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MANY-BODY INTERACTIONS IN SOLIDS STUDIED BY HIGH-RESOLUTION ARPES USING SYNCHROTRON RADIATION

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Angle-resolved photoelectron spectroscopy (ARPES) reveals energy-band dispersions and Fermi surfaces of solids. Recently, energy and angular (momentum) resolutions of ARPES have been improved drastically, and now one can directly observe superconducting gaps or renormalization effect (or "kink") in the energy band dispersion. It is important to evaluate magnitudes of manybody interactions such as the electron-electron and electron-phonon interactions, to understand physical properties of solids.

In this talk, based on the quantitative lineshape analyses of high-resolution ARPES spectra, we discuss coupling parameters of the electron-phonon and electron-electron interactions in the surface and bulk-derived electronic states in metals (Fe, Ni, Cu, and Al) [1-4]. We also report our new ARPES measurement system to utilize linear polarization of undulator radiation. It is very effective to selectively observe the electronic states of solids depending on the symmetry with respect to the mirror planes.

High-resolution ARPES experiments with VUV and soft X-ray range ($h\nu$ = 5-30 eV and 25-300 eV) were performed on the undulator beamlines (BL-1 and BL-9A) of a compact electron-storage ring (HiSOR) at Hiroshima University [5-7]. Clean surfaces of single crystals were obtained by repeated cycles of sputtering and annealing for metal samples (Fe, Ni, Cu, Pd and Al) and by cleaving *in situ* for layered compounds. Samples were mounted on the 5 or 6 axes manipulator. Temperature was controlled from 300 K down to 8 K, using liquid He. Typical energy and momentum resolutions were ΔE = 4 meV, Δk = 0.0006 Å^{-1} at $h\nu$ ~ 10 eV, ΔE = 15 meV, Δk = 0.01 Å^{-1} at $h\nu$ ~ 40 eV.

For most of the single crystalline metals we examined (Fe, Ni, Cu, and Al), the kink structure in the energy-band dispersions was observed at the binding energy corresponding to the energy scale of the Debye temperature. We have experimentally obtained the imaginary and real parts of the self-energy due to the electron-phonon interaction. As for the maginitude of the electron-electron interaction, we have evaluated the reduction of the band width or the group velocity with respect to the theoretical one given by the band-structure calculation.

Figure 1 shows the evaluated electron-phonon and electron-electron coupling parameters (λ_{ep} and λ_{ee}). The Fermi velocity is reduced due to the many-body interactions by the renormalization factor of $Z = 1/(1+ \lambda_{ep} + \lambda_{ee})$, and the effective mass is enhanced by the factor of $Z^{-1} = 1+ \lambda_{ep} + \lambda_{ee}$. These coupling paramters are also related to the superconducting transition temperatures of solids.

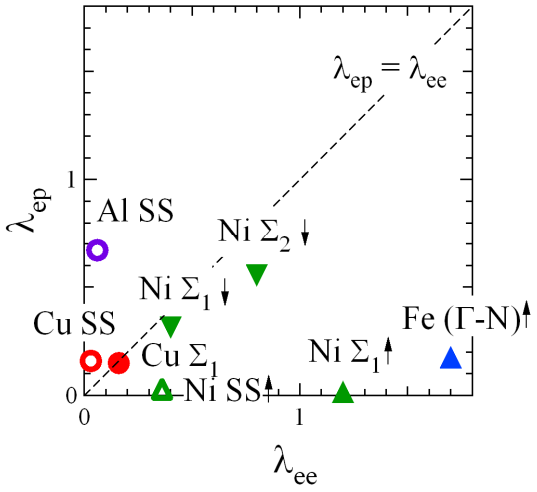

Figure 1. Evaluated coupling parameters for the electron-phonon (λ_{ep}) and electron-electron (λ_{ee}) interactions. Al SS, Cu SS and Ni SS are determined for the surface state. In the case of Fe, we determined coupling parameters along the Γ-N direction. Arrows indicate the spin direction of magnetic materials.

If several Fermi surfaces exist (multi-band systems), it is not always easy to perform detailed lineshape analyses. In order to selectively observe the Fermi surfaces or energy-band dispersions, one can utilize the dipole selection rule with a linearly polarized incident light. We have constructed new ARPES measurement system at HiSOR BL-1 which can be rotated around the light axes of linearly polarized undulator radiation. By changing the *s*- or *p*-polarization geometries, we could selectively observe the Fermi surfaces and energy-band dispersions of multi-band systems such as Pd(100), Sr_2RuO_4 and iron-based superconductors.

With tunable photon energy and tunable polarization geometries, we have more chance to quantitatively evaluate electronic structures of multi-band systems, which is very helpful to understand physical properties of novel materials.

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