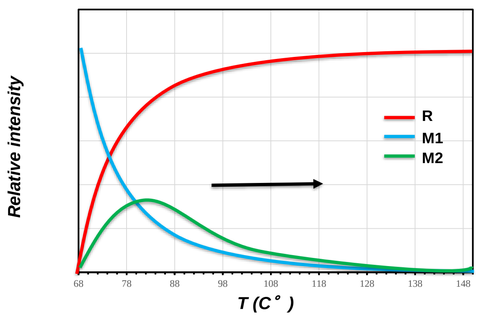



Carrier gas flow direction

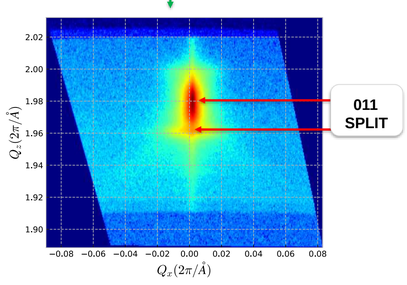
40µm




*Phase transition of $VO_2$*



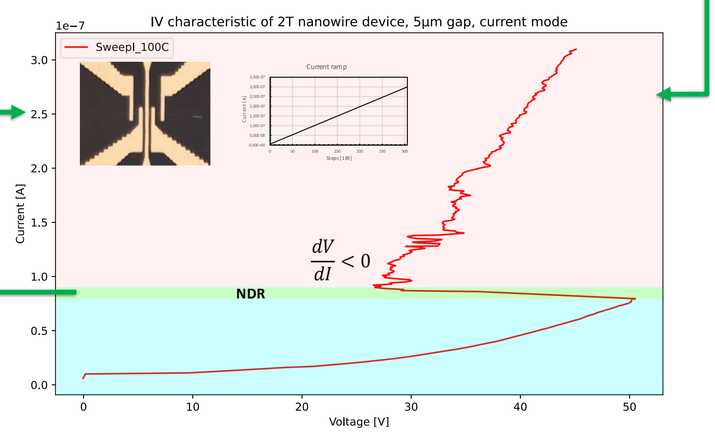

*Evolution of phases relative intensity with increasing temperature*




*Reciprocal space map of 011 (Room temperature)*

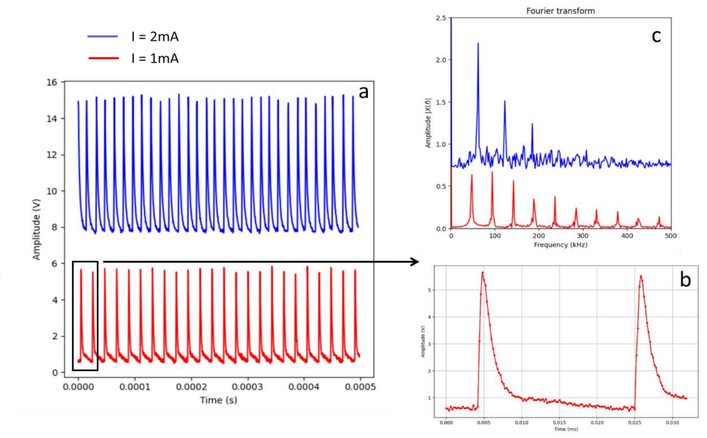
- Different microstructures, due to the probability of nucleation $P_N$
- **(011) orientation**
- Reciprocal space map: **splitting** of the **011** peak→**2 deformation states in M1**

## Electrical properties




- **Negative Differential Resistance (NDR)**
- **Onset of electrical oscillations**

[2] Beaumont et al: http://dx.doi.org/10.1063/1.4871543




*Oscillations obtained on **thin films** 2T devices*

## Conclusion

- **Reliable method to synthetize nanowires**
- **Structural properties of $VO_2$ micro-structures**
- **NDR on nanowire and films integrating 2T devices**
- **IMT engineering through doping, strain modification**
- **Coupling oscillators → phase encoded logic**
- **Neuromorphic applications**

This work was funded by the National Agency of Research (ANR) through the CIRANO grant (ANR-22-CE24-0016)

**More on the project:**

CIRANO
Oscillateurs à relaxation couplés à base de nanofils de $VO_2$ pour des dispositifs neuromorphiques

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