



## UvA-DARE (Digital Academic Repository)

### Glow with the flow: Quantifying blood flow and photoluminescence signal in biological tissue

Nadort, A.

**Publication date**

2015

**Document Version**

Final published version

[Link to publication](#)

**Citation for published version (APA):**

Nadort, A. (2015). *Glow with the flow: Quantifying blood flow and photoluminescence signal in biological tissue*.

**General rights**

It is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), other than for strictly personal, individual use, unless the work is under an open content license (like Creative Commons).

**Disclaimer/Complaints regulations**

If you believe that digital publication of certain material infringes any of your rights or (privacy) interests, please let the Library know, stating your reasons. In case of a legitimate complaint, the Library will make the material inaccessible and/or remove it from the website. Please Ask the Library: <https://uba.uva.nl/en/contact>, or a letter to: Library of the University of Amsterdam, Secretariat, Singel 425, 1012 WP Amsterdam, The Netherlands. You will be contacted as soon as possible.

GLOW WITH THE FLOW

Glow With The Flow.

A thesis that contributes to the development of optical techniques to assess microcirculation functionality for the diagnosis, monitoring, therapy guidance and understanding of many diseases ranging from the onset of septic shock to the delivery of drugs to tumours. The first part of this thesis aims to develop a non-invasive technique to quantify microcirculatory blood flow velocity based on laser speckle flowmetry. The second part is devoted to the quantification of optical signals arising from photoluminescent upconversion nanoparticles for sensitive detection in biomedical tissues.

The combination of these techniques is particularly useful in the context of tumour therapy by providing information on tumour angiogenesis, enabling molecular contrast and delivering nanoparticle-based drugs.

GLOW WITH THE FLOW

Quantifying Blood Flow and Photoluminescence Signal in Biological Tissue

Annemarie Nadort

GLOW WITH THE FLOW

Quantifying Blood Flow and Photoluminescence Signal in Biological Tissue

Annemarie Nadort

Annemarie Nadort

GLOW WITH THE FLOW: QUANTIFYING BLOOD FLOW  
AND PHOTOLUMINESCENCE SIGNAL IN BIOLOGICAL TISSUE

Annemarie Nadort

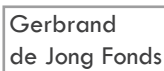
---

Glow with the flow: Quantifying blood flow and photoluminescence signal in biological tissue  
PhD thesis, University of Amsterdam, The Netherlands

The research in this thesis was funded by:



The public defence ceremony and printing of this thesis were kindly sponsored by:



**Author:** Annemarie Nadort  
**ISBN:** 978-94-6182-546-9  
**Printing:** Off-page, [www.offpage.nl](http://www.offpage.nl)  
**Cover design:** **CAPITAL T**  
Tim Casey, [CapitalT.net](http://CapitalT.net)

Copyright 2015 © Annemarie Nadort, Amsterdam, The Netherlands. All rights reserved.  
No part of this publication may be reproduced, stored in a retrieval system, or transmitted  
in any form or by any means, electronic, mechanical, photocopying, recording or otherwise,  
without the prior permission of the copyright owner.

---

GLOW WITH THE FLOW: QUANTIFYING BLOOD FLOW  
AND PHOTOLUMINESCENCE SIGNAL IN BIOLOGICAL TISSUE

ACADEMISCH PROEFSCHRIFT

ter verkrijging van de graad van doctor  
aan de Universiteit van Amsterdam  
op gezag van de Rector Magnificus  
prof. dr. D.C. van den Boom

ten overstaan van een door het College voor Promoties ingestelde  
commissie, in het openbaar te verdedigen in de Agnietenkapel  
op woensdag 1 april 2015, te 14:00 uur

door

Annemarie Nadort

geboren te Zaanstad

## PROMOTIECOMMISSIE

Promotores:	prof. dr. A.G.J.M. van Leeuwen prof. dr. M.C.G. Aalders	Universiteit van Amsterdam Universiteit van Amsterdam
Co-promotor:	dr. ir. D.J. Faber	Universiteit van Amsterdam
Overige leden:	prof. dr. E.T. van Bavel prof. dr. W.J. Buma prof. dr. H.J.C.M. Sterenborg prof. dr. ir. W. Steenbergen dr. E.G. Mik	Universiteit van Amsterdam Universiteit van Amsterdam Erasmus Universiteit Rotterdam Universiteit Twente Erasmus MC

Faculteit der Geneeskunde

## TABLE OF CONTENTS

Chapter 1	Introduction	7
Chapter 2	Laser speckle contrast imaging	25
Chapter 3	Quantitative laser speckle flowmetry of the <i>in vivo</i> microcirculation using sidestream dark field microscopy	37
Chapter 4	Quantitative blood flow velocity imaging using laser speckle flowmetry	57
Chapter 5	Upconversion nanoparticles	91
Chapter 6	Quantitative imaging of single upconversion nanoparticles in biological tissue	103
Chapter 7	Feasibility study of the optical imaging of a breast cancer lesion labeled with upconversion nanoparticle biocomplexes	133
Chapter 8	Discussion and conclusion	155
Chapter 9	Outlook	173
Appendices	List of abbreviations	181
	List of symbols	182
	Samenvatting van het proefschrift	185
	Thesis summary	191
	List of publications	197
	Portfolio	200
	Curriculum vitae	203
Acknowledgments	205	