Plasmonic Zero Mode Waveguide for enhanced confined fluorescence emission

Paolo Ponzellini[1¥]
Xavier Zambrana-Puyalto[1¥], Nicolò Maccaferri[1], Luca Lanzanò[1], Francesco De Angelis[1] and Denis Garoli[1*]

[1] Istituto Italiano di Tecnologia, via Morego 16, Genova, Italy
[¥] These authors contributed equally

Denis.garoli@iit.it

Single-molecule fluorescence[1] has been successfully applied to many fields in biomedicines, including DNA sequencing,[2,3] diagnostics, and molecular biology. One of the most used platforms for single molecule sequencing is based on zero-mode waveguides (ZMWs). A ZMW reduces the detection volume by 3 to 6 orders of magnitude, with respect to a standard confocal microscope, allowing for single-molecule detection. Nevertheless, in ZMW the emitted fluorescence is not enhanced. In contrast, optical nanoantennas fabricated on Ag or Au films are known to provide field and fluorescence enhancement (FE), thanks to plasmonic effects.

Inspired by the theoretical work by Zhao and co-workers[4], we have fabricated a bilayer, Au-Al plasmonic rectangular nanoslot (Fig. 1a,b) that provides the tiny detection volume of a ZMW, but with a 20 fold fluorescence enhancement[5]. These features allowed us to perfom single-molecule fluorescence detection.

Here we report on the performed simulations, on the encountered fabrication challenges, and on the gathered experimental fluorescence correlation spectra measurements.

References

[1] M. Wanunu, T. Dadosh, V. Ray et al. *Nat. Nanotechnol.*, 2010, **5**, 807–814.
[2] J. Eid, A. Fehr, J. Gray et al. *Science (80-.).*, 2009, **323**, 133–138.
[3] S. Uemura, C. E. Aitken, J. Korlach et al. *Nature*, 2010, **464**, 1012–1017.
[4] C. Zhao, Y. Liu, J. Yang et al. *Nanoscale*, 2014, **6**, 9103–9109.
[5] P.Ponzellini, X. Zambrana, N.Maccaferri et al. Submitted to Nanoscale, 2018.

Figures

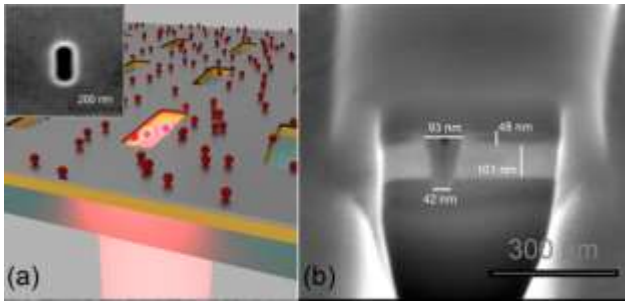

Figure 1. SEM images of the fabricated structures. (a) Schematic illustration of the Au-Al nanoslots; **Inset**: SEM micrograph of a fabricated nanoslot; (b) Au-Al nanoslot, cross section. A 101 nm gold layer and a 48 nm aluminum layer are visible. A platinum layer is visible on top, deposited to improve the cross section cut.

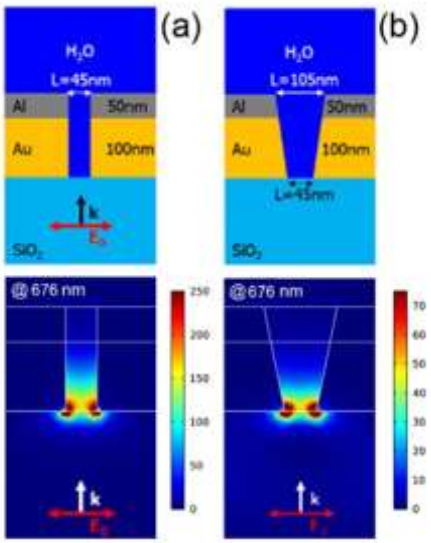

Figure 2. **Top**: ketch of a section of the ideal (a) and fabricated (b) rectangular Au-Al nanoslot. **Bottom**: near-field distributions of the ideal (a) and fabricated (b) Au-Al nanoslot at the experimental excitation wavelength (676 nm). The section planes of the rectangular antennas are parallel to the short axis.