

# Flagship AXION = nAnoXITrONics

Goal : *To realize large scale industrial transferable functional perovskite oxide heterostructures for silicon compatible and beyond CMOS microelectronics*

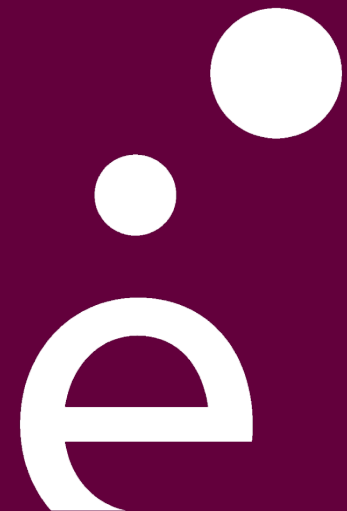
Agnès Barthélémy UMPHy 2016 - 2017  
=> Yves Dumont GEMAC 2018 - 2020

Flagship 2016 – 2019, ... extended to 2020



NanoSaclay Day 2019  
19th of Sept. 2019 at C2N

<http://nanosaclay.fr/>

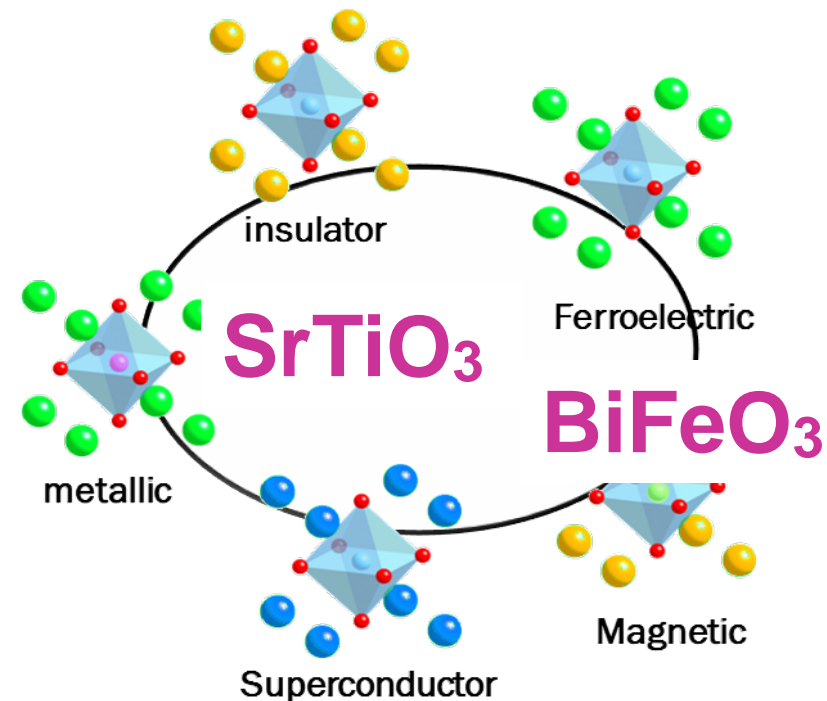




## Advantages of oxide perovskites $ABO_3$

- **New functionalities (broad range of properties)**
- **iso-structure allowing vertical integration**
- **nanometric characteristic length scales allowing for size reduction**
- **New properties at interfaces**

=> *Field of oxide electronics (Oxitronics) is a exponentially growing field due to its potential for future microelectronics*



## Challenges for industrial transfer

- **Large scale growth for Si-CMOS technology compatibility**
- **Low temperature growth**
- **Epitaxy to keep exceptional properties of perovskite**
- **Growth technique transferable to industry**

**Choice of  
Atomic Layer  
Deposition  
set-up**



## Consortium : 50-60 persons , 11 teams , 8 labs

- **UMφ CNRS/Thales**
- **GEMaC** : équipe FOX et NSP + **ILV / EPI**
- **Centrale Supélec: SPMS + GeePs.**
- **LPS:** STEM and theory teams
- **C2N:** OXIDE team
- **CSNSM**
- **DSM/IRAMIS/SPEC**
- **Synchrotron SOLEIL:** GALAXIES, CASSIOPEE beamlines

*PLD, and CVD growth  
magnetic, ferroelectric and  
transport  
advanced characterizations  
theory*

## Workpackages and challenges

1. **To realize epitaxial perovskite oxide thin films on large surface (2 inch) on silicon:** Equip ParisSaclay plateau with a semi-industrial Atomic Layer Deposition (ALD) set-up profiled for perovskite ternary oxides LabEx NanoSaclay + Region IdF (DIM OXYMORE) : **New tuned ALD set-up in GEMaC**
2. **To imagine and realize new electronic functions with new heterostructures and devices :** new materials, new heterostructures and interfaces by PLD studied with advanced characterizations + theory

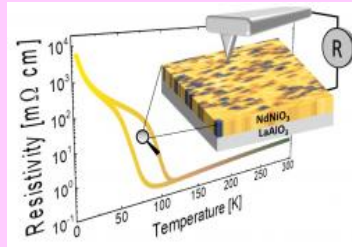
# AXION results

## « Cf Highlights NanoSaclay 2018 »

### Direct Mapping of Phase Separation across the Metal-Insulator Transition of NdNiO<sub>3</sub>

(CNRS-Thales, LPS, ICMAB Barcelona, Helmholtz-Zentrum Berlin)

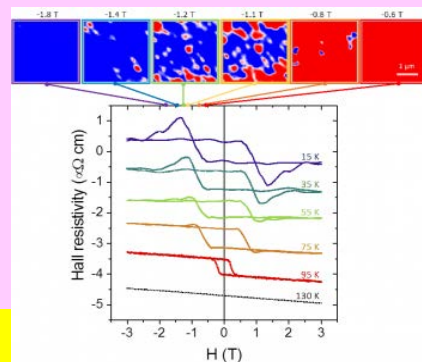
*Nano Letters* **18**, 2226 (2018)



### Giant topological Hall effect in correlated oxide thin films ((Ca,Ce)MnO<sub>3</sub>)

(CNRS-Thales, Rutgers Univ., ICMAB Barcelona, Helmholtz-Zentrum Berlin, Osaka Univ., Nagoya Univ., Univ. Complutense de Madrid)

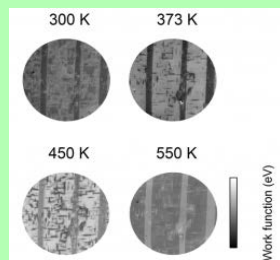
*Nature Physics* **15**, 67 (2019)



### Surface Proximity Effect, Imprint Memory of Ferroelectric Twins, and Tweed in the Paraelectric Phase of BaTiO<sub>3</sub>

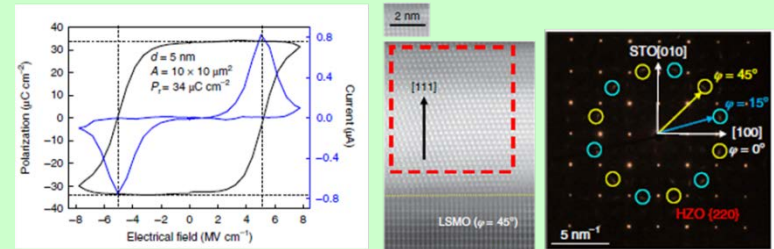
(SPEC, SPMS, Bristol Univ.)

*Scientific Reports* **8**, 13660 (2018)

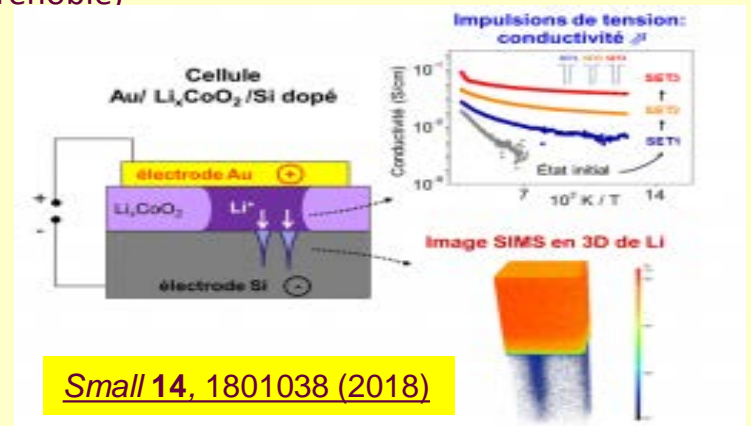


### A rhombohedral ferroelectric phase in epitaxially strained Hf<sub>0.5</sub>Zr<sub>0.5</sub>O<sub>2</sub> thin films (Gröningen Univ., C2N, SPMS, LIST Luxembourg)

*Nature Materials* **17**, 1095 (2018)



### Direct Evidence of Lithium Ion Migration in Resistive Switching of Lithium Cobalt Oxide Nanobatterie (GeePs, C2N, LPS, GEMaC, SPMS, ICMMO, Le Quy Don Technical Univ., Cyprus University, Nat. Instit. Laser – Roumanie, CEA-Grenoble)



*Small* **14**, 1801038 (2018)



## Other dissemination of knowledge: sponsoring and co-chairing

- GDR MEETICC focused meeting on « Advanced Techniques », 15-16 oct 2018, Versailles
- International conference HAXPES2019, 2-7 juin 2019, Paris
- International School of Oxide Electronics, Cargèse, June 25 - July 5 2019

## And today:

« Atomic Layer Deposition of functional oxide perovskites  $ABO_3$  on large surface: cases of  $SrTiO_3$ ,  $BiFeO_3$  “

André GRISHIN

GEMAC + CEFS2\EPI\ILV + SPMS\CentraleSupélec

“Strain dependence of surface screening and Curie temperature in the giant tetragonal phase of  $BiFeO_3$ ”

Myriam LACHHEB

SPEC\IRAMIS\CEA + UMPHy + LPS + SPMS\CentraleSupélec

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