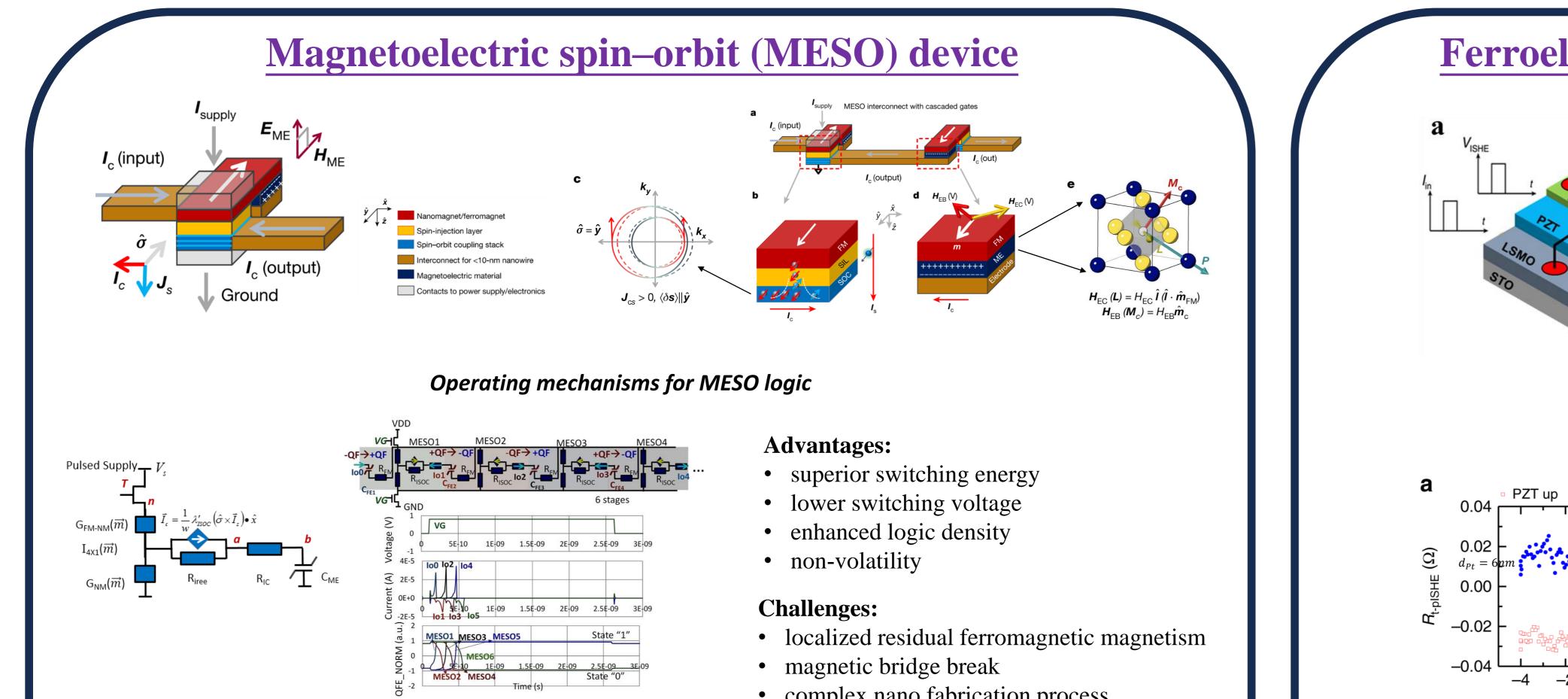
Energy-efficient Ferroelectric Spin-Orbit logic

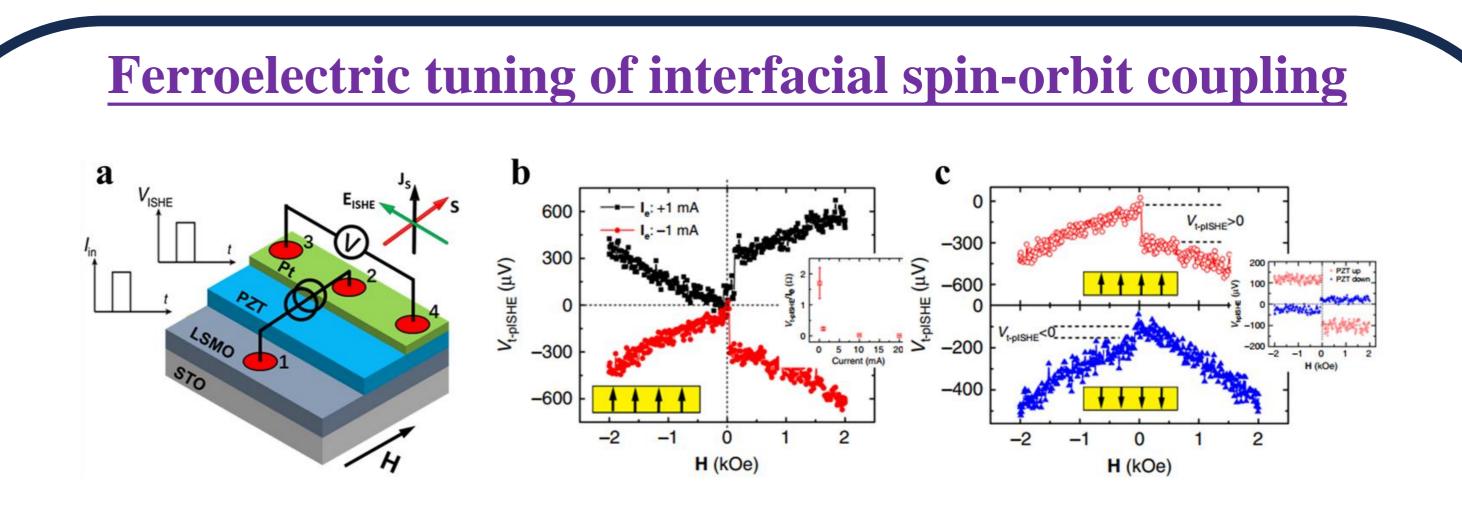


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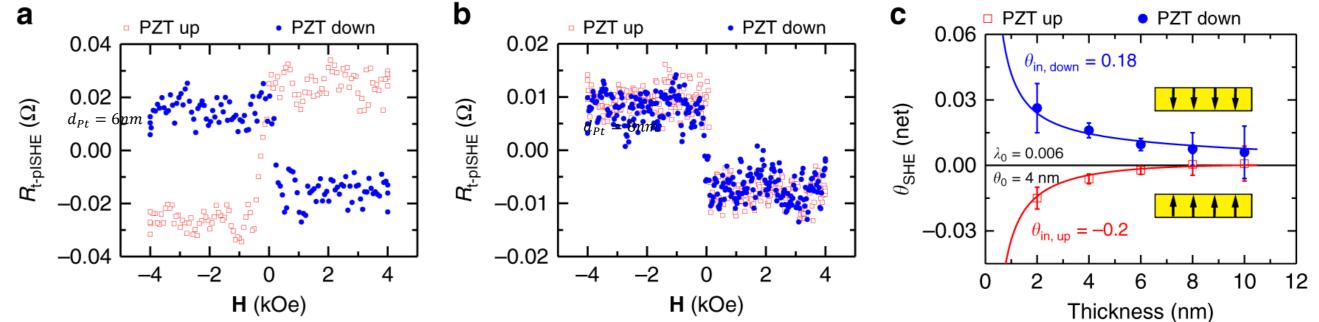
Ferroelectric control of spin transport in ISHE devices

• complex nano fabrication process

Circuit schematics of single and cascaded 6-stage Vector Spin Equivalent Model for MESO Logic device

Manipatruni, Sasikanth, et al. Nature 565, 35–42(2019)

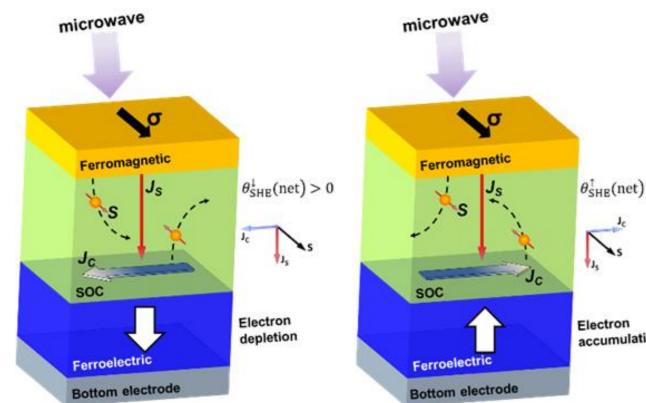


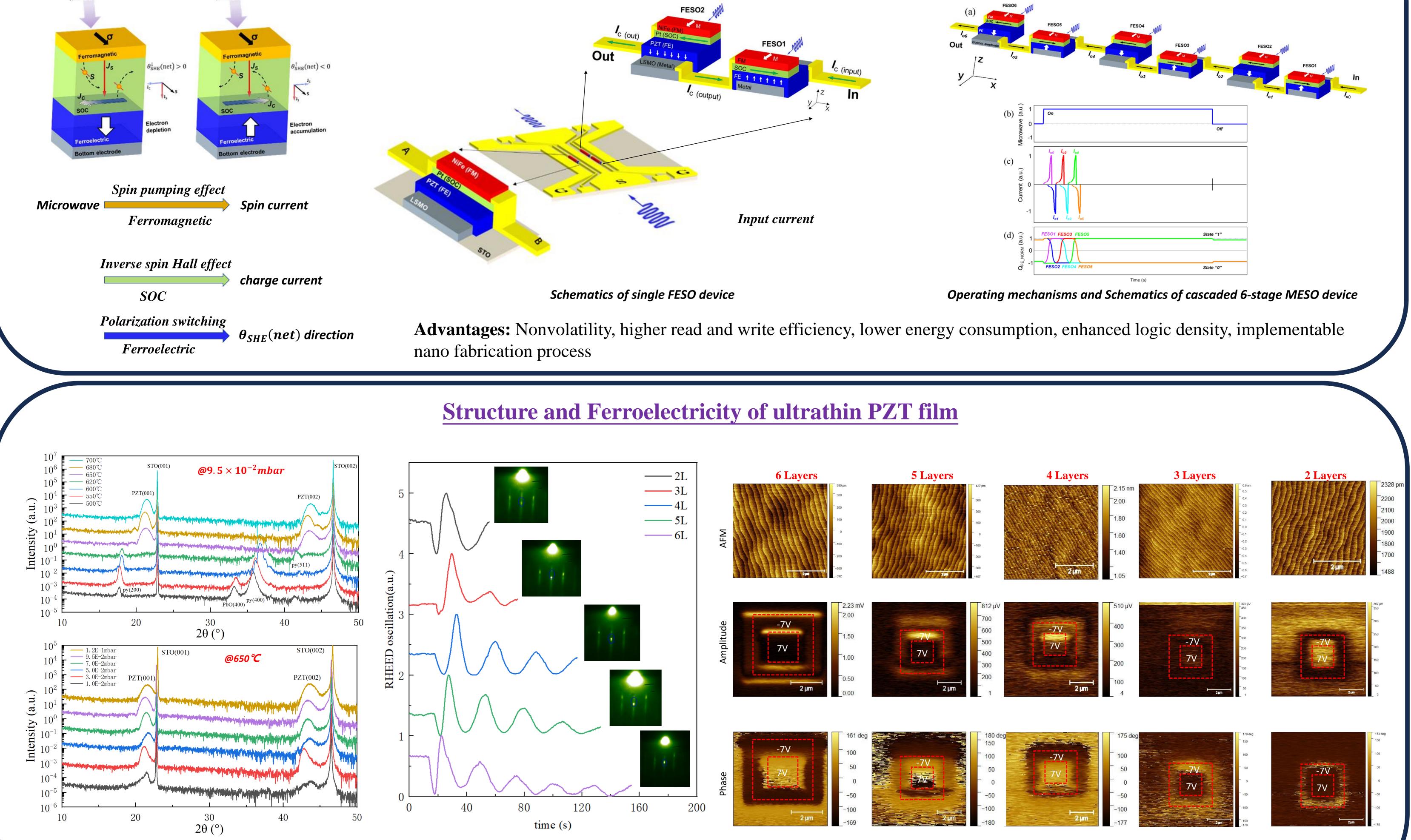


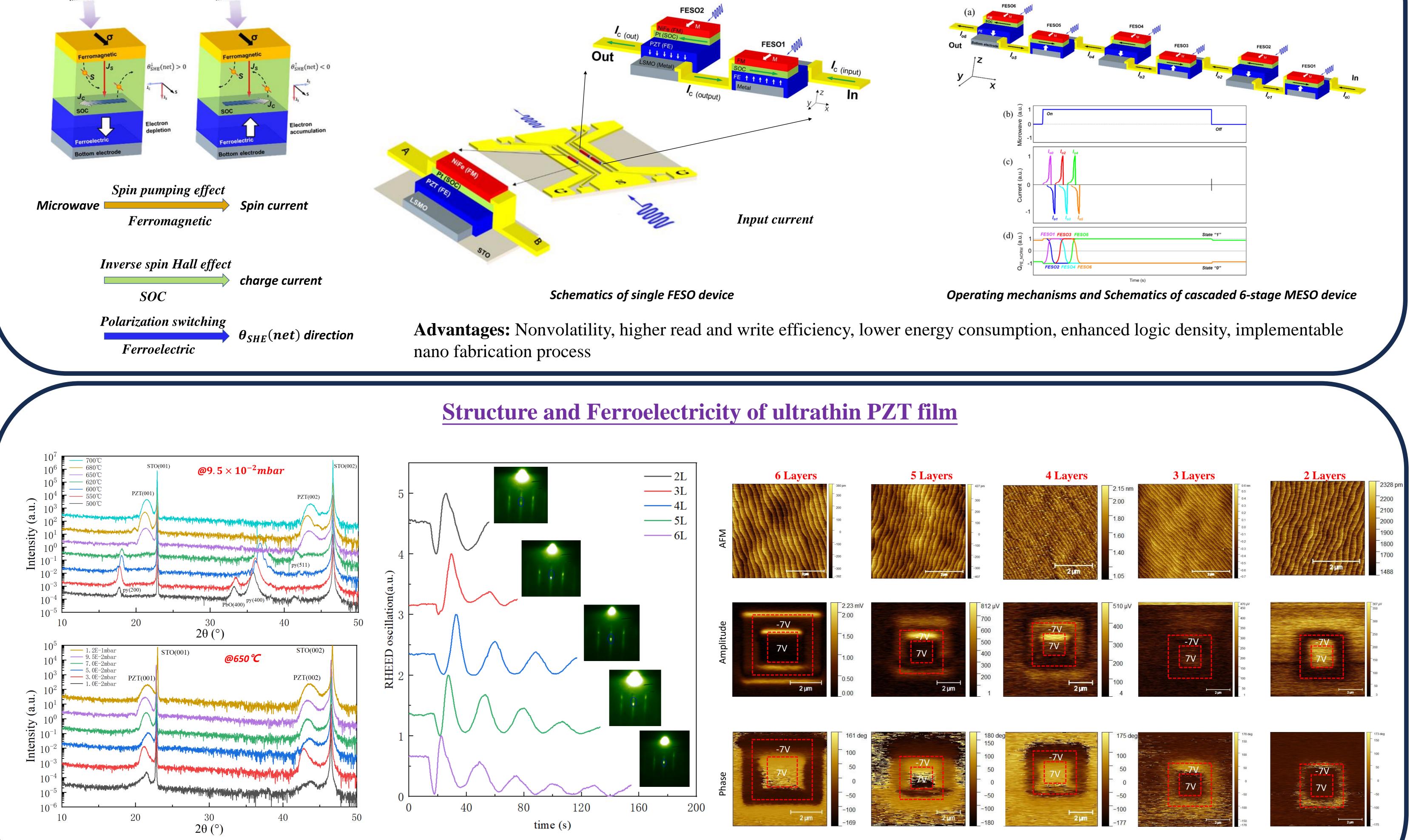
Pt-thickness-dependent t-pISHE response at the two ferroelectric polarization states of PZT. a, b t-pISHE response in 6 nm and 8 nm Pt at two PZT polarization states. c net spin Hall angle as a function of Pt thickness.

Shen, Jian, et al. Nat.Commun. **11**, 2627 (2020)

Design of FESO (Ferroelectric Spin-Orbit) device







Temperature and oxygen pressure dependence of PZT structure

RHEER oscillations of the PZT films in different thickness

Morphologies and ferroelectric properties of the ultrathin PZT film

Conclusion

- > Propose a scalable spintronic logic device operates via spin–orbit transduction Spin pumping and inverse spin
- > Hall effect are used to efficiently convert spin currents into charge currents
- > Perovskite phase PZT growth is sensitivity to temperature and oxygen pressure.

- **FESO** device consist of ferroelectric/spin-orbit coupling/ferromagnetic (PZT/Pt/NiFe) heterostructure.
- > Net spin Hall angle is active controlled by the ferroelectric polarization.
- > PZT films keep the ferroelectricity even down to the thickness of 2 unit cells.