Giant Spin-splitting in Surface Alloys of Heavy Elements on Ag(111)

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Surface alloying is shown to produce electronic states with a very large spin-splitting. We have used angle-resolved photoemission spectroscopy (ARPES) to study the long range ordered bismuth/silver(111), antimony/silver(111), and lead/silver(111) surface alloys. Figure 1 shows the characteristic dispersion in the experimental band structure of bismuth/silver(111) near the surface Brillouin zone center, where an energy band separation of up to one eV is achieved. The virtual crystal approximation, often used to describe binary alloys, predicts a spin-splitting strength about one order of magnitude lower than what has been experimentally observed. Such strong spin-splitting enables angular resolved photoemission spectroscopy to directly observe the region close to the band edge. However, ARPES is a real-space averaging technique and only sensitive to occupied states, so for a more complete picture local detection of the spin-splitting as well as sensitivity in the unoccupied states is desirable. We show that a singularity at the band edge in the density of states induced by the characteristic "momentum shift" in the spin-split band dispersion can be observed in the local density of states measured by STS. The singularity introduces a characteristic energy, which is in direct relation to the spin-splitting and can be extracted from the experimentally determined density of states. Combining different dopant atoms, such as lead, bismuth or antimony, to form a mixed surface alloy on silver(111) the different properties of the dopant atoms can be exploited to create new structures with custom tailored spin-splitting and charge carrier densities.

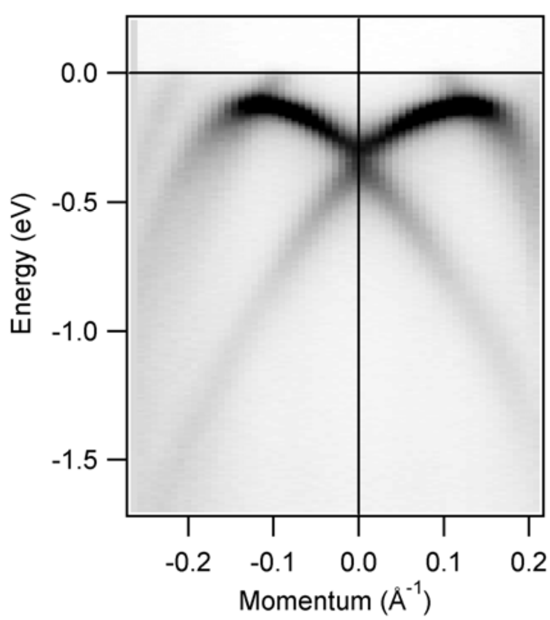

Figure 1