Bulk and surface sensitive energy-filtered photoemission microscopy using synchrotron radiation for the study of resistive switching memories

Marten Christopher Patt
Bulk and surface sensitive energy-filtered photoemission microscopy using synchrotron radiation for the study of resistive switching memories

Marten Christopher Patt
Contents

1. Introduction

2. Fundamental aspects of energy-filtered photoemission microscopy
   2.1. Photoemission spectroscopy
       2.1.1. Penetration of the incoming photons and photo-ionization cross section
       2.1.2. The photo-excitation process
       2.1.3. Photoelectron transport to the surface and inelastic mean free path
       2.1.4. Transmission through the surface and momentum conservation
   2.2. Angular and momentum resolved photoemission
   2.3. X-ray absorption spectroscopy
   2.4. Work function
       2.4.1. Work function and contact potential
       2.4.2. Influence of an accelerating field
   2.5. Conclusions

3. Instrumental aspects
   3.1. Instrumental aspects of the NanoESCA microscope
       3.1.1. The objective
       3.1.2. The Projection column
       3.1.3. The energy filter
       3.1.4. The image detection
       3.1.5. The channeltron detection
       3.1.6. Photoemission microscopy and momentum microscopy
   3.2. Light sources
       3.2.1. UV excitation
       3.2.2. Soft X-ray and hard x-ray synchrotron sources
   3.3. Conclusions
4. Evaluation methods

4.1. Work function analysis
  4.1.1. About the nature of the work function edge
  4.1.2. Fit model for the work function edge
  4.1.3. The fitting procedure
  4.1.4. Applicability and robustness of the procedure

4.2. Principal Component Analysis

4.3. Conclusions

5. Objective lens calculations

5.1. Basic calculations
  5.1.1. Electron kinetics between sample and extractor
  5.1.2. Conversion from the electron emission angle $\alpha$ to the microscope entrance angle $\alpha'$
  5.1.3. Estimation of relativistic corrections

5.2. Acceptance angle of the objective lens
  5.2.1. Relation between contrast aperture and energy analyzer entrance slit

5.3. Transmission of the objective lens

5.4. Spatial resolution of the objective lens
  5.4.1. Spherical aberration of the accelerating field
  5.4.2. Chromatic aberration of the acceleration field
  5.4.3. Aberrations of the objective lens
  5.4.4. Diffraction at the contrast aperture
  5.4.5. The total aberration of the objective

5.5. Conclusions

6. Non-Isochromaticity of the Energy Filter

6.1. Non-Isochromaticity analysis and correction
  6.1.1. Impact of the energy shift on the intensity distribution of a photoemission image
  6.1.2. Determination of the energy shift by a work function analysis
  6.1.3. Energy shift correction of the image spectrum

6.2. Energy filter calculations
  6.2.1. The set of transfer functions to calculate the electron trajectories
  6.2.2. Calculating the electron trajectories passing the filter
  6.2.3. Analysis of the calculated trajectories
Bulk and surface sensitive energy-filtered photoemission microscopy using synchrotron radiation for the study of resistive switching memories

Marten Christopher Patt