GRAPHENE AND 2DM VIRTUAL CONFERENCE & EXPO

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LARGE-SCALE GROWTH AND PROPERTIES OF LAMELLAR VANADIUM SULPHIDE

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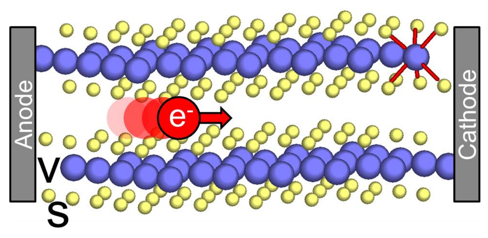
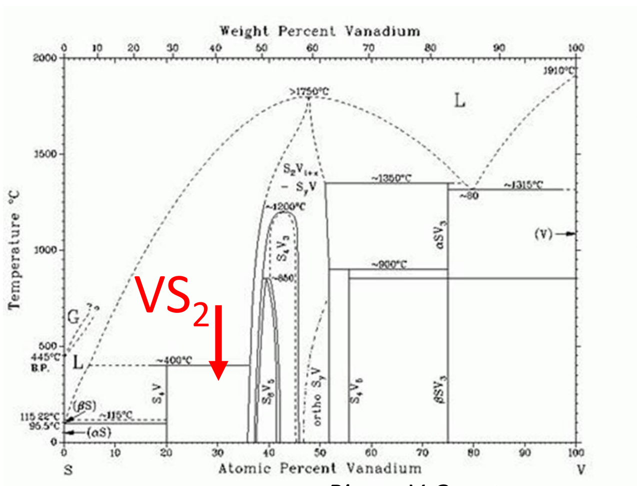
CONTEXTE OF THE WORK



- VS_2 has been reported with a 2D-layered structure
- VS_2 is known to show specific conduction mechanisms and simulation predicts a semi-metallic behavior.
- It is highly conductive along the 2D plans.



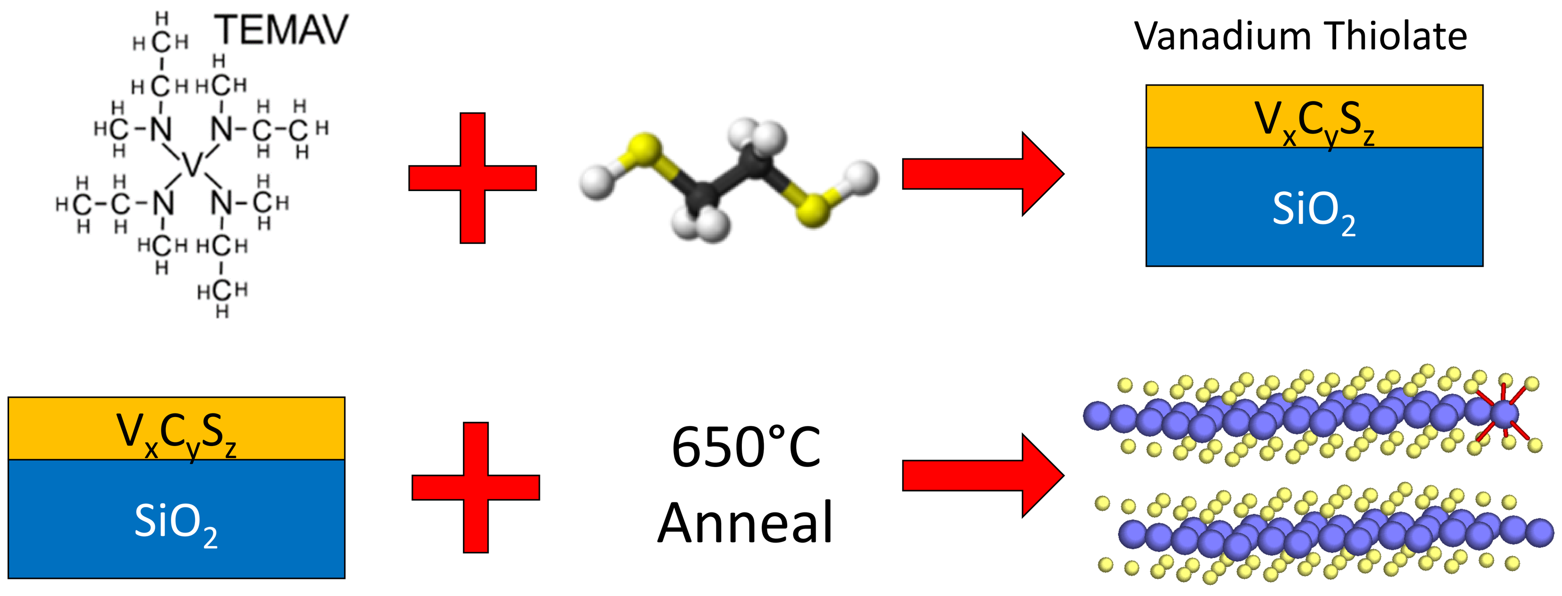
Binary V-O system

- It is difficult to stabilize due to the high solubility of sulfur in the V-S structure
- It is highly reactive with oxygen in ambient atmosphere.
- Synthesis has been achieved on small surfaces using de-lithiatium process of $LiVS_2$ or in the form of flakes in CVD mode[1,2]

Is there any solution to grow and stabilize VS_2 on large surface ?

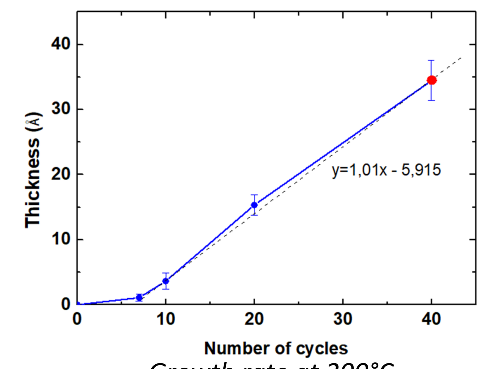
EXPERIMENTAL SECTION

- The deposition is based on a 2 steps process : deposition of amorphous VS_2 by ALD/CVD at low temperature followed by annealing.
- The growth is achieved in an ALD/CVD reactor at 200°C, using TEMAV and ethane di-thiol as chemical precursors.
- Annealing is achieved at medium temperature in a controlled environment to insure crystallization.



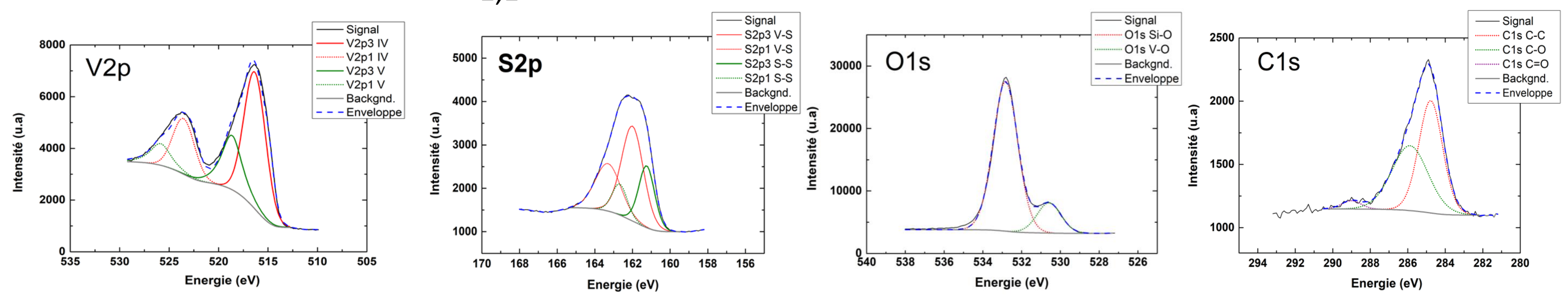
GROWTH RESULTS

- A stable growth condition is obtained at 200°C at rate of 1Å per ALD/CVD cycle.



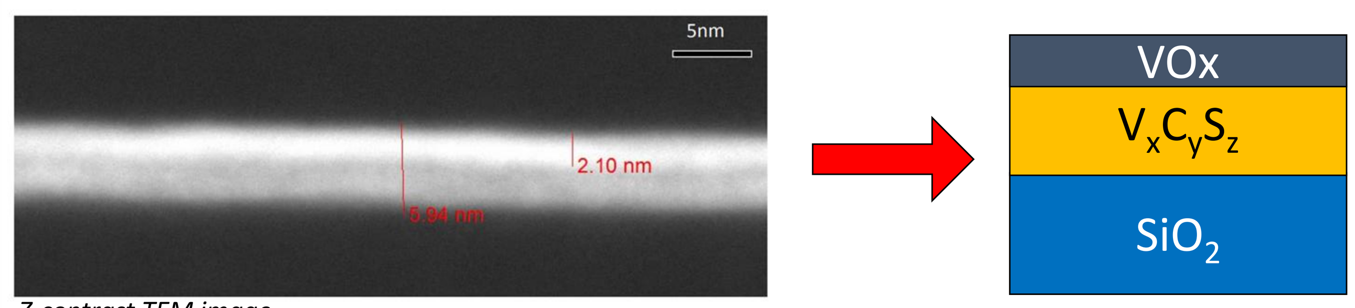
Growth rate at 200°C

- Polysulfides, oxygen and carbon are alloyed in the film resulting on a stoichiometry of $VS_{1,1}O$ (C~5%).



XPS analysis of V2p, S2p, O1s, and C1s core regions

- The oxygen is mainly localized on top of an amorphous $V_xC_yS_z$ layer

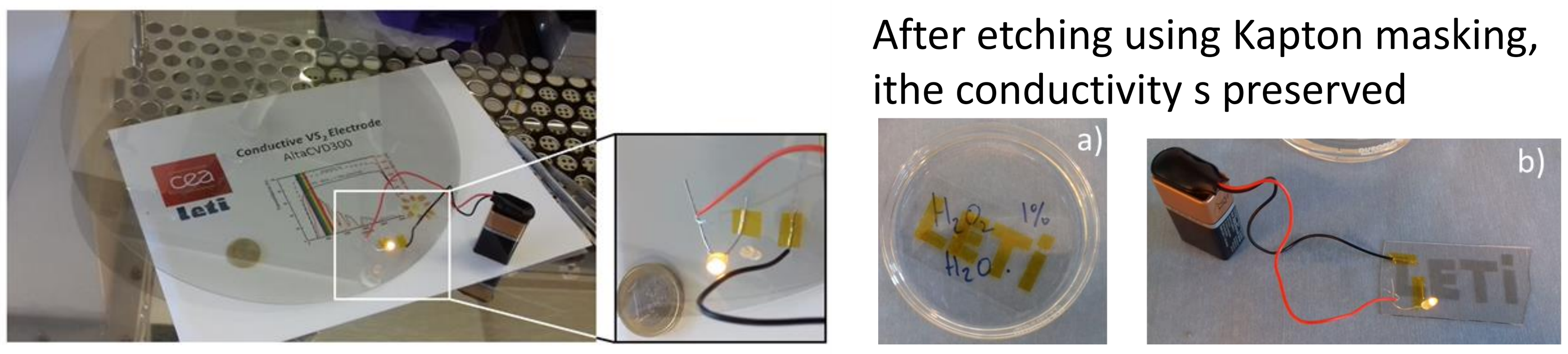


Z-contrast TEM image

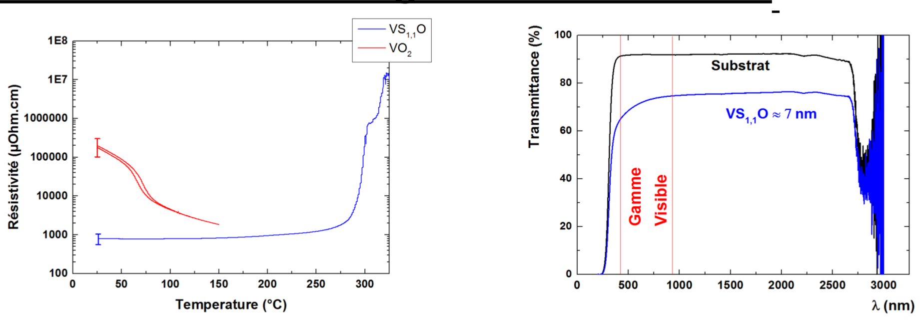
ANNEALING AND ELECTRICAL PROPERTIES

- Amorphous film deposited on 300mm Borosilicate wafer shows a resistivity <1mOhm.cm.

After etching using Kapton masking, ithe conductivity s preserved



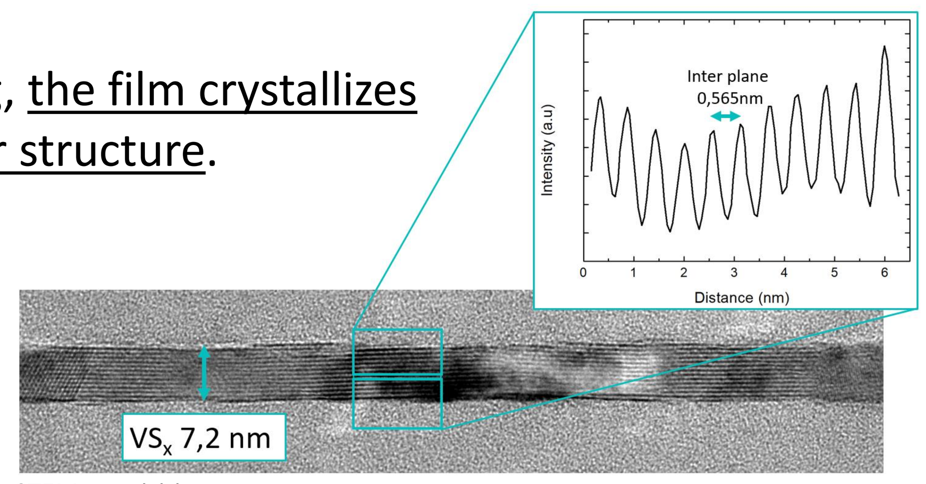
- The as-deposited film is relatively transparent @7nm with a 70% of photons transmission recorded in the range 500 - 3000 cm^{-1} on Borosilicate substrate



4 probes acquisition vs temperature

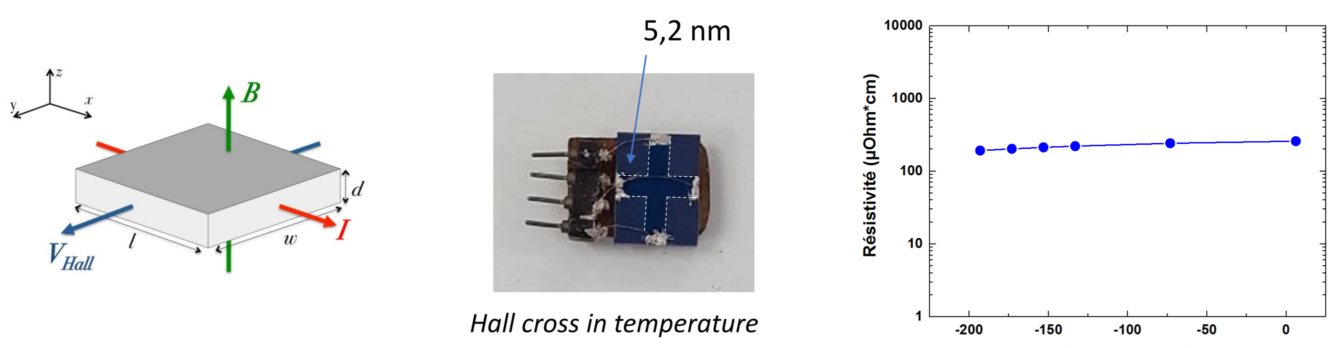
Transmittance measurement

- After annealing, the film crystallizes in a 2D lamellar structure.



STEM acquisition

- After annealing, the hall measurement in temperature indicates that the conductivity is due to p-type carriers.



Hall cross in temperature

CONCLUSIONS

- Vanadium sulfide-based alloys have been successfully deposited using an ALD/CVD method on large surface.
- The nanometer thick as-deposited film is conductive, and crystallize in a 2D lamellar structure after annealing.

It could become an alternative to standard CTO films even if it shows a metallic behavior thanks to its high conductivity at reduced thickness.

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REFERENCES

1. D. W. Murphy, C. Cros, F. J. Di Salvo, J. V. Waszczak, Inorg. Chem. 1977, 16, 3027
2. J. Yuan *et al*, Adv. Mater. 2015, 27, 5605–5609

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