INTEGRATED SPECTROSCOPIC SETUP WITH PLASMONIC NANO STRUCTURES FOR THE ENHANCEMENT OF FLUORESCENCE AND RAMAN SENSING

Badrul Alam (1), Francesca Grossi (1), Antonio Ferraro (2), Roberto Caputo (2), and Rita Asquini* (1)

SAPIENZA UNIVERSITÀ DI ROMA

UNIVERSITÀ DELLA CALABRIA

(1) Department of Information Engineering, Electronics and Telecommunications, University of Rome "La Sapienza", via Eudossiana 18, 00184 Rome, Italy

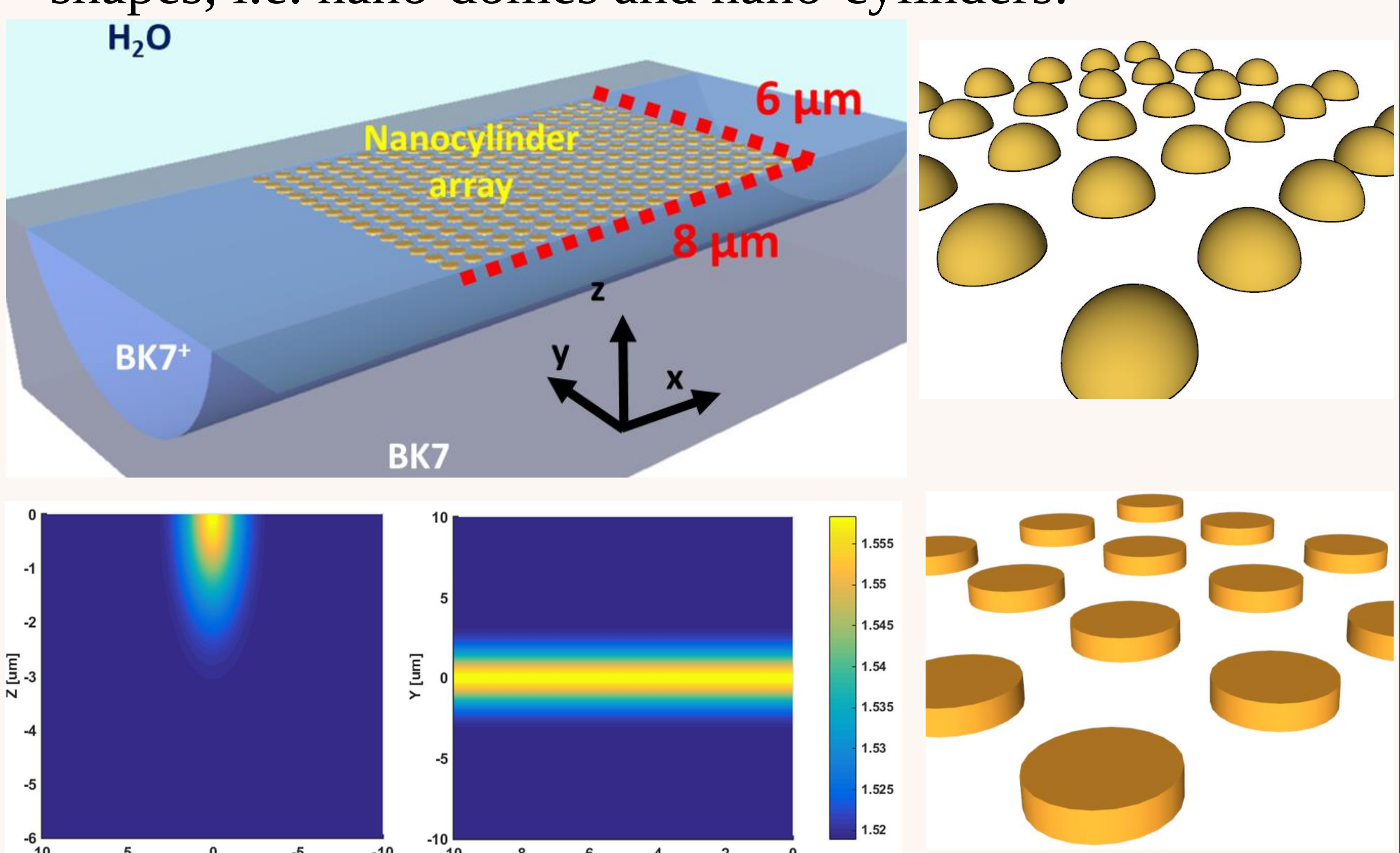
(2) Department of Physics, University of Calabria, Via Pietro Bucci 31c, 87036 Cosenza, Italy

** Corresponding author: rita.asquini@uniroma1.it*

EMPhASys Laboratory

Goal

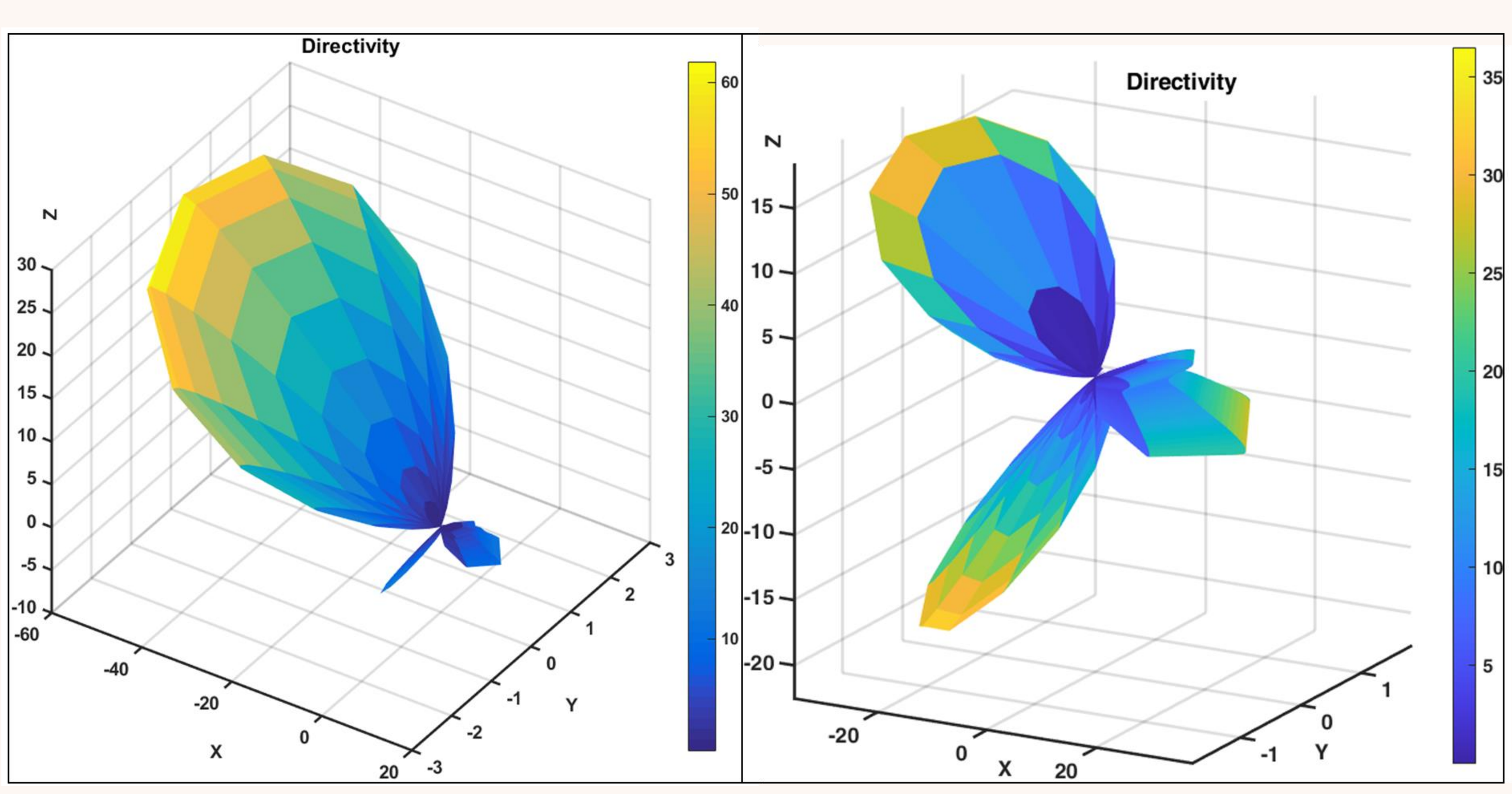
Development of a high sensibility sensor through an integrated optical setup for fluorescence and Raman spectroscopy. It is based on an ion-exchanged waveguide on glass substrate (BK7), combined with a periodic array of metallic nano-structures of various shapes, i.e. nano-domes and nano-cylinders.



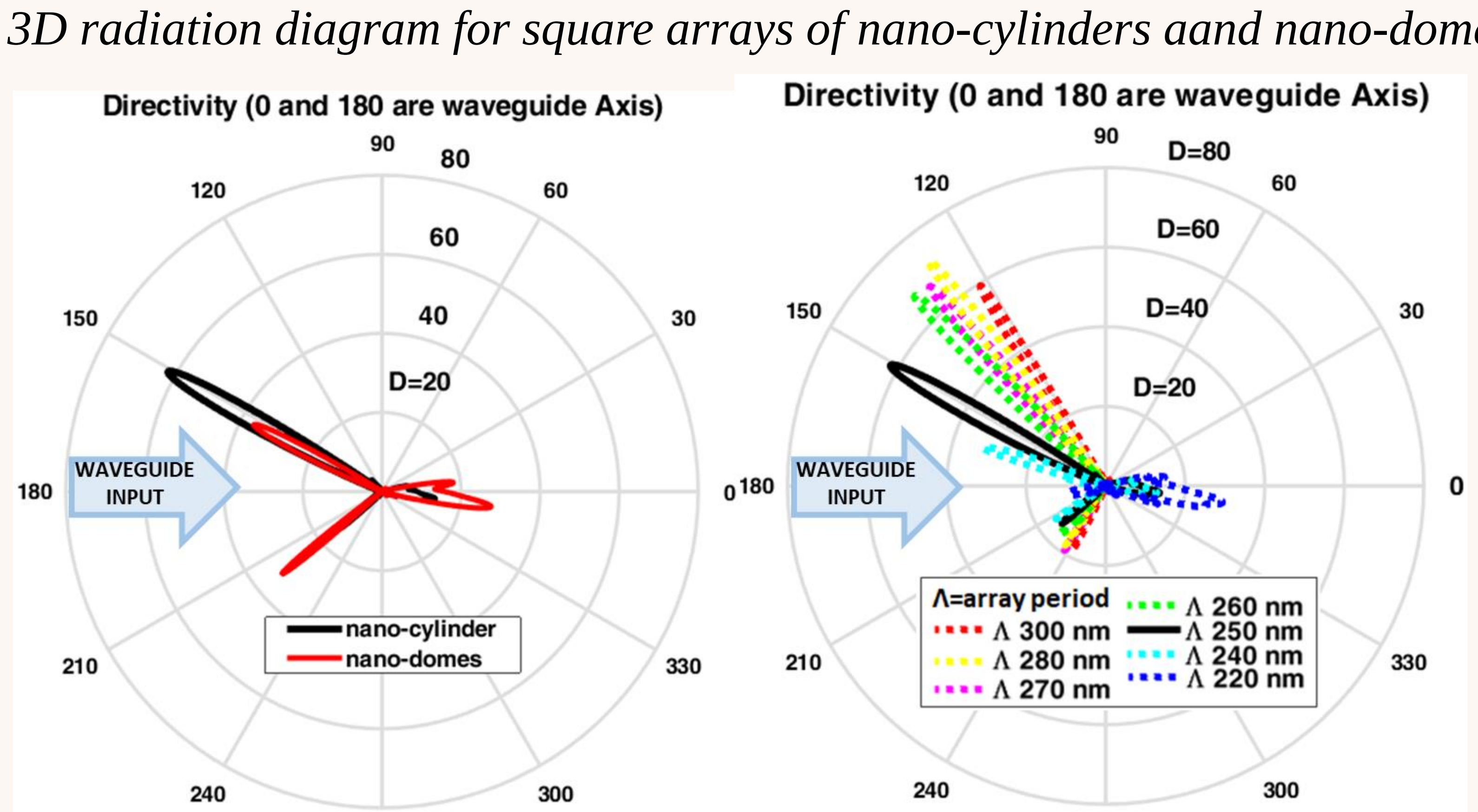
Schematic of the main characteristics of the systems: an ion- exchanged waveguide in a glass (BK7) substrate, and two different types of nanostructures

Beam control through periodic array

Various parameters of the periodic nano-arrays can be tuned to control beam far-field characteristics. In particular, array period is decisive to impose a preferential direction. The main lobes' direction is almost indifferent to the nanostructures' profile.



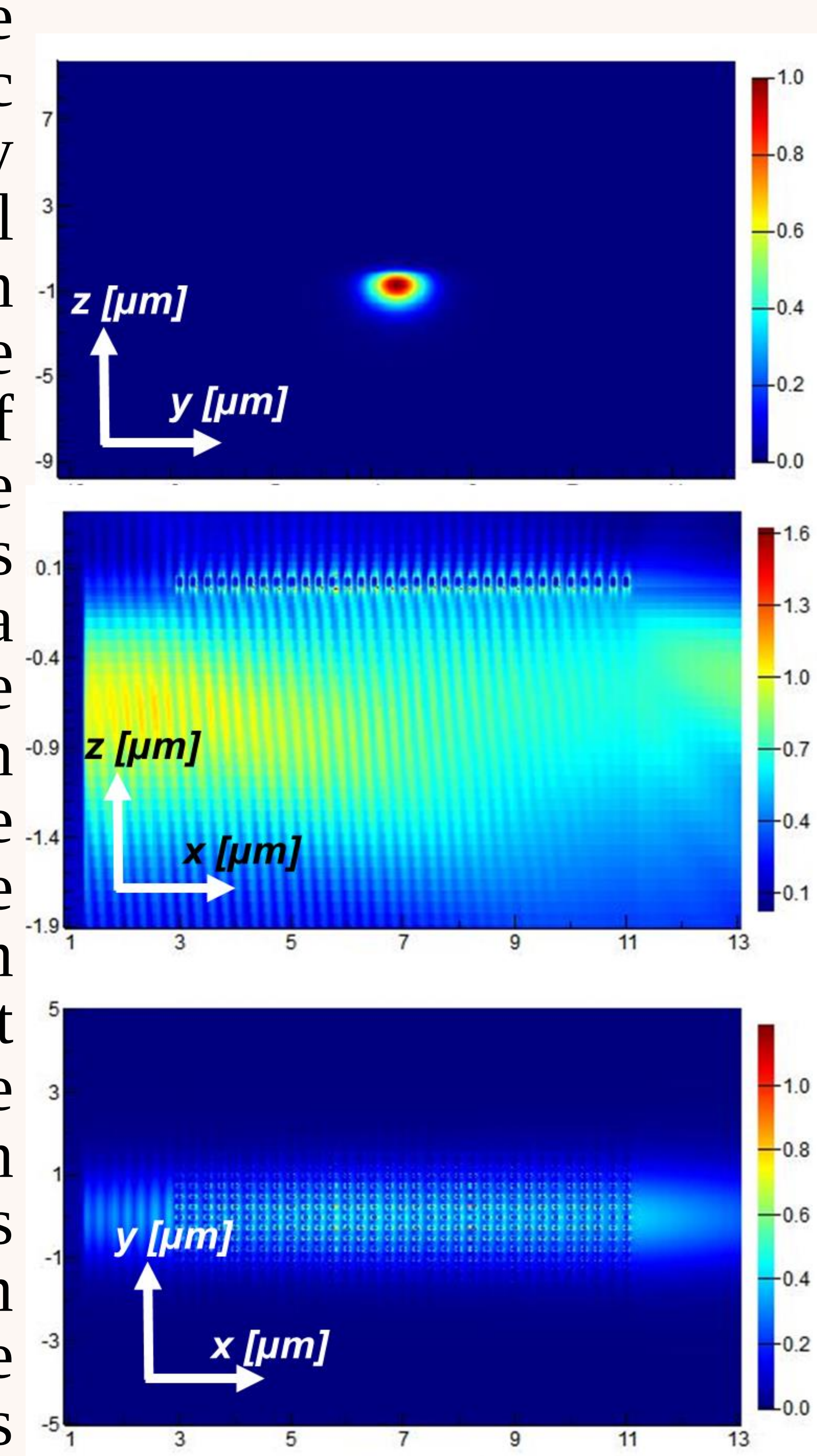
3D radiation diagram for square arrays of nano-cylinders aand nano-domes



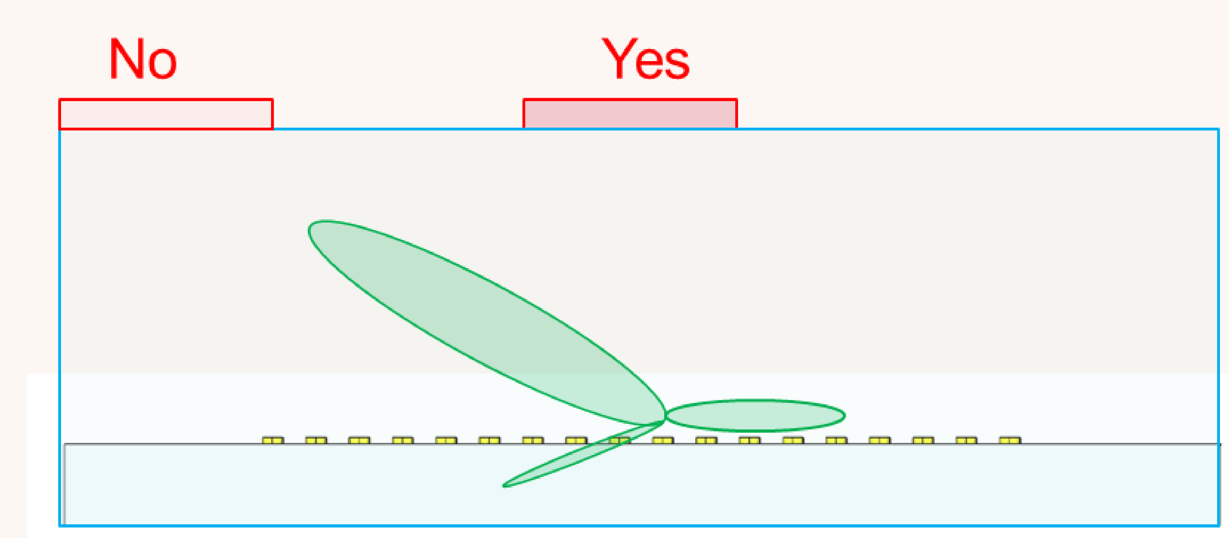
2D Radiation diagram with square nano-array, with nano-cylinders and different array periods

Excitation signal characteristics

TM modes interact more with plasmonic structured, although they induce a relevant optical loss. As an excitation signal, TM_{00} mode will be used. In terms of amplitude, signal profile on the nano-array plane is uneven, and follows a gaussian distribution. The enhancement of emission is obtained through three mechanisms. First, the direct illumination from waveguide's evanescent field. Second, the interaction with plasmonic modes originating from illumination. And last, the reflected charge effects from nanostructures to the emitters.



Field profile along the waveguide, representing the feeding signal that excites the nanoarray and the fluorophores



Concept schematic of the spatial filtering operation, and the related topological decisions

Conclusions

From the first analysis, we have discerned a high directionality of the scattered excitation beam. This can be controlled through array period, and exploited to obtain spatial filtering. This can reduce the mixing between the emitted fluorescence/Raman signal and the excitation signal, which allows to reduce reading time and noise. Further analysis of enhancement of emission is being operated.

[1] Mahi, N., Lévêque, G., Saison, O., Marae-Djouda, J., Caputo, R., Gontier, A., Maurer, T., Adam, P.M., Bouhafs, B., Akjouj A.: In Depth Investigation of Lattice Plasmon Modes in Substrate-Supported Gratings of Metal Monomers and Dimers. The Journal of Physical Chemistry C 121 (4), 2388-2401 (2017).

[2] Alam, B, Ferraro, A., Caputo, R., and Asquini, R.: "Optical properties and far field radiation of periodic nanostructures fed by an optical waveguide for applications in fluorescence and Raman scattering", Opt Quant Electron 54, 307 (2022).