Center for Artificial Low D Electronic Systems

# 2021 Spring Seminar
# with CALDES, IBS & SRC, POSTECH

- ✓ **Date&Time:** March 26 (Fri), 3:00PM~
- ✓ **Venue:** Online (Zoom)
- ✓ **Speaker & Title**

1) 3:00PM~ Prof. Jun Hee Lee (UNIST)
Scale-free unit-cell ferroelectricity by flat phonon band in HfO2

2) 4:10PM~ Prof. Woo Seok Choi (Sungkyunkwan Univ.)
Exchange Interaction induced by Chiral Phonons

Organized by Prof. Jun Sung Kim (js.kim@postech.ac.kr, 054-279-2098 )
Dr. Jewook Park (jewookpark@ibs.re.kr, 054-279-9893)

- **3:00PM~**

# Scale-free unit-cell ferroelectricity by flat phonon band in HfO2

**Jun Hee Lee**
**School of Energy & Chem. Eng., UNIST**

Since ferroelectricity is a collective phenomenon necessitating at least thousands of atoms' simultaneous displacements, it's been believed for the last 100 years that finite-sized domains (10~100nm) are required to stabilize and switch the ferroelectric dipole moments. We can break the 100-years myth by introducing flat-band theory into the history of ferroelectricity [1]. As flat bands are known to induce intrinsically localized states and thus to cause unusual phenomena such as graphene superconductivity and electron lattices, we, for the first time, show that flat bands in ferroelectricity induce intrinsic local dipoles whose width is of half-unit-cell of a few angstroms. Strikingly, these intrinsic local dipoles are individually stable and switchable, so one can circumvent the formation of the domains for the dipole switching. We can directly switch the unit-cell-scale dipoles and finally pave a way to achieve ultimate-density (~100TB) ferroelectric devices.

[1] Lee et al., Science 369, 1343 (2020)

- **4:10PM~**

## Exchange Interaction induced by Chiral Phonons

**Woo Seok Choi**
**Dept. of Physics, Sungkyunkwan University**

Artificial crystals synthesized by atomic-scale precision epitaxy is a suitable platform for exploring, controlling, and understanding the quantum mechanical regime of solid state. The excellent tenability of the crystal itself enables observation of exotic phenomena, that are not attainable in natural crystals.
In this presentation, we demonstrate the existence of chiral phonons and their unprecedented role of inducing novel exchange interaction. Phonons with broken chiral symmetry strongly couples to the spin degree of freedom, which mediates an interlayer exchange interaction. Using pulsed laser epitaxy, we fabricated atomically-designed $SrRuO_3/SrTiO_3$ superlattices. $SrRuO_3$ is a ferromagnetic metal, whereas $SrTiO_3$ is a nonmagnetic insulator. Between the ferromagnetic $SrRuO_3$ layers, a synthetic spiral (conical) spin state was observed. This originated from the rotation of the magnetic moments as a function of nonmagnetic insulating spacer $SrTiO_3$ layer thickness, via the chiral phonon propagation. The observation of phonon Zeeman effects further manifested the chiral phonon-spin coupling. The manifestation of the chiral phonons and their strong interaction with spins unveil the critical roles of chiral phonons in magnetic materials.

Jeong et al., *Appl. Phys. Lett.* **115**, 092905 (2019).
Jeong et al., *Phys. Rev. Lett.* **124**, 026401 (2020).
Jeong et al., *Nanoscale*. **12**, 13926 (2020).
Jeong et al., *Adv. Sci*. **7**, 2001643 (2020).
Seo et al., *Phys. Rev. B* **103**, 045104 (2021).
Jeong et al., *ACS Appl. Nano Mater*. **4**, 2160 (2021).
Jeong et al., submitted (2021).