eV-TEM: transmission electron microscopy with few-eV electrons

Geelen, D.

List of Publications

1. Geelen D. & Löffler W. Walsh modes and radial quantum correlations of spatially entangled photons. *Optics Letters* **38,** 4108 (2013).
2. Thete A., Geelen D., Wuister S., van der Molen S. J. & Tromp R. M. Low-energy electron (0-100eV) interaction with resists using LEEM. *Proc.SPIE* **9422,** Extreme Ultraviolet (EUV) Lithography VI (2015).
3. Geelen D., Thete A., Schaff O., Kaiser A., van der Molen S. J. & Tromp R. M. eV-TEM: Transmission electron microscopy in a low energy cathode lens instrument. *Ultramicroscopy* **159,** 482–487 (2015).
4. Jobst J., Kautz J., Geelen D., Tromp R. M. & van der Molen S. J. Nanoscale measurements of unoccupied band dispersion in few-layer graphene. *Nature Communications* **6,** 8926 (2015).
5. Thete A., Geelen D., van der Molen S. J. & Tromp R. M. Charge Catastrophe and Dielectric Breakdown During Exposure of Organic Thin Films to Low-Energy Electron Radiation. *Physical Review Letters* **119,** 266803 (2017).

Curriculum vitæ

I was born on 21 August 1988 in Rotterdam. I grew up in Berkel en Rodenrijs. After completing my secondary school (VWO NG/NT) at Caland Lyceum (later renamed to Wolfert Dalton) in 2006, I started studying physics at Leiden University. I wrote my thesis under supervision of Marcel Rost and Joost Frenken on the behaviour of a stick-slip motor. I obtained my BSc degree in 2009.

Subsequently, I started the research MSc program, also at Leiden University. I did a research project on rearrangements in two-dimensional foams under supervision of Martin van Hecke, a project on detecting correlations of high-dimensional spatially-entangled photons using phase-only modulation under supervision of Wolfgang Löffler, and I did a project outside university, at cosine measurement systems in Leiden. Here I wrote a thesis named "X-Ray Shadowgram Counting Analysis", under supervision of Marcelo Ackermann and Marco Beijersbergen. During my masters, I also spent time on extra-curricular activities: I was a volunteer at Rino, an outreach project with physics shows at high schools, I gave tours at Teylers Museum in Haarlem, and I was student ambassador for the Leiden University physics bachelor and masters. I received my MSc degree in 2012.

Following this, I stayed at cosine as junior scientist. I worked on a hyperspectral imaging system and was tasked to develop applications with an emphasis on food. Among these was a fish-freshness determination system which led to the Herman Wijffels Innovatieprijs 2014.

Afterwards, I joined Sense Jan van der Molen and Ruud Tromp for my PhD, at LION Leiden University in 2013, to develop eV-TEM. My teaching duty consisted of the optics course.

Currently, I work as scientist for Condi food where I develop non-destructive food inspection systems. Condi food was the food division of cosine that has now split off as a daughter company.

Acknowledgements

Ever since I was a little boy, I have been fascinated by nature, science, and technology. I would therefore like to express my gratitude to Sense Jan van der Molen and Ruud Tromp, my supervisors, for giving me the opportunity to do research with them. I want to thank them for their involvement, patience, help, and for sharing their expertise. This allowed me to become a more skilled physicist.

Most of the time I worked with my direct colleagues, the LEEMers. There has always been a very friendly atmosphere in the group. When my setup, once again, only started to work at the very end of my measurement campaign, you were always prepared to give up some of your own LEEM time to let me finish the experiment. This has been of great help, thank you. Special thanks to Marcel Hesselberth for sharing his incredible technical expertise. I always enjoyed working with you, especially during the maintenance weeks. I also want to thank the other members of the Van der Molen group: Sander Blok for the fruitful discussions and Huseyin Atesci for his help with AFM.

The development of the low-energy electron source was a very important part of this project. I would therefore like to thank Ruud van Egmond and his colleagues at the department of fine mechanics (FMD) for always coming up with smart ways to make the tiny eV-TEM components. Also thanks to Raymond Koehler and Bert Crama from the electronics department (ELD) for realizing the eV-TEM electronics. This project would not have been possible without the support of Oliver Schaff and Alexander Kaiser from SPECS GmbH. Grégory Schneider, Liuba Belyaeva, Casper Remeijer, Kirsten Martens, and Aniket Thete have been of great help with sample preparation.

I want to thank my other lab mates and friends for the very nice time during my PhD: Sasha Vrbica, Gesa Welker, Bob van Waarde, Marc de Voogd, Flavio Mariani, Yasmine Sfendla. Kaveh Lahabi for keeping me up and sane when we were pulling one of our many all-nighters, Benny van Zuiden for the staircase workouts and the Latex support, and of course Chris Smiet for always being there for me as a true friend.

Finally, I want to thank my family for always believing in me and standing up for me. Their support allowed me to come where I am now and do something I really love.