

Contents

1	Introduction	1
2	Theoretical background	5
2.1	The photoemission process	5
2.1.1	The free-electron final state model	7
2.2	Density functional theory and Local density approximation	9
2.3	Strongly correlated electron systems	9
2.4	Probing the spectral function $A(\vec{k},E)$ by photoemission	10
2.5	Spin-orbit coupling	15
2.5.1	Magnetic dichroism	17
2.6	Two-photon photoemission	17
2.7	Quantum well states in metallic thin films	20
3	Experimental methods	23
3.1	The momentum microscope	23
3.2	Electron spin detection principles	25
3.3	Spin-resolved photoemission measurements	26
3.3.1	Characterization of the imaging spin polarization analyzer	28
3.3.2	Evaluation of the spin polarization	30
3.3.3	Generation of an unpolarized electron image from Cu(001)	32
3.3.4	Analysis of the propagation of experimental errors	33
3.3.5	Time behaviour of the spin sensitivity of the W(100) crystal	38
3.4	Co thin films on Cu(001)	39
4	Measurements	43
4.1	Fermi surface of fct cobalt mapped by constant-initial state photoemission	43
4.1.1	Photon energy scan	43
4.1.2	Momentum distributions at discrete photon energies	47
4.2	Valence electronic structure of Co/Cu(001)	52
4.2.1	Valence electronic structure in the Γ WXK plane	52
4.2.2	Spin-resolved results	54
4.2.3	Exchange and spin-orbit contribution to the spin polarization	58
4.2.4	valence electronic structure in the WLWL plane	61
4.3	Beyond the bulk valence electronic structure	63
4.3.1	Final-state resonances	65
4.3.2	Surface resonances	65

4.4	Unoccupied electronic states probed by two-photon photoemission	66
4.4.1	Quantum well states in Co/Cu(001)	66
4.4.2	Dispersion and thickness dependence	70
4.4.3	Non-resonant two-photon processes versus one-photon processes	72
4.4.4	Spin polarization in resonant two-photon photoemission	72
4.4.5	Spin-orbit hybridization of majority and minority QWS	76
4.4.6	Conclusion	80
5	Discussion	83
5.1	The complex band structure	83
5.2	Self-energy lifetime from photoemission linewidths	87
5.3	Strong versus weak correlation	92
6	Conclusion	97
	Appendix	101
7.1	2D color code for spin-polarized images	101
7.2	Intensity asymmetries due to spin-orbit interaction	101
7.3	Asymmetry relations for off-normal photoemission (cubic (001) surface)	103
7.4	Point groups in the fcc (and fct) lattice	104
	Bibliography	107
	Publications	121
	Acknowledgements	123