



Universiteit
Leiden
The Netherlands

Probing molecular layers with low-energy electrons

Tebyani, A.

Citation

Tebyani, A. (2024, March 14). *Probing molecular layers with low-energy electrons*. Retrieved from <https://hdl.handle.net/1887/3721791>

Version: Publisher's Version

License: [Licence agreement concerning inclusion of doctoral thesis in the Institutional Repository of the University of Leiden](#)

Downloaded from: <https://hdl.handle.net/1887/3721791>

Note: To cite this publication please use the final published version (if applicable).

Probing Molecular Layers with Low-Energy Electrons

Proefschrift

ter verkrijging van
de graad van doctor aan de Universiteit Leiden,
op gezag van rector magnificus prof.dr.ir. H. Bijl,
volgens besluit van het college voor promoties
te verdedigen op donderdag 14 maart 2024
klokke 16.15 uur

door

Arash Tebyani

geboren te Tehran, Iran

in 1990

Promotores:

Prof.dr.ir. S.J. van der Molen

Prof.dr. M.A.G.J. Orrit

Promotiecommissie:

Prof.dr. R. Coehoorn (Technische Universiteit Eindhoven)

Dr.ir. J.P. Hoogenboom (Technische Universiteit Delft)

Prof.dr. J. Aarts

Dr. T. Lamberts

Prof.dr.ir. T.H. Oosterkamp

Prof.dr. J.M. van Ruitenbeek

ISBN: 978-94-6496-069-3

An electronic version of this dissertation is available at: <https://openaccess.leidenuniv.nl>

The work presented in this dissertation was funded by the Dutch Research Council (NWO) as part of the Frontiers of Nanoscience program.

Cover illustration by Steffie Padmos, www.steffiepadmos.com

The cover depicts the experimental setup. In a Low-Energy Electron Microscope, a beam of electrons is emitted from an electron gun at the top, and is directed to the sample, i.e. molecular layers. After interaction with the sample, the reflected electrons are collected and guided to the detector at the bottom, where they form an image.

Printed by: Gildeprint – Enschede

Table of Contents

1 Introduction	1
References	7
2 Low Energy Electron Microscopy	15
2.1 Introduction	16
2.2 Imaging in LEEM	18
2.3 Bright-field and dark-field imaging	22
2.4 Photoemission	22
2.5 Sample preparation	23
2.6 LEEM-IV spectroscopy	24
2.7 Angle-Resolved Reflected-Electron Spectroscopy (ARRES)	25
2.8 Electron Energy Loss Spectroscopy (EELS)	26
References	29
3 Comparison of Pentacene Layer Growth on Graphite and hBN Flakes	35
3.1 Introduction	36
3.2 Experimental Technique	37
3.3 Results	37
3.4 Discussion	43
3.5 Conclusions	46
References	48
Supporting Information	53
4 Low-Energy Electron Irradiation Damage in Few-Monolayer Pentacene Films	57
4.1 Introduction	58
4.2 Experimental Technique	59
4.3 Results	61
4.4 Discussion	65
4.5 Conclusions	68
References	70
Supporting Information	76

5	Critical Role of Electronic States above the Vacuum Level in Photo-Electron and Secondary-Electron Emission in Few-Monolayer Pentacene Films	85
5.1	Introduction	86
5.2	Experimental Technique	87
5.3	Results and Discussion	88
5.4	Conclusions	94
	References	95
	Supporting Information	100
6	Band Structure of Few-Monolayer Pentacene Films Above the Vacuum Level	105
6.1	Introduction	106
6.2	Experimental Technique and Results	106
6.3	Conclusions	117
	References	118
7	Low Energy Electron Microscopy at Cryogenic Temperatures	121
7.1	Introduction	122
7.2	Experimental Technique	123
7.3	Results and Discussion	128
7.4	Conclusions	133
	References	134
	Summary	141
	Samenvatting	145
	Curriculum Vitae	151
	List of Publications	153
	Acknowledgments	155

