Direct observation of the electron-phonon scattering in Graphite by using the angle-resolved photoelectron spectroscopy

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The electron-phonon coupling (EPC) rules many important properties of the Carbon-related nanomaterial, but the ‘direct’ observation to resolve the energy and momentum is difficult. In this report, we attempted to conduct a ‘direct’ investigation of the EPC in Graphite by using the angle-resolved photoelectron spectroscopy (ARPES). All the experiments were made at the BL7U in UVSOR-II, which enabled us to make the high-resolution (less than 10meV) ARPES measurements for an HOPG (highly oriented pyrolytic graphite) sample at 50K with tunable photon-energy. Figure 1(a) shows a series of the surface normal photoelectron spectra taken at $6 \text{ eV} \leq h\nu \leq 16 \text{ eV}$. The observed electron-emission is due to the scattering from the K-point to the $\Gamma$-point via the EPC since no direct electron-emission is expected. The energy conservation rule during the phonon-emission makes the pseudo-gap structure in the ARPES spectra near the Fermi level [Fig.1 (b,c)], and the angle-resolved measurements show the dispersions of phonons to contribute the EPC [Fig.1(d)] thanks to the momentum conservation rule. The 155 and 67 meV gaps are ascribed to the LO- and/or LA-phonon ($K_s$) and the ZA- and/or ZO- phonon ($K_o$) of Graphite, respectively. The $h\nu$-dependence in the EPC is ascribed to different final states of the photoexcitation. This demonstrates the validity of the selection rule in the phonon-assisted optical transition. Further discussions together with results of the single-crystalline Graphite will be presented.