Soft X-Ray ARPES: From Bulk Materials to Buried Heterostructures and Impurities

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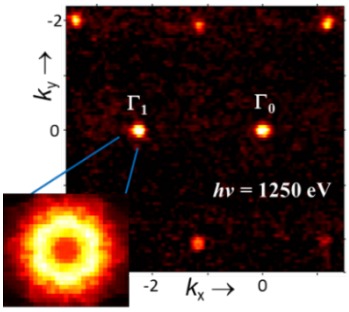
Soft-X-ray ARPES in the photon energy range around 1 keV enhances the **k**-resolving capabilities of this experimental technique with large probing depth and resonant photoexcitation delivering chemical specificity. These advantages allow access to 3D bulk materials, buried heterostructures and impurity systems for real electronic devices.

Bulk materials. – Applications of soft-X-ray ARPES to bulk materials are based on sharp definition of the out-of-plane **k** resulting from the enhanced photoelectron delocalization. Examples include 3D-nested Fermi surface of VSe_2 forming exotic charge-density waves [*Phys. Rev. Lett*. **109** (2012) 086401], 3D band dispersions in complex oxides and topological materials, etc.



Buried heterostructures. – Semiconductor systems are illustrated by AlN/GaN high-electron-mobility transistor (HEMT) heterostructures, where soft-X-ray ARPES resolves the anisotropic Fermi surface (Figure) and band dispersions of the interfacial quantum-well states [*Nature Comm*. **9** (2018) 2653]. A paradigm example of oxide interfaces is $LaAlO_3/SrTiO_3$. Resonant photoexcitation at the Ti *L*-edge resolves here the interfacial states, whose peak-dip-hump spectral function identifies their multiphonon polaronic nature [*Nature Comm*. **7** (2016) 10386].

Impurity systems. – An example of impurity systems is Ga(Mn)As where resonant photoexcitation at the Mn *L*-edge identifies the energy alignment and hybridization of the Mn impurities with host GaAs, disclosing the mechanisms of the ferromagnetic electron transport [*Phys. Rev. B* **89** (2014) 205204]. Other cases include magnetic V impurities in topological Bi_3Se_2 competing with the quantum anomalous Hall effect, etc.

Finally, I introduce an ongoing instrumental project on iMott the multichannel spin detector that boosts the spin detection efficiency by a few orders of magnitude, allowing access to spin textures of heterostructure and impurity systems for spintronics.