



Tailoring neuroelectronic interfaces via combinations of oxides and molecular layers

Xiaobo Yuan

Schlüsseltechnologien / Key Technologies

Band / Volume 246

ISBN 978-3-95806-572-7

Forschungszentrum Jülich GmbH
Institute of Biological Information Processing
Bioelectronics (IBI-3)

Tailoring neuroelectronic interfaces via combinations of oxides and molecular layers

Xiaobo Yuan

Schriften des Forschungszentrums Jülich
Reihe Schlüsseltechnologien / Key Technologies

Band / Volume 246

ISSN 1866-1807

ISBN 978-3-95806-572-7

CONTENTS

| | |
|---|----|
| 1. Introduction..... | 1 |
| 2. Theoretical background and state of the art..... | 5 |
| 2.1 Cell-substrate interface | 5 |
| 2.1.1 Cell-substrate adhesion..... | 6 |
| 2.2 Engineering the cell-substrate interface | 7 |
| 2.2.1 Engineering the cell-substrate interface towards biocompatibility | 7 |
| 2.2.2 Engineering the cell-substrate interface towards guided growth | 8 |
| 2.3 Surface functionalization with organic SAMs..... | 13 |
| 2.3.1 Silane SAM on oxides | 14 |
| 2.3.2 The role of the functional group | 17 |
| 2.4 Electronic cell-chip coupling..... | 19 |
| 2.4.1 Action potential and cell-electrolyte interface..... | 20 |
| 2.4.2 Electrode-electrolyte interface..... | 22 |
| 3. Sample preparation, characterization and experimental techniques | 26 |
| 3.1 Deposition techniques..... | 26 |
| 3.1.1 Molecule layer deposition..... | 26 |
| 3.1.2 Atomic layer deposition..... | 29 |
| 3.1.3 Electron beam evaporation | 31 |
| 3.2 Lithography and lift-off technique..... | 32 |
| 3.2.1 Design..... | 32 |
| 3.2.2 Lithography and lift-off..... | 33 |
| 3.2.3 Etching | 35 |
| 3.3 Characterization methods | 38 |
| 3.3.1 Ellipsometry..... | 38 |
| 3.3.2 Contact angle measurements..... | 39 |
| 3.3.3 Surface potential measurement..... | 41 |
| 3.3.4 X-ray photoelectron spectroscopy..... | 43 |
| 3.3.5 X-ray diffraction | 44 |
| 3.3.6 Scanning electron microscope..... | 45 |
| 3.3.7 Fluorescence microscopy | 46 |
| 3.4 Cell culture | 48 |
| 3.4.1 Cortical neuron culture | 48 |
| 3.4.2 HL-1 cell culture..... | 49 |
| 3.4.3 Live-dead staining..... | 49 |
| 3.4.5 Critical point drying | 50 |
| 3.5 Electrical characterization | 51 |
| 3.5.1 Multi electronic arrays..... | 51 |

| | |
|--|-----|
| 3.5.2 MEA Encapsulation..... | 52 |
| 3.5.3 BioMAS | 52 |
| 4. Results and discussion..... | 54 |
| 4.1 Vapor-phase deposition and electronic properties of APTES SAMs on SiO ₂ | 54 |
| 4.1.1 Deposition of self-assembled APTES monolayers | 55 |
| 4.1.2 Titration analysis | 61 |
| 4.1.3 Evaluation of the electrokinetic charge..... | 62 |
| 4.1.4 Conclusion | 66 |
| 4.2 Guided neurons growth on patterned functionalized oxides..... | 66 |
| 4.2.1 Functionalization of different oxides with APTES..... | 67 |
| 4.2.2 Neuronal cell growth on SiO ₂ and Ta ₂ O ₅ | 70 |
| 4.2.3 Guided cell growth on patterned oxides..... | 74 |
| 4.2.4 Conclusion | 78 |
| 4.3 Cell-chip coupling on ALD passivated MEAs..... | 80 |
| 4.3.1 Development and characterization of MEAs..... | 80 |
| 4.3.2 Cell chip coupling for the different MEAs..... | 88 |
| 4.3.3 Neuron cultures on ALD MEAs | 96 |
| 4.3.4 Conclusion | 98 |
| 5. Conclusion and outlook..... | 99 |
| References..... | 103 |
| Acknowledgements..... | 112 |

Schlüsseltechnologien / Key Technologies
Band / Volume 246
ISBN 978-3-95806-572-7