Plasmonic enhancement of single-molecule fluorescence under one- and two-photon excitation
Lu, X.

Citation

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/1887/3245677

Note: To cite this publication please use the final published version (if applicable).
Plasmonic Enhancement of Single-Molecule Fluorescence under One- and Two-Photon Excitation

Proefschrift

ter verkrijging van
 deed 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 woensdag 08 december 2021
klokke 11.15 uur

doors

Xuxing Lu

geboren te Fujian, China
in 1983
Front & Back: The color stripes are the analogs of the single-molecule spectra from infrared dye under one-photon (red) and two-photon (blue) excitation. The graphics was modified from the art by Jorch (kde store).

Copyright © 2021 by X. Lu
Casimir PhD Series, Delft-Leiden 2021-44
An electronic version of this dissertation is available at
http://openaccess.leidenuniv.nl/.

The present work is financially supported by the Netherlands Organization for Scientific Research (NWO). The author acknowledges a Ph.D. grant from the China Scholarship Council.
# Contents

1 Introduction ........................................... 1
   1.1 Surface plasmon resonance of gold nanoparticles .................. 3
   1.2 Fluorescence and fluorescence enhancement .......................... 7
   1.3 Outline of the thesis ..................................... 10
References .................................................. 11

2 Theoretical investigations of the single-molecule fluorescence enhancements ..... 17
   2.1 Introduction ........................................... 18
   2.2 Theoretical framework ..................................... 18
   2.3 Results and discussion ..................................... 21
   2.4 Conclusions .............................................. 33
References .................................................. 33

3 Quantum yield limits for the detection of single-molecule fluorescence ... 37
   3.1 Introduction ........................................... 38
   3.2 Results and discussion ..................................... 39
   S3.1 Supporting information .................................... 48
      S3.1.1 Experimental Details .................................. 48
      S3.1.2 Theoretical Framework ................................. 59
References .................................................. 66

4 Controlled synthesis of gold nanorod dimers with end-to-end configurations 71
   4.1 Introduction ........................................... 72
   4.2 Materials and Method ...................................... 73
      4.2.1 Materials ............................................ 73
      4.2.2 Methods .............................................. 73
   4.3 Results and discussion ..................................... 76
   4.4 Conclusions .............................................. 81
   S4.1 Supporting information .................................... 82
References .................................................. 90

5 Two-photon-excited single-molecule fluorescence enhanced by gold nanorod dimers 95
   5.1 Introduction ........................................... 96
   5.2 Results and discussion ..................................... 97
   5.3 Conclusion .............................................. 104
   S5.1 Supporting Information .................................... 104
References .................................................. 108
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 Summary</td>
<td>113</td>
</tr>
<tr>
<td>Samenvatting</td>
<td>117</td>
</tr>
<tr>
<td>Curriculum Vitae</td>
<td>121</td>
</tr>
<tr>
<td>List of Publications</td>
<td>123</td>
</tr>
<tr>
<td>Acknowledgements</td>
<td>125</td>
</tr>
</tbody>
</table>