Hybrid plasmonic waveguides for sensing – outcome report –

Aim of the visit

The aim of the project was the study of the propagation of a hybrid metallo-dielectric mode inside a new type of waveguide aimed at telecom wavelengths. The initial simulations showed that the mode will have, on one side, long propagation lengths while, on the other, due to its plasmonics nature, will have high sensitivity with the surrounding media.

Carried out work

The first part of the work was carried out at DTU and consisted in fabricating the structures. Using various nanofabrication techniques ranging from plasma enhanced chemical vapour deposition (PECVD) to electron-beam lithography (EBL), we prepared the structures.

The fabrication steps were as follows:

1. Deposition of 6micrometers of silica using PECVD
2. Deposition of the EBL resist
3. Thermal deposition of Al for avoiding charge accumulation during the EBL exposure
4. Electron beam lithography for defining the waveguides
5. Removal of the Al layer
6. Develop of the resist
7. Deposition of the gold layer and lift-off in order to define the waveguides in gold
8. Deposition of a thin (200nm) layer of silica
9. Cleaving of the substrate for end-fire coupling

Once the structures were fabricated, the second step consisted in scanning near field microscopy (SNOM) measurements of the propagation modes, part that took place at King's college, London. Using the advanced SNOM capabilities available within the King's college department of Physics, Prof. A. Zayats' group, we could take high resolution scans of the field present at the interface.

Obtained results

In the below image one can observe the topography (figure 1a) and the field distribution (figure 1b) obtained during one of the measurements[1]. As it can be seen, although there might be some plasmons propagating (and interfering) on the metallic waveguides, in between the two waveguides there is actually a lack of field and not a maximum, as predicted by simulations (figure 1c).

The field on top of the metal in figure 1b does not look like a propagating wave but more like a standing wave. We believe that such characteristic may arise due to two cases. In the first one, the reflection of

[1] We present here only the most important measurements. If needed, the rest of the measurements can be sent for analysis.

the plasmon at the end of the waveguide will return and interfere with itself, thus effectively creating a Fabry-Perrot kind of distribution. Still, due to the long length of the waveguide (3mm) and the expected propagation length of such plasmons, such interference pattern would be very weak thus this explanation is lacking a bit of consistency.

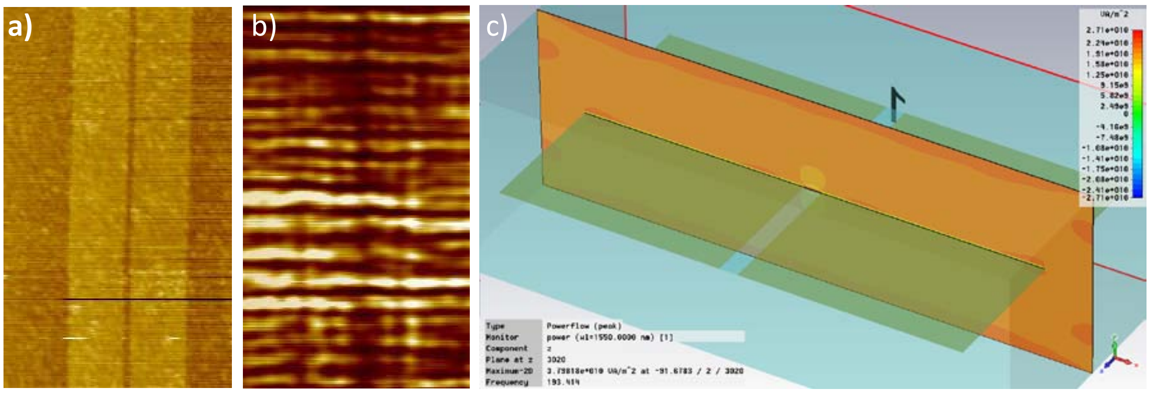

Figure 1. a) Topological image of the waveguide; b) field distribution top of the waveguide; c) theoretical predicted results of the field

The other possible explanation is that we failed to couple into the plasmonic modes. To be noted that such pattern can be found in most of the measures, even the ones when the fibre is relatively far from the pattern (see figure 2). As an extra, the lack of field in the middle of the structure gives more probability to this interpretation. We believe such interpretation to be the correct one also due to the difficulty to accurately position the excitation fibre with respect to the waveguide.

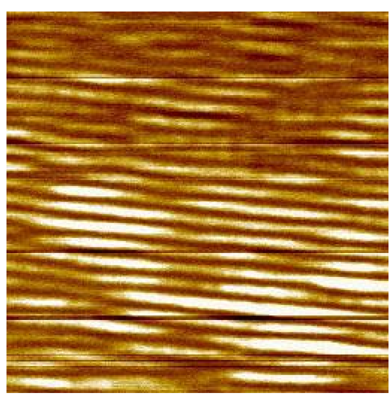

Figure 2. Image of the field distribution when the excitation is far from the wire

Future collaboration

The next natural step in this project is to modify the structure such that to couple using a different technique. The most plausible to work in this moment is the grating coupling technique. In order to couple using it, a new design has to be devised and fabricated where the end of the waveguide will be tapered into a grating that allows coupling of a normal incident beam to the waveguide. Using this technique, the alignment constraints of the beam with the waveguide are not so strict thus there is more probability of coupling to the desired mode.

Projected publications

Although the measures performed during the week spent at King's college were not successful, we believe such mode can be extremely effective for both sensing applications as well as on-chip optical interconnects thus the impact of a future possible publication will be high. Based on the results of the next measurements, we will decide over which journal to publish our findings.

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