Probing molecular layers with low-energy electrons

Tebyani, A.

Curriculum Vitae

Arash Tebyani

I was born in September 1990 in Tehran, Iran. I obtained my bachelor's degree in "Electrical Engineering – Electronics" at Amirkabir University of Technology in Tehran. Afterwards, I continued my studies in the "Nanoscience" master's program of the Zernike Institute for Advanced Materials at University of Groningen. I carried out my research project in the "Nanostructures of Functional Oxides" group under the supervision of Prof. Beatriz Noheda, studying the deposition of ferroelectric thin films, with the goal of investigating the effects of growth parameters and post-deposition treatments on the domain structure and the properties of the films. In June 2018, I joined the group of Prof. Sense Jan van der Molen at Leiden University for my PhD. I studied the growth and electronic properties of few-monolayer molecular films primarily using the technique "Low Energy Electron Microscopy". In October 2022, I joined the group of Prof. Michel Orrit at Leiden University to study the fluorescence of individual molecules adsorbed on surfaces at cryogenic temperatures.

List of Publications

1. **A. Tebyani**, R.M. Tromp, S.J. van der Molen, *"Critical Role of Electronic States above the Vacuum Level in Photo-Electron and Secondary-Electron Emission in Few-Monolayer Pentacene Films"*, Phys. Rev. B 108, 045425 (2023)

2. **A. Tebyani**, S. Schramm, M. Hesselberth, D. Boltje, J. Jobst, R.M. Tromp, S.J. van der Molen, *"Low Energy Electron Microscopy at Cryogenic Temperatures"*, Ultramicroscopy 253, 113815 (2023)

3. **A. Tebyani**, F.B. Baalbergen, R.M. Tromp, S.J. van der Molen *"Low-Energy Electron Irradiation Damage in Few-Monolayer Pentacene Films"*, J. Phys. Chem. C 125, 26150 (2021)

4. **A. Tebyani**, R.M. Tromp, S.J. van der Molen, *"Comparison of Pentacene Layer Growth on Graphite and hBN Flakes"*, Submitted for Publication

5. R. Smit, **A. Tebyani**, J. Hameury, S.J. van der Molen, M. Orrit, *"Sharp zero-phonon lines of single organic molecules on a hexagonal boron-nitride surface"*, Nat. Commun. 14, 7960 (2023)

Acknowledgments

The work presented in this dissertation would not have been possible without the generous support and contributions of many others in the institute. Here, I would like to take the opportunity to express my gratitude.

First, I would like to thank my supervisor, Prof. Sense Jan van der Molen, for offering me this position and welcoming me in the group. You were always available for discussions, knowledgeable and showed great interest in my work. In addition, I'm grateful for the freedom and flexibility you offered me regarding managing the project, and being open to new experiment ideas. I'm thankful for your guidance and support throughout the project.

Next, I want to thank Prof. Ruud Tromp. Our regular discussions about the experiments, and your immense knowledge about LEEM were invaluable in understanding the results and planning the experiments.

I would also like to thank my second promotor, Prof. Michel Orrit. Although we didn't eventually carry out the combined LEEM-fluorescence charge transport experiments that were initially planned, I enjoyed our discussions during my PhD, one of which resulted in the project on terrylene/hBN fluorescence. I would also like to thank you for offering me a position to work on that project after my PhD.

Next, I want to thank Marcel Hesselberth. I'm grateful for your technical support and help in setting up new experiments with LEEM. I especially enjoyed working together in the final stages of the development and the first measurements in the cryogenic chamber. I'm also thankful to Ruud van Egmond for technical support regarding LEEM hardware parts. I thank Federica Galli for her support regarding AFM measurements, Douwe Scholma for his technical support with cleanroom and annealing setups, Peter van Veldhuizen and Raymond Koehler from the electronics department, Martijn Witlox from the fine mechanical department, and Wilfred van der Geest from the cryogenics department. I'm also grateful for the administrative support from Ellie van Rijsewijk, Michelle Wijfje, Marije Boonstra and Henriette van Leeuwen.

I thank Dr. Johannes Jobst for supervision of the initial part of the project, and help regarding measuring with LEEM as well as the first pentacene experiments. I'm also grateful to my PhD colleagues for their help regarding scientific experiments, as well as general discussions and enjoyable company throughout the years, in particular, I would like to thank Peter Neu,

Norman Blümel, Jedrzej Tepper, Guido Stam, Amin Moradi, Junxiang Yao, and Robert Smit. I wish you success in your research.

During my PhD, I had the pleasure to work closely with several students as their supervisor. Emile Ankoné, the results of your work on the electron gun emission project, specifically the implementation of imaging with reduced beam currents, proved very useful during many of my later experiments. Erik Baalbergen, your work on the analysis of electron beam irradiation damage in pentacene films was very fruitful. I'm glad we published that work together. Auke Vlasblom, I'm glad you decided to come to Leiden from Utrecht for your research project to work on charge transport through pentacene layers. In the end, we successfully performed potentiometry measurements, although not on hBN substrates. We also observed some unexpected field-effect phenomena. Tomas Osterholt, we worked further on pentacene transport measurements, and solved some of the remaining obstacles, although the pentacene growth still remained challenging. I was impressed by the quality of your work in parallel on the theory and simulation of mapping potential drop during charge transport. Leander Kalff, we performed experiments on electron transmission through pentacene layers together with Peter. You prepared several high-quality samples, and the results of your analysis on the mean free path through the layers were insightful. I wish you all success in your PhDs and future careers.

I also want to thank Prof. Björn Baumeier and Ruben Gerritsen at Eindhoven University of Technology. I enjoyed our collaboration on the electronic band structure of pentacene layers, and appreciate your efforts in calculating the band structure with different methods.

Finally, I would like to thank my family. I'm immensely grateful for all your support and encouragement throughout my education.