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RESEARCH & COLLABORATION PROFILE |

KEY WORDS: Metal Halide Perovskite, Electronic Structure, ARPES, NanoESCA, Strongly Correlated System



Research Snapshot. Dr. Seong investigates the electronic structure of materials by photoemission and X-ray spectroscopy. His current work focuses on metal halide perovskites, which are too fragile for high-energy synchrotron light, so he applies low-energy ultraviolet photoemission and spatially resolved band-structure measurements with NanoESCA. Previously, he conducted research utilizing the Pohang Accelerator Laboratory (PAL) synchrotron, using angle-resolved photoemission (ARPES), X-ray absorption (XAS), and X-ray magnetic circular dichroism (XMCD) on strongly correlated, topological, and magnetic materials.

RESEARCH EXPERTISE

- **Photoemission of fragile, beam-sensitive materials:** valence electronic structure of metal halide perovskites measured with UV light sources, where high-energy photons cannot be used.
- **Spatially resolved band-structure measurement:** NanoESCA-based band-structure analysis of single-crystalline thin films.
- **Synchrotron ARPES:** momentum-resolved band dispersions and Fermi surfaces of single crystals and films at PLS-II (4A1, 4A2, 10D) and ALS (4.0.3).
- **XAS and XMCD:** element-specific valence, orbital, and magnetic-moment analysis of oxides, Heusler films, and other magnetic materials at PLS-II (2A, 6A, 8A1).

RECENT RESEARCH HIGHLIGHTS

- **Perovskite thin films (ongoing):** investigating the band structure of single-crystalline $FA_{0.6}MA_{0.4}PbI_3$ thin films with NanoESCA, together with photoemission studies of $MAPbI_3$.
- **Bi-oxide interfaces (J. Phys. Chem. Lett. 2026):** showed that native bismuth oxide on Bi(111)/MoS_2 switches between n-type and p-type by air annealing and in situ annealing, with a highly dispersive Bi-O valence band in the p-type Bi_2O_3 overlayer.
- **Kondo semimetals and insulators (Phys. Rev. B 2025):** temperature-dependent ARPES at the Ce 4d resonance revealed a Ce 4f Kondo resonance in CeNiSn, CeRhSb, and CeRhAs, with Kondo temperatures of about 80, 180, and 200 K and a pseudogap of about 30 meV in the insulating CeRhAs.
- **Magnetization flip (Phys. Rev. Mater. 2025):** XMCD and XAS at the Co, Cr, and Fe 2p edges of $CoCr_{2-x}Fe_xO_4$ showed divalent Co on tetrahedral sites and trivalent Fe and Cr on octahedral sites, and sign changes of all XMCD signals above x = 0.15, directly demonstrating the magnetization flip.

POTENTIAL COLLABORATION RESEARCH

Best-fit collaborator areas: perovskite crystals & thin films | 2D & semiconductor heterostructures | strongly correlated & magnetic materials

- **1. Photoemission analysis of perovskites:** PES analysis of the electronic structure of your perovskite crystals and films, linking composition and processing to band structure.
- **2. NanoESCA measurements in Suwon:** spatially resolved band-structure measurements of your thin-film samples using the NanoESCA at AICT.
- **3. Synchrotron experiments at PAL:** ARPES, XAS, and XMCD at PLS-II for band dispersion and element-specific electronic and magnetic structure of your crystals and films.
- **4. Interface and heterostructure studies:** ARPES and X-ray spectroscopy of overlayers and 2D heterostructures to reveal band structure and carrier-type changes at interfaces.

SELECTED RECENT PUBLICATIONS

- **J. Phys. Chem. Lett. 2026, 17, 5921:** Polarity-programmable bismuth oxide overlayers on Bi(111)/MoS_2 heterostructures via oxidation and annealing.
- **Chem. Mater. 2025, 37, 2358:** Twist-induced dimensional crossover and topological phase transitions in bismuthene quasicrystals.
- **Phys. Rev. Mater. 2025, 9, 114413:** Direct observation of magnetization flip in $CoCr_{2-x}Fe_xO_4$ spinel ferrites via temperature-dependent XMCD study.
- **Phys. Rev. B 2025, 111, 235123:** Electronic structures and pseudogap nature of the strongly correlated Kondo semimetals and insulators CeNiSn and CeRhX (X = As, Sb).

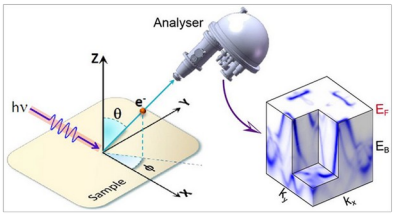
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REPRESENTATIVE RESEARCH FIGURES / SCHEMES

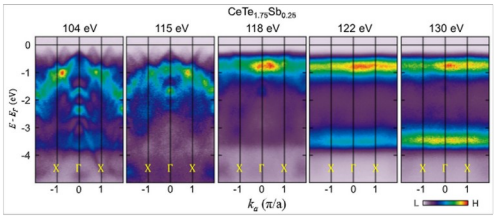
ARPES via Photoelectron Spectroscopy



- **Measure kinetic energies(E_k) of photoelectrons & emission angles (θ, Φ)**

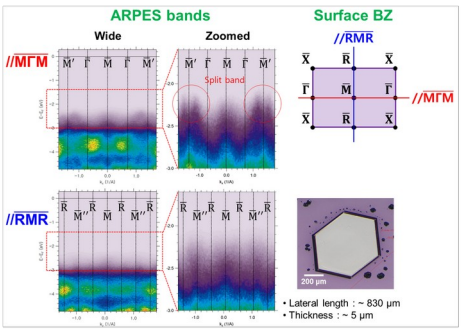
- **Using ARPES, one can determine**
  - Band structures : $E(k_{||})$
  - Fermi surfaces (FS)
  - Effective mass of carriers

ARPES of Strongly Correlated Materials



Photon-energy-dependent band maps of $CeTe_{1.75}Sb_{0.25}$.

Metal Halide Perovskite Band Structure



Single-crystalline thin film (~830 μm, ~5 μm thick): bands along M-Γ-M and R-M-R, with surface BZ.