

Motivation

Current information devices based on spin and charge

Quest for higher data density without need of magnetic field to manipulate magnetization

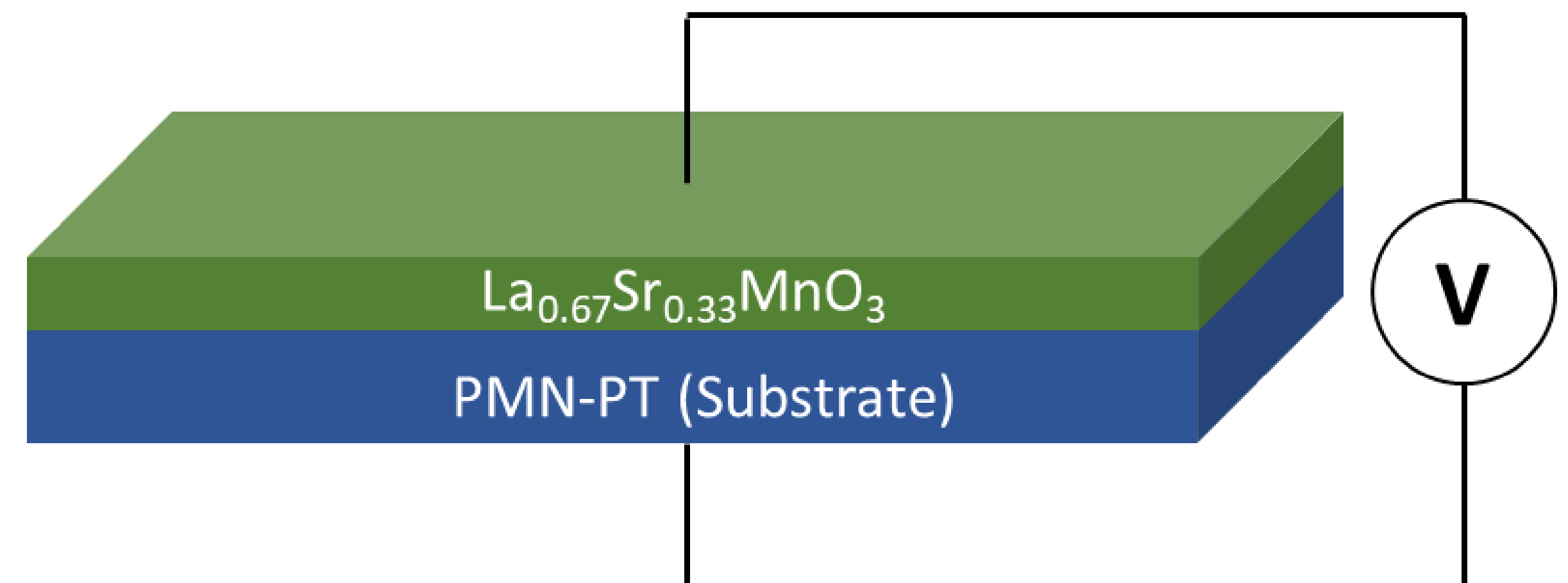
Complex oxides- strong coupling between lattice, charge, spin & orbital degrees of freedom

Voltage control of magnetism

Ferromagnetic/Ferroelectric heterostructures (FM/FE)

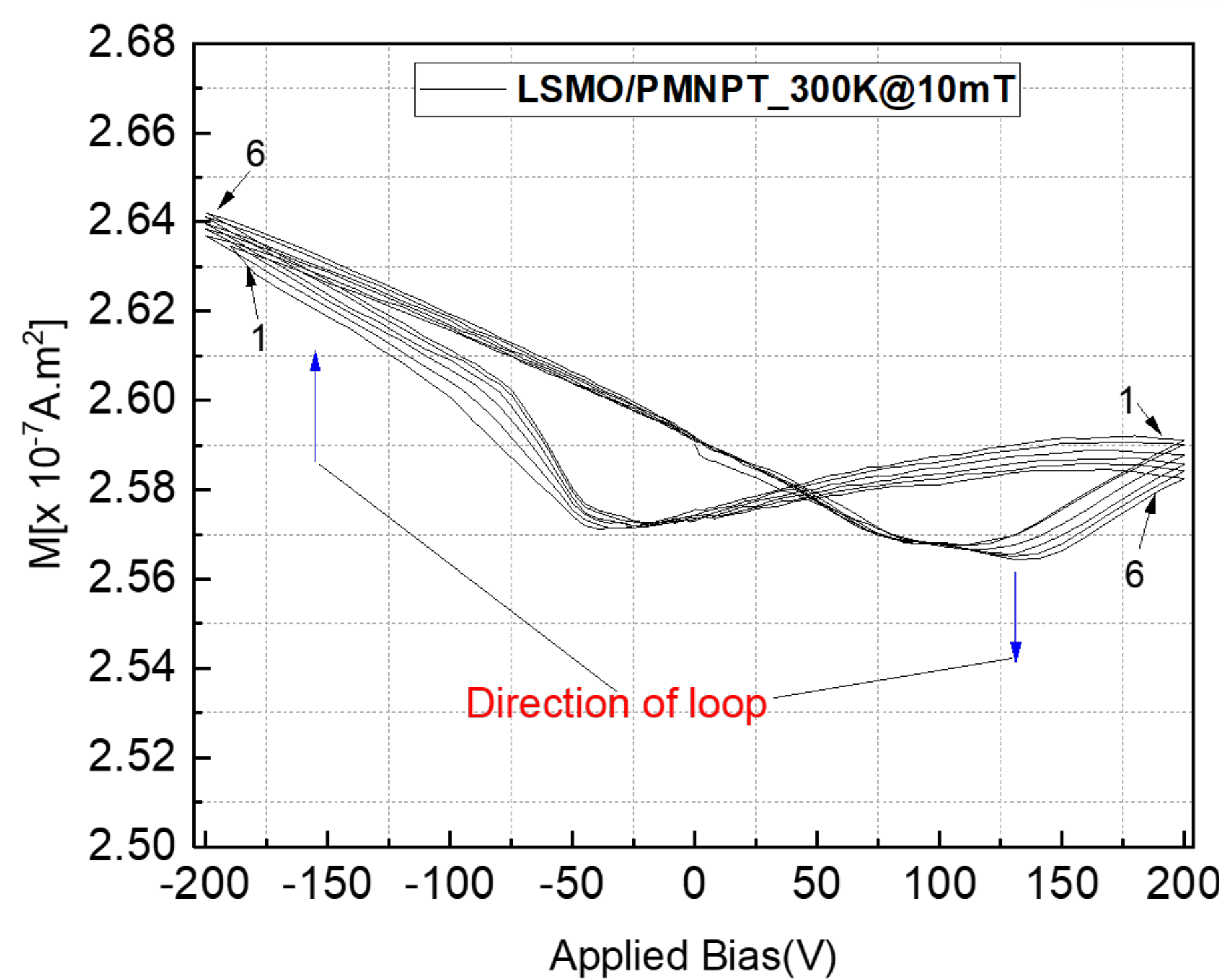
Magnetoelectric coupling

System

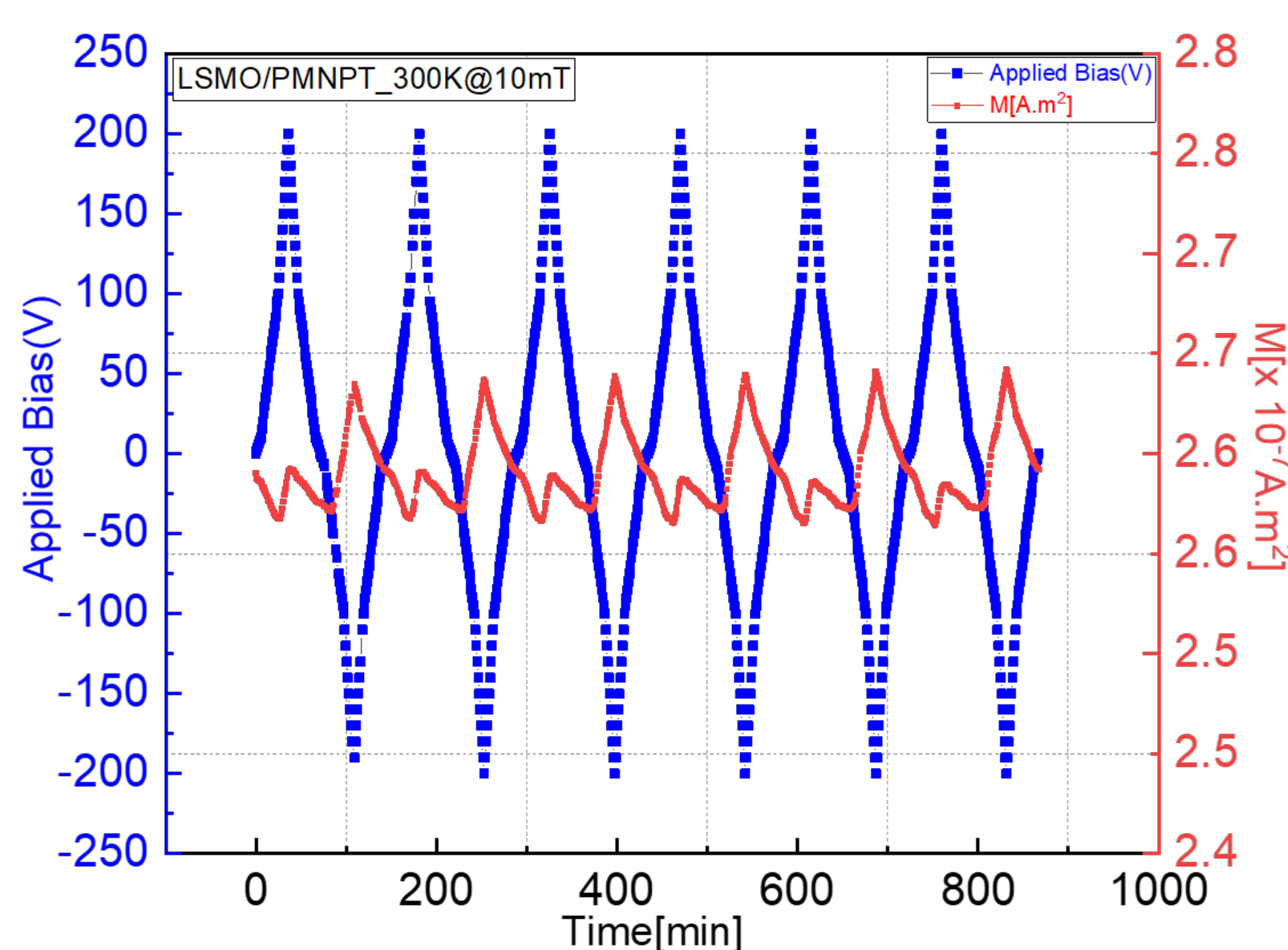


FM layer - $\text{La}_{0.67}\text{Sr}_{0.33}\text{MnO}_3$ (LSMO-30nm)
Piezoelectric substrate – PMN-PT ($0.7\text{Pb}(\text{Mg}_{1/3}\text{Nb}_{2/3})\text{O}_3$ - 0.3PbTiO_3 (001))

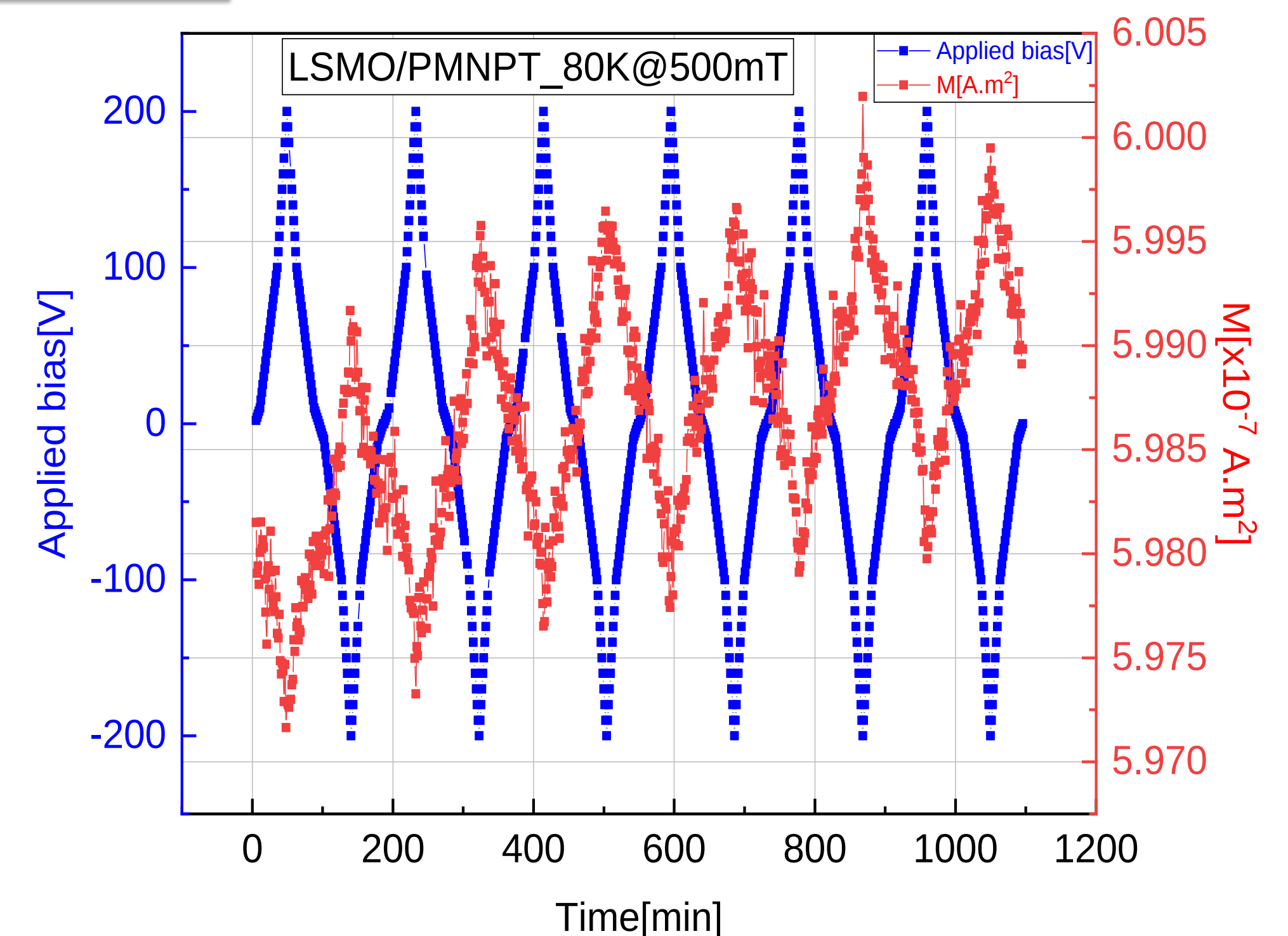
Magnetoelectric SQUID measurements



Strain-mediated magnetoelectric coupling

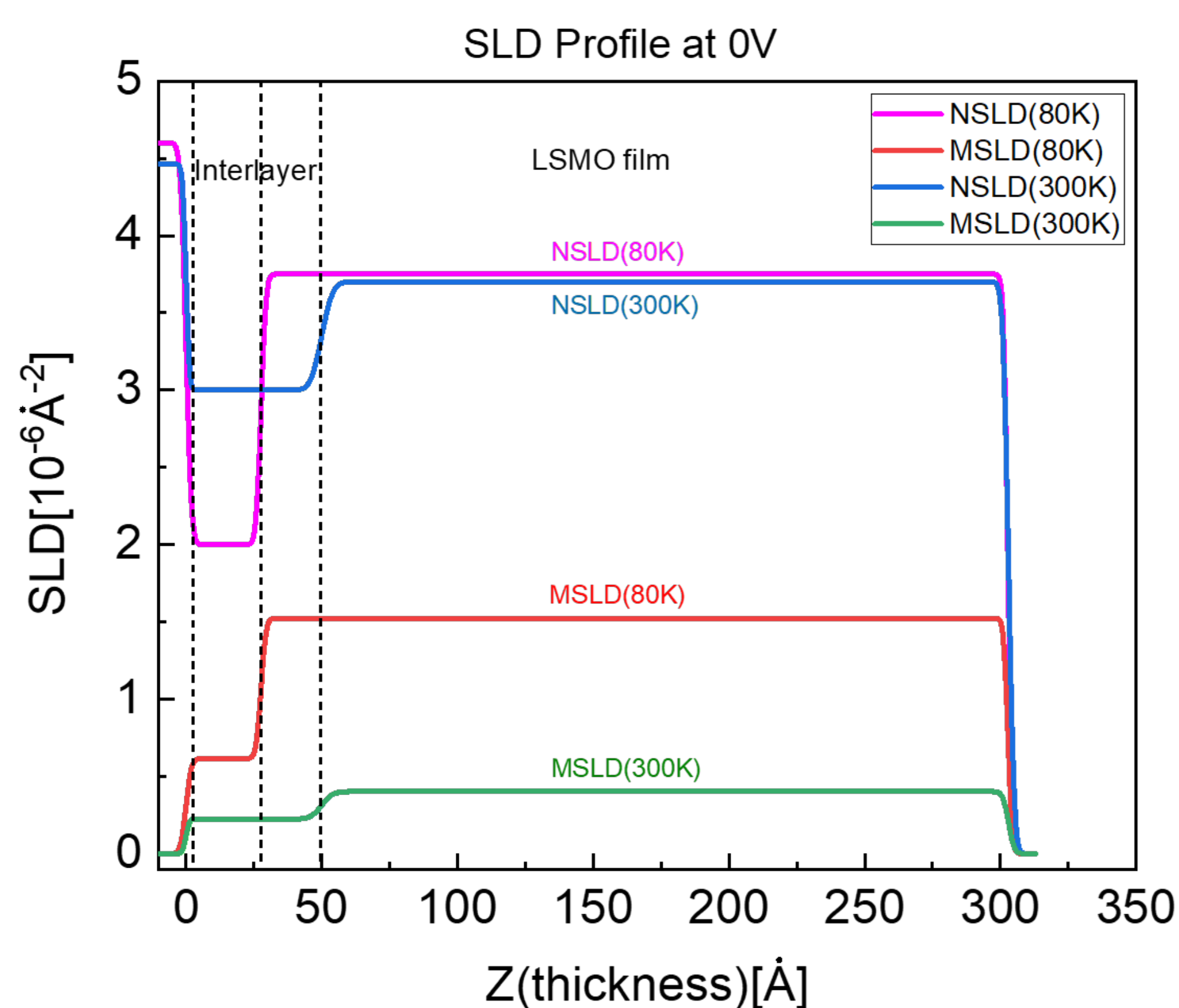
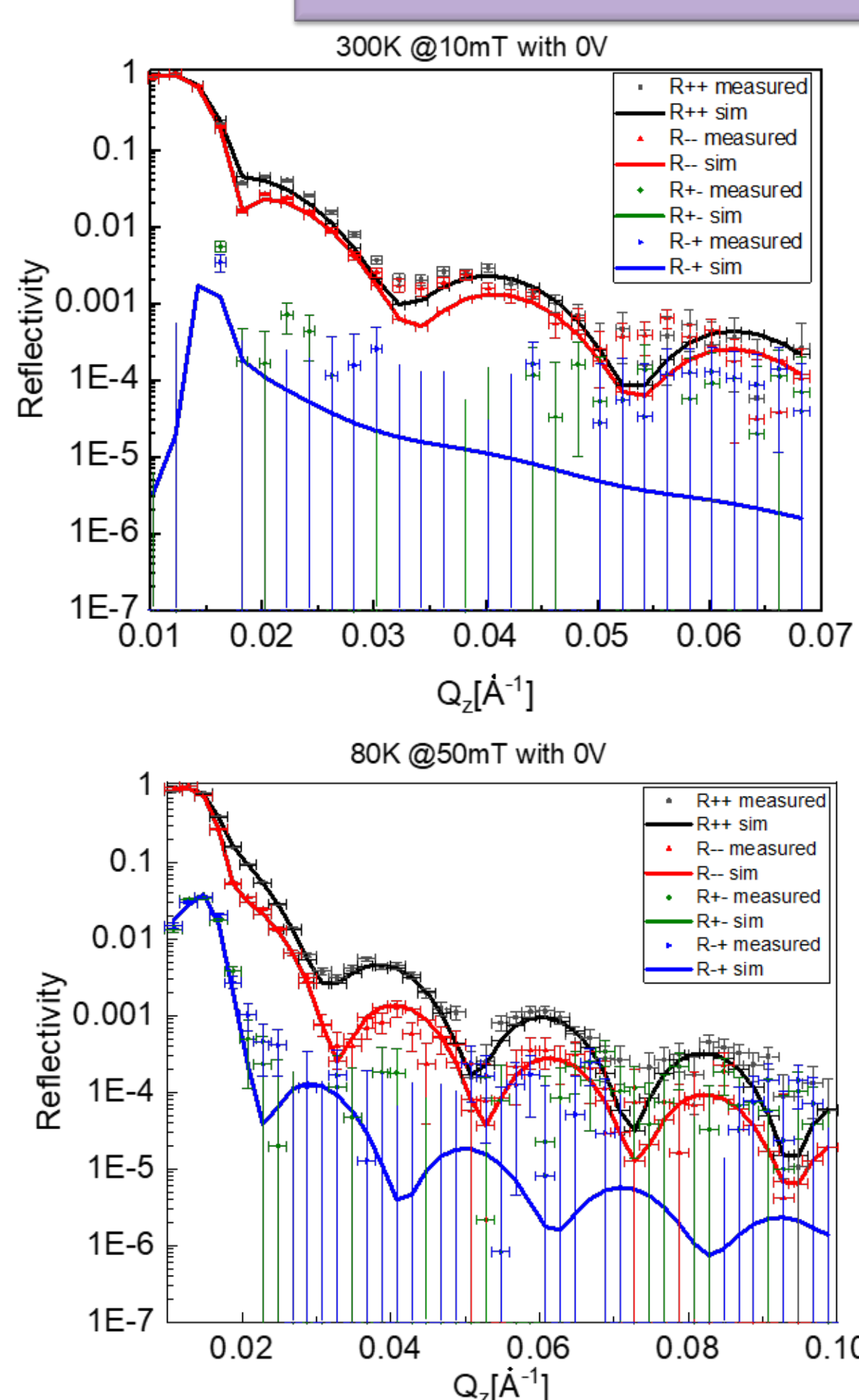


Rich correlation between magnetization and applied voltage



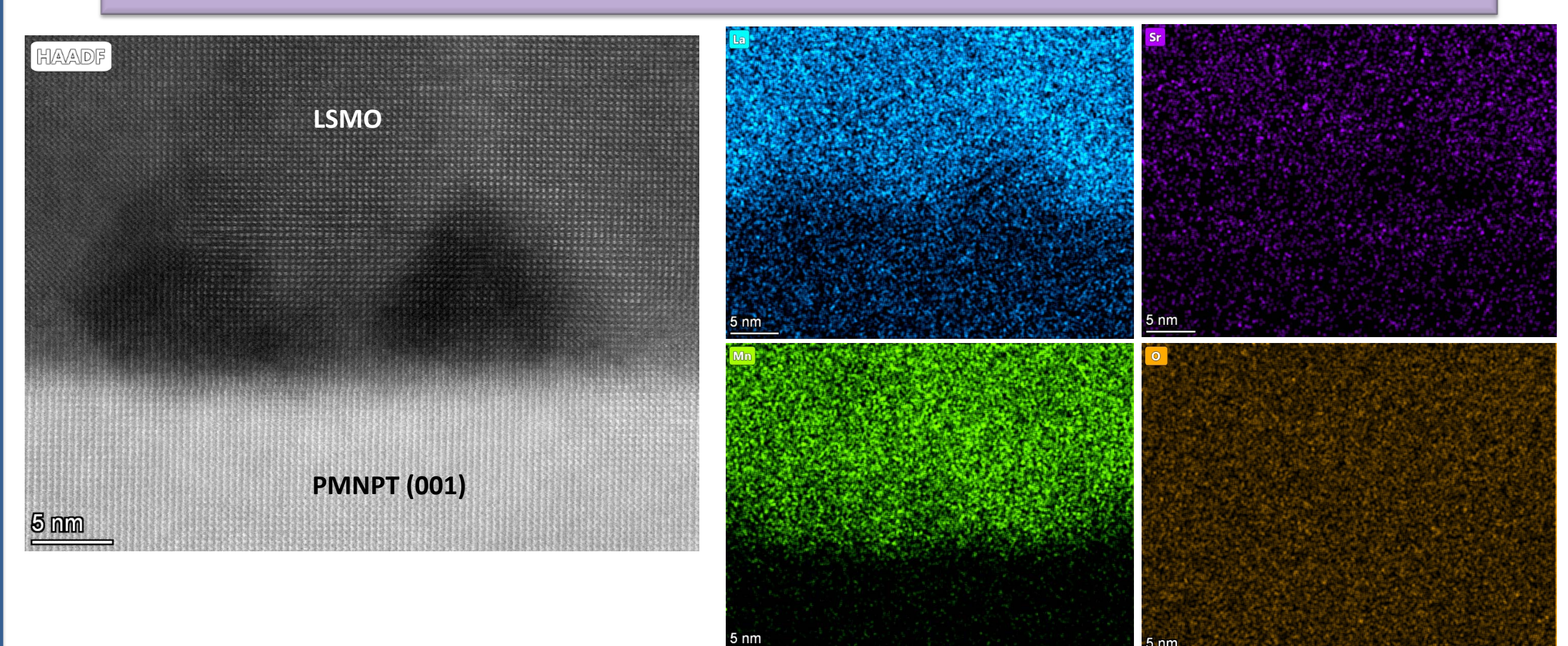
Low temperature magnetoelectric coupling

Polarized Neutron Reflectometry

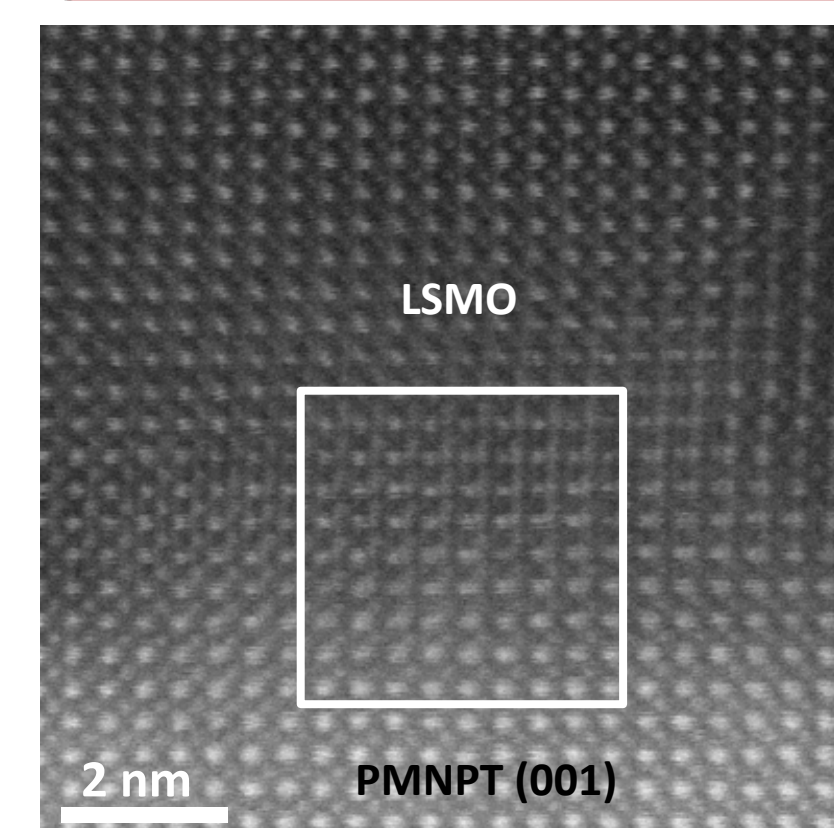


- The magnetic depth profile deduced from PNR datasets indicate the presence of interlayer between LSMO/PMNPT.
- Spin-flip signal indicates presence of canted magnetic moments due to the strain imparted by the substrate.

Transmission Electron Microscopy



Darker contrast regions show La- deficiency at the interface



LSMO has grown epitaxially on PMNPT and is strained at the interface

Conclusions and outlook

- ✓ Clear proof of strain-mediated magnetoelectric coupling.
- ✓ Possible indication of charge-mediated magnetoelectric coupling due different magnetization values for opposite polarity of applied voltage.
- ✓ Presence of interlayer with reduced SLD and La-deficiency at the interface.
 - Analysis of PNR curves with voltages is in progress.
 - Further structural investigation will be done using TEM.

Acknowledgement

- PNR measurements were performed at NIST Center for Neutron Research, Gaithersburg, Maryland, USA
- All other measurements were performed at Forschungszentrum Jülich GmbH, Germany

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