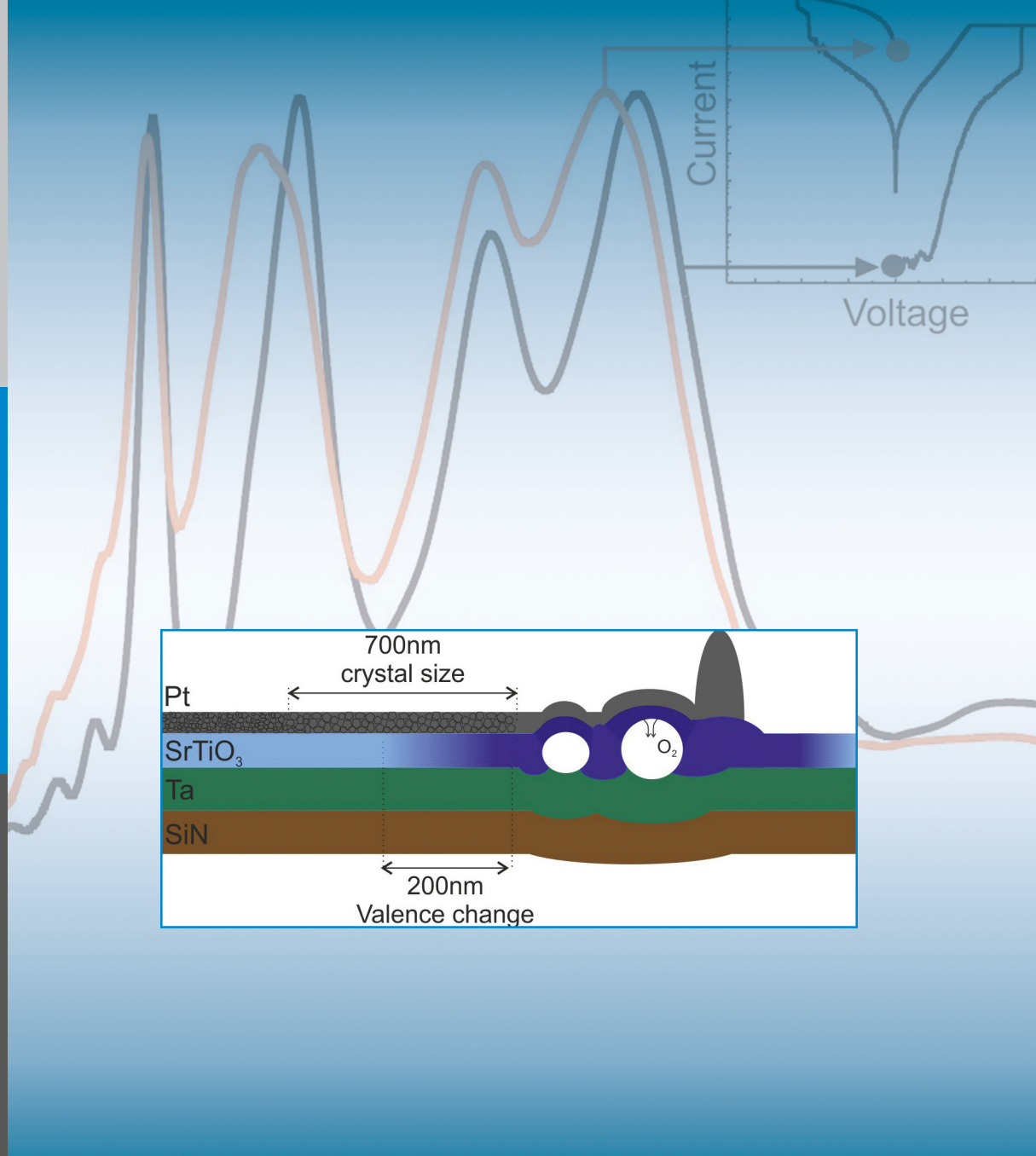




Micro-spectroscopic investigation of valence change processes in resistive switching SrTiO_3 thin films

Annemarie Köhl

Forschungszentrum Jülich GmbH
Peter Grünberg Institute (PGI)
Electronic Materials (PGI-7)

Micro-spectroscopic investigation of valence change processes in resistive switching SrTiO₃ thin films

Annemarie Köhl

Schriften des Forschungszentrums Jülich
Reihe Information / Information

Band / Volume 39

ISSN 1866-1777

ISBN 978-3-89336-988-1

Contents

1	Introduction	1
2	Background	5
2.1	Fundamentals of SrTiO_3	5
2.2	Resistive switching in SrTiO_3	9
2.3	Absorption signature of Fe:SrTiO_3	13
2.3.1	Ti L-edge	14
2.3.2	Fe L-edge	17
2.3.3	O K-edge	18
3	Experimental Techniques	21
3.1	Pulsed laser deposition (PLD)	21
3.2	Atomic force microscopy (AFM)	23
3.3	X-ray photoelectron spectroscopy (XPS)	24
3.4	X-ray absorption spectroscopy (XAS)	26
3.5	Resonant photoelectron spectroscopy (RESPES)	28
3.6	Transmission X-ray microscopy (TXM)	29
3.7	Photoemission electron microscopy (PEEM)	30
4	PLD growth and spectroscopic characterization of Fe:SrTiO_3 thin films	35
4.1	PLD growth and surface morphology	35
4.2	Film stoichiometry and electronic structure by XPS	40
4.3	Characterization of the oxidation state by XAS	47
4.3.1	Fe absorption	47
4.3.2	Ti and O absorption	58
4.4	Element specific valence band contributions by RESPES	60
4.4.1	Ti- and O-resonance	61
4.4.2	Fe-resonance	63
5	Bulk sensitive studies in transmission geometry	67
5.1	Investigation of polycrystalline samples	67
5.1.1	Sample preparation	67

5.1.2	Structural analysis by TEM	69
5.1.3	Micro-spectroscopic analysis by TXM	72
5.1.4	Summary	78
5.2	Investigation of epitaxial films	79
5.2.1	Sample preparation	79
5.2.2	Micro-spectroscopic analysis by TXM	86
5.3	Comparison of Ti L-edge line shape upon structural and electronic changes	90
6	Surface sensitive studies of the active film	93
6.1	Delamination of top electrodes	93
6.1.1	Top electrodes fabrication	93
6.1.2	In situ electrode removal with delamination chamber	96
6.1.3	Verification of electrode removal with PEEM	97
6.2	Thickness dependent switching characteristics	98
6.2.1	10 nm SrTiO ₃ film	99
6.2.2	20 nm SrTiO ₃ film	101
6.2.3	40 nm SrTiO ₃ film	102
6.2.4	Summary	103
6.3	Micro-spectroscopic analysis of 20 nm SrTiO ₃ film by PEEM	103
6.3.1	Modifications of the chemical structure of formed devices	104
6.3.2	Identification of new phase by density functional theory	108
6.3.3	Cross section analysis by TEM	111
6.3.4	Microscopic signature of ON state	114
6.4	Micro-spectroscopic analysis of 10 nm SrTiO ₃ film by PEEM	116
6.5	Micro-spectroscopic analysis of 40 nm SrTiO ₃ film by PEEM	121
6.6	Summary	124
6.7	Outlook	129
6.7.1	The role of Fe tracer in PEEM experiments	129
6.7.2	Changes in doping level determined from work function contrast	130
7	Summary and Outlook	133
A	Appendix	139
	List of abbreviations	147
	Bibliography	149

Information / Information
Band / Volume 39
ISBN 978-3-89336-988-1

