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Direct spectroscopic evidence of spin-dependent hybridization between Rashba-split surface states and quantum-well states

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In nanometer- or atomic-scale structures, size reduction implies an increase of the surface/volume ratio and the emergence of various quantum phenomena, intimately linked to the formation of electronic states different from those of the corresponding bulk materials. Recently, there have been vigorous investigations on nanometer-thick metal films, showing the quantum size effect, and on two-dimensional surfaces with large spin-orbit interactions, exhibiting the Rashba effect. In the present study, we prepared an quantum metal Ag(111) film, covered with a Rashba-type surface alloy of √3 ×√3-Bi/Ag, to examine mixture of these two effects, especially their spin characters

Spin-polarized band structure of the system was investigated by high-resolution spin- and angle-resolved photoemission spectroscopy (SARPES) at KEK-PF BL-18A,19A. The surface state (SS) bands are spin-slit by the Rashba effect and hybridize with quantum-well states (QWS) in the film. The QWS subbands of the same spin orientation with the SS bands formed energy gap-opening, while those of the opposite orientation kept the free-electron band dispersion, as shown in Fig.1. The present results give the direct evidence of the spin-dependent hybridization between the Rashba-type SS and the QWS, demonstrating that in a non-magnetic metal film the spin-degeneracy of the valence levels can be lifted by hybridization with Rashba-type SS bands.

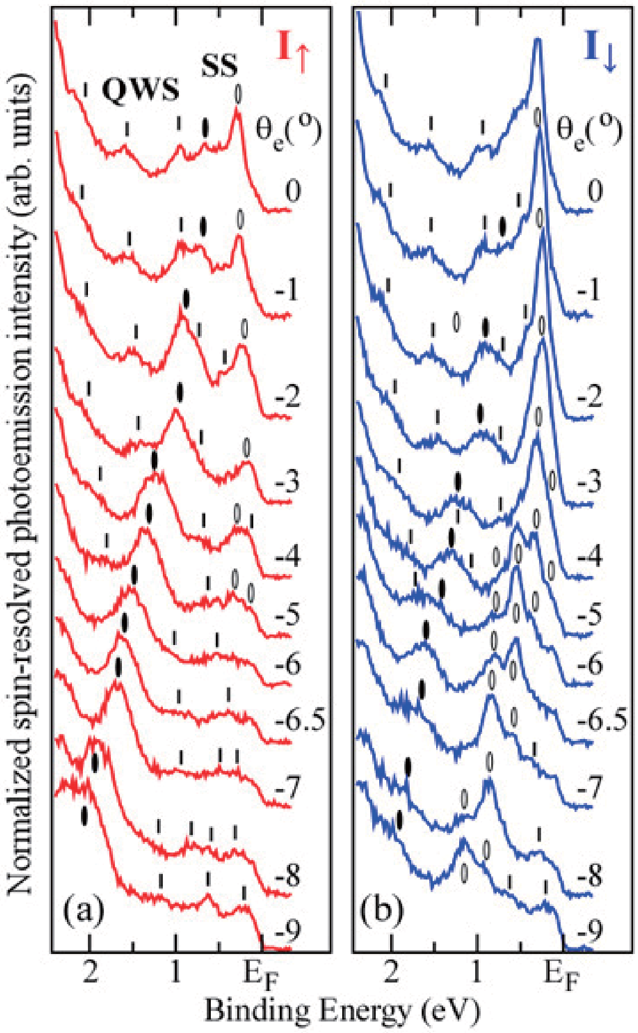

Fig. 1 SARPES spectra and band diagrams of (a) spin-up, I↑, and (b) spin-down, I↓, orientations. Dispersion of the SS and QWS bands are traced with symbols..

References

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