Optical manipulation and study of single gold nanoparticles in solution

Ruijgrok, P.V.

Curriculum Vitae

of Paul Victor Ruijgrok, born in Ubbergen (The Netherlands) on February 8, 1981.

From 1995 to 1999 I obtained my secondary education at the Karel de Grote College in Nijmegen. In 2000 I obtained my pre-university degree from the Regionaal Opleidingen Centrum (ROC) in Nijmegen. After a year of traveling and voluntary work in South-East Asia, I started the study of Aerospace Engineering at Delft University of Technology in September 2001. After one year, I switched fields and enrolled at Leiden University to study physics. At the end of my Bachelor studies I performed a junior research project in the group of Prof. Joost W. M. Frenken; I conducted an analysis of the role of surface stress on the thermal stability of vacancy islands on a metal surface, based on scanning tunneling microscopy measurements on Cu [1 0 0]. I obtained my Bachelor degree in Physics in February 2006.

During my MSc study at Leiden University, I was selected to attend the CERN summer student program on elementary particle physics in 2006 in Geneva (Switzerland). In Leiden, I did a MSc project in the group of Prof. Michel Orrit, where I used an ultra-fast optical pump-probe technique to study the melting transition of single gold nanoparticles. I also carried out a MSc project in the group of Prof. Vahid Sandoghdar at the Eidgenössische Technische Hochschule (ETH) in Zürich (Switzerland), where I measured the fluorescence decay rate of nitrogen-vacancy centers in single diamond nanocrystals to probe the local photonic structure in strongly scattering random media. In December 2007 I obtained my MSc diploma in Physics with distinction (cum laude) at Leiden University. In January and February 2008 I worked at the ETH Zürich to continue the work of my MSc research project theme.

In March 2008 I started a PhD project at the Leiden Institute of Physics

in the group of Prof. Michel Orrit, on the optical trapping of single gold nanoparticles. The results obtained during the following four years are described in this thesis. During the PhD project, I contributed to the teaching at the Physics Department by assisting with the first year Physics laboratory course and with a first year course on Optics. I also supervised a MSc student project, organized the regular bi-weekly seminars of the Biological and Molecular Physics section, and was a member of the Institute council. I presented my work at several summer schools and international conferences. For the poster presentation at the Nanometa conference on Nanophotonics and Metamaterials in Seefeld (Austria) in 2011 I received a best poster prize.

From June 2012 onward, I will work as a postdoctoral researcher in the group of Prof. Zev Bryant at Stanford University in the United States of America.

List of Publications

1. A. L. Tchebotareva, M. A. van Dijk, P. V. Ruijgrok, V. Fokkema, M. H. S.Hesselberth, M. Lippitz, and M. Orrit, "Acoustic and Optical Modes of Single Dumbbells of Gold Nanoparticles", Chem. Phys. Chem. **10**, 111–114 (2009).

2. P. V. Ruijgrok, R. Wüest, A. A. Rebane, A. Renn, and V. Sandoghdar, "Spontaneous emission of a nanoscopic emitter in a strongly scattering disordered medium", Opt. Express **18**, 6360–6365 (2010).

3. A. L. Tchebotareva, P. V. Ruijgrok, P. Zijlstra, and M. Orrit, "Probing the acoustic vibrations of single metal nanoparticles by ultrashort laser pulses", Laser Photonics Rev. **4**, 581–597 (2010).

4. A. Gaiduk, P. V. Ruijgrok, M. Yorulmaz and M. Orrit, "Detection limits in photothermal microscopy", Chem. Sci. **1**, 343-350 (2010). *Chapter 2 of this thesis*

5. A. Gaiduk, M. Yorulmaz, P. V. Ruijgrok and M. Orrit, "Room-temperature detection of a single molecule's absorption by photothermal contrast", Science **330**, 353–356 (2010).

6. A. Gaiduk, P. V. Ruijgrok, M. Yorulmaz, and M. Orrit,
"Making gold nanoparticles fluorescent for simultaneous absorption and fluorescence detection on the single particle level",
Phys. Chem. Chem. Phys. **13**, 149-153 (2011).

7. P. V. Ruijgrok, N. R. Verhart, P. Zijlstra, A. L. Tchebotareva and M. Orrit,
"Brownian fluctuations and heating of an optically aligned gold nanorod",
Phys. Rev. Lett. **107**, 037401 (2011).
Chapter 4 of this thesis

8. P. V. Ruijgrok, P. Zijlstra, A. L. Tchebotareva and M. Orrit,
"Damping of acoustic vibrations of single gold nanoparticles optically trapped in water",
Nano Lett. **12**, 1063–1069 (2012).
Chapter 6 of this thesis

9. P. V. Ruijgrok, et al. ,
"Optical trapping of single gold nanorods: manipulating forces, torques and heat on the nanoscale",
in preparation for publication,
based on Chapter 3 of this thesis.

10. P. V. Ruijgrok, et al.,
"On the temperature dependence of the plasmon width and its use to measure the temperature of a single gold nanoparticle",
in preparation for publication,
based on Chapter 5 of this thesis.

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During my PhD I have had the pleasure of working together with three postdoctoral researchers, dr. Anna L. Tchebotareva, dr. Alexander Gaiduk and dr. Peter Zijlstra. They have contributed greatly to shaping this thesis. I thank Prof. Lene B. Oddershede for a very valuable visit to her lab in Kopenhagen at the start of the PhD project, and her continued support and advice. I am indebted to Nico Verhart, whose work during his MSc project has greatly contributed to Chapter 4.