



Nanoantennas and Biosensors: An Integrated Approach

PhD Programme in Electrical and Computer Engineering

Ricardo A. Marques Lameirinhas (ricardo.lameirinhas@tecnico.ulisboa.pt)

Introduction

In 1998, Ebbesen reported radiation spectra peaks higher than predicted by classical theories, calling this phenomenon extraordinary optical transmission (EOT).

Why classical theories fail to predict EOT?

- They do not consider propagation in the metal (SPP, Surface Plasmon Polaritons);
- They assume that the metal is opaque and perfectly conductive, reflecting all the radiation.

Methodology

A model based on the Fresnel equations and wave-corpucle dualism is proposed.

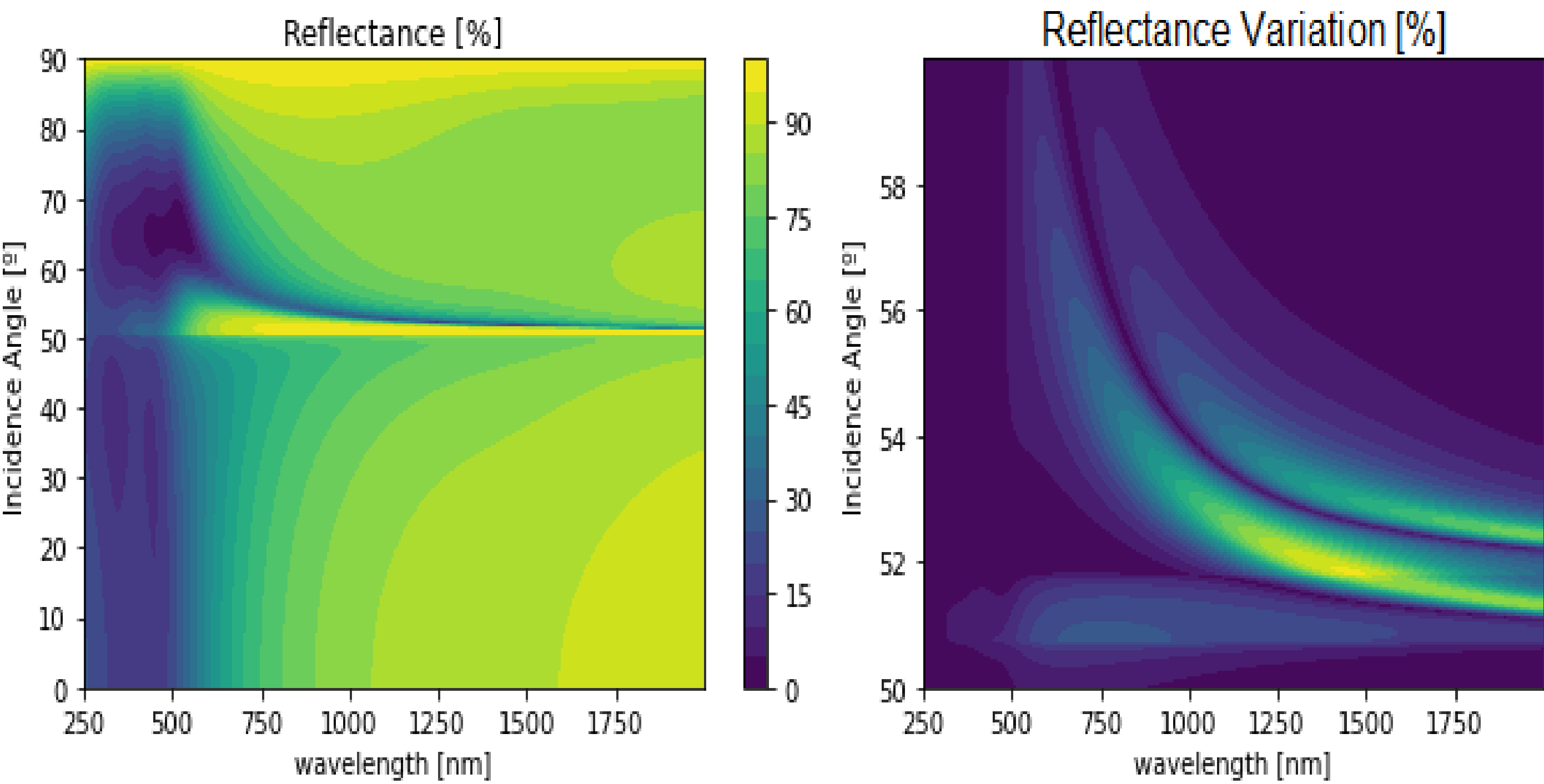
Generalised Fresnel equations and refraction and reflection laws are used to characterise photons movements.

An Object-Oriented Program is developed in Python, where:

- Photons are generated and characterised by a wavevector;
- Their movement changes at the interfaces.
- For a high number of photons, the response tends towards that of classical predictions. For a low number of photons, photon fluctuations in time can be analysed;

Kretschmann's Structure

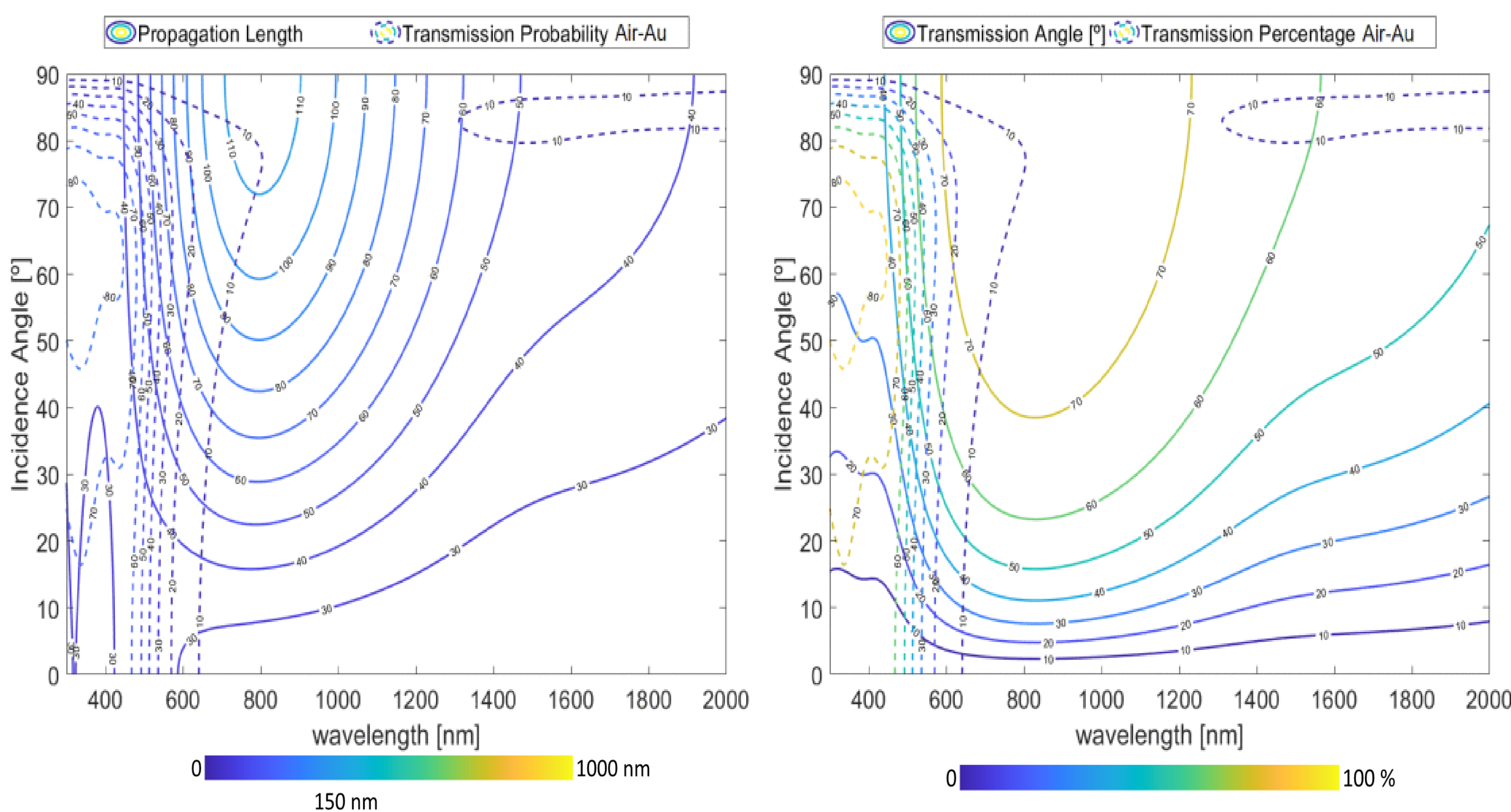
Since there are metals in the stack of materials, the structure reflects almost all the radiation. However, under certain conditions the metal transmits and the reflectance of the structure decreases.



Surface Plasmon Polaritons

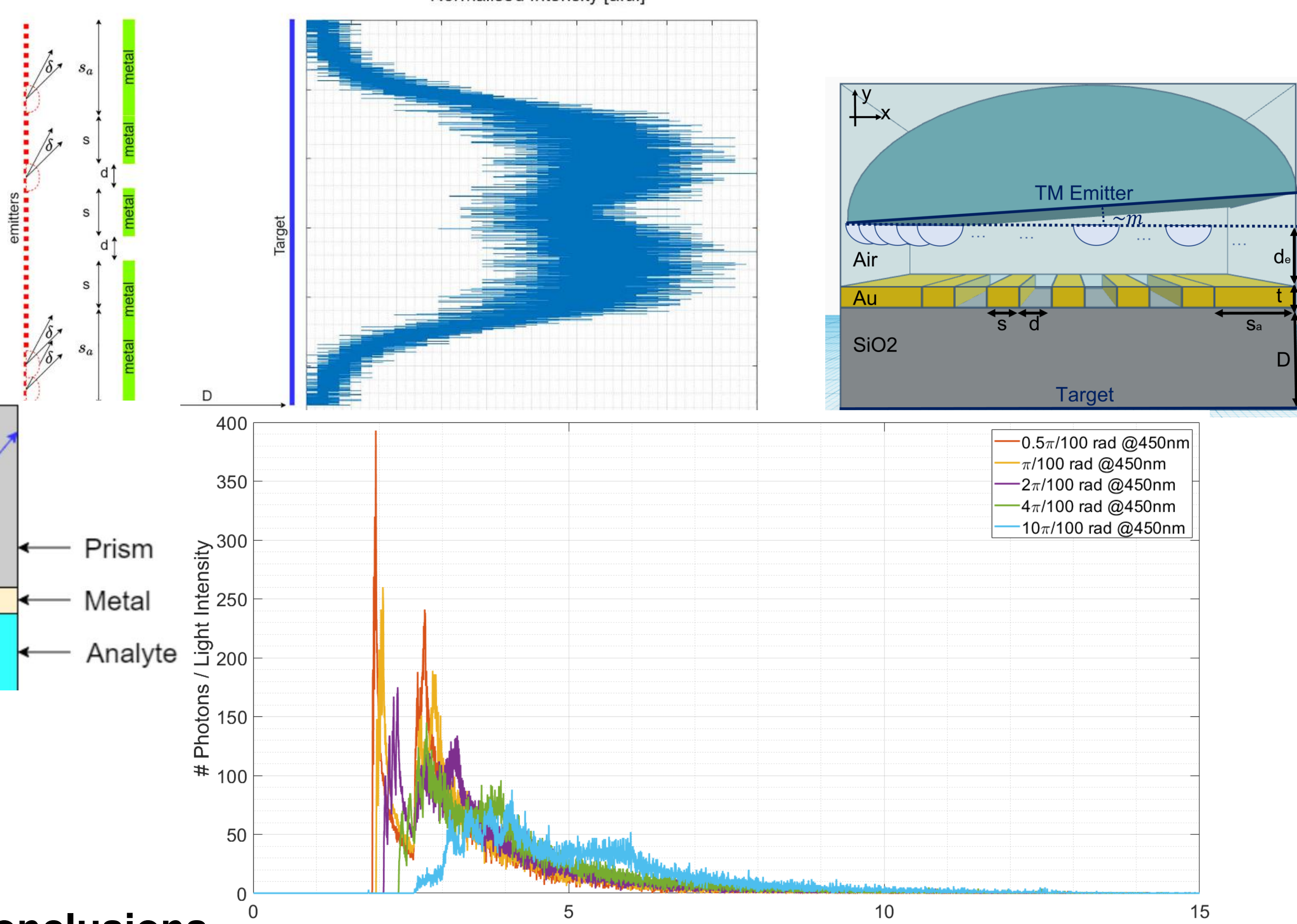
For an air-gold interface, it is concluded that:

- Transmission is quite high, and angle tends towards 90°;
- Propagation distance at nanometer orders.



Tilt Angle Sensor

Based on the results, it is possible to conclude that nanoantennas can detect variations of at least $0.5\pi/100$ rad (0.9°) and that the EOT increases the sensors' sensitivity.



Conclusions

- Under SPP conditions: high transmission percentage, high transmission angles and propagation nano-distances;
- The proposed model recovers geometric intuition, and it can describe complex electromagnetic effects such as EOT;
- EOT is a novel degree of freedom to design sensors with excellent figures of merit.

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