



HAL
open science

Projet ciblé EMCOM: Emerging Memories for COMputing

Thomas Buttiens, Maxime Culot, Théo Frottier, Salvatore Teresi, Anouk Goossens, Fernando Gallego, Williams Savero Torres, Aurélie Kandazoglou, Paolo Sgarro, Laurent Vila, et al.

► To cite this version:

Thomas Buttiens, Maxime Culot, Théo Frottier, Salvatore Teresi, Anouk Goossens, et al.. Projet ciblé EMCOM: Emerging Memories for COMputing: Résultats marquants 2023. Journées Scientifiques Nationales 2024 du PEPR électronique et PEPR réseaux du Futur, Mar 2024, Grenoble, France. . hal-04697094

HAL Id: hal-04697094

<https://hal.science/hal-04697094>

Submitted on 16 Sep 2024

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Thomas Buttins², Maxime Culot¹, Théo Frottier¹, Salvatore Teresi¹, Anouk Goossens², Fernando Gallego², Williams Savero-Torres¹, Aurélie Kandazoglou¹, Paolo Sgarro¹, Laurent Vila¹, Manuel Bibes², Thomas Maroutian³, Louis Hutin⁴, Pierre Noé⁴, Jean-Philippe Attané¹

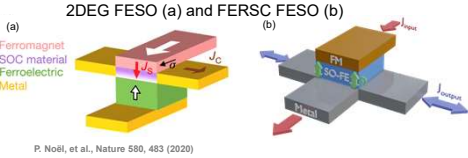
¹UGA/CEA/CNRS, Spintec, Grenoble
²CNRS/Thales/UPS, Laboratoire Albert Fert, Palaiseau
³CNRS/UPS, C2N, Palaiseau
⁴CEA, LETI, Grenoble

Abstract

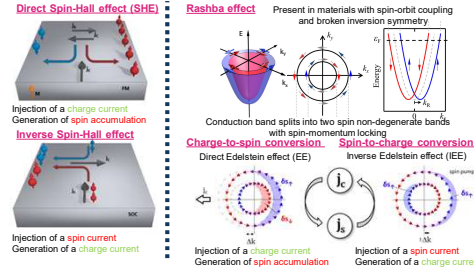
- The Ferroelectric Spin Orbit (**FESO**) device is based on the **ferroelectric** control of spin charge interconversion, for **logic in memory** applications
- Ultra low energy **aJ switching** and **non volatility** are achievable thanks to **ferroelectricity**
- We aim to demonstrate **room temperature** operation of a **nanopatterned FESO** device
- We developed two strategies based on two material family, **oxides** (Lab Albert-Fert, C2N) and ferroelectric Rashba semiconductors, **GeTe** (Spintec, LETI)

Motivation

- The FESO is a magnetoelectric-free alternative to the MESO device proposed by INTEL. (Manipatruni, S. *et al. Nature* **565**, 35–42 (2019)).
- These **non volatile ultra low energy aJ** switching devices have a potential for in memory computing applications (**majority gate**)

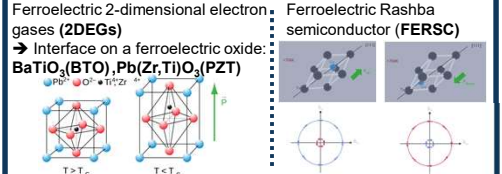


Spin charge interconversion

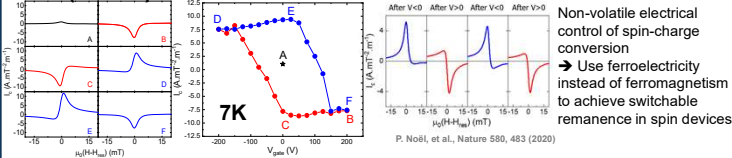


Material challenges

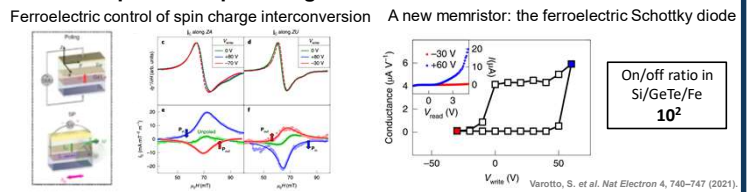
- #### Device requirements
- Demonstrate **non volatile control** of spin charge conversion in nano patterned FESO devices < 200 nm at **room temperature**
 - High interconversion output $V_{out} > 10$ mV
 - High endurance $N > 10^7$ cycles



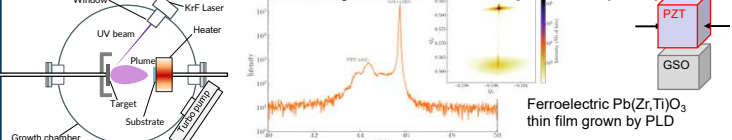
Ferroelectric control of spin-charge conversion in SrTiO3 2D Electron Gas (2DEGs)



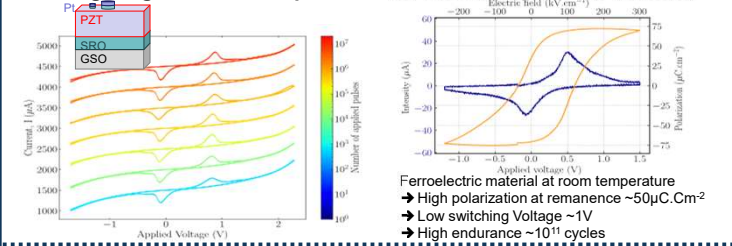
Room temperature spin charge interconversion in ferroelectric GeTe



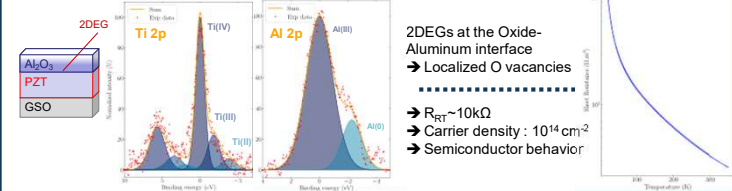
Growth of Ferroelectric Oxide by Pulsed laser deposition (PLD)



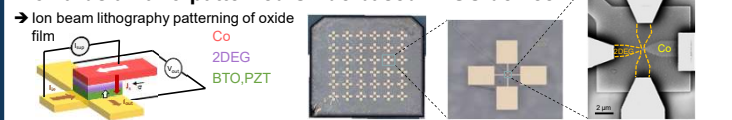
Investigating the room temperature ferroelectricity in PZT thin film



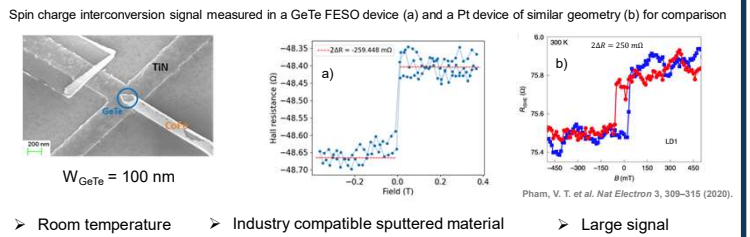
A 2DEGs in Ferroelectric PZT thin film



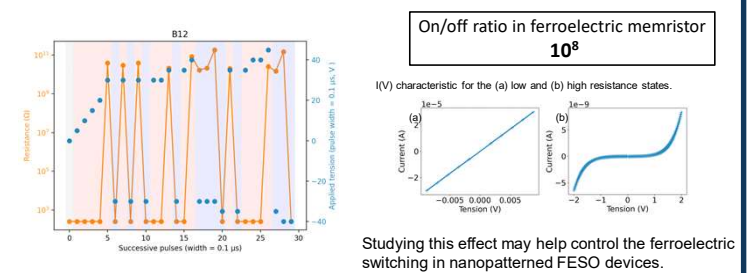
Towards a nano-patterned Oxide based FESO device



Towards a nano-patterned GeTe FESO device



Ferroelectric resistance switching effect



Integration of the memristor in a crossbar array

- Benefits of the ferroelectric memristor
- High on/off ratio : 10^8
 - Low sensibility to variability
- Expected benefits :
- High endurance of ferroelectric switching : 10^{12}
 - Low variability
 - Self-rectifying behaviour
-

Conclusion

- High-quality thin films of PZT, with characterized ferroelectric properties, have been fabricated
- 2DEG on PZT has been obtained at Room temperature
- Oxide based FESO transistors has been patterned

Perspective

- ❖ Investigating spin-to-charge conversion in PZT 2DEG at room temperature is necessary
- ❖ The FESO devices need to be studied

- Spin to charge conversion in a nano patterned room temperature FESO device with sputtered GeTe has been demonstrated
- The spin charge interconversion material GeTe has shown potential as a ferroelectric memristor with a giant 10^8 on/off ratio

- ❖ Ferroelectricity in GeTe needs to be optimized, potentially through doping
- ❖ The memristors could be integrated in a crossbar array

