Surface Plasmon Polaritons in Different Copper Film Thickness and Copper Oxide Films

Shing Hin (John) Yeung[1]

[1]School of Mathematical and Physical Sciences, UTS, Australia

INTRODUCTION

We have found the different conditions of copper films where surface plasmon polariton (SPP) were observed. SPP is a surface wave where electrons from metallic atoms resonant to the incident electromagnetic wave[1], some energy would travel along the metallic surface and form an evanescent wave. SPP only occurs at a specific launching angle[1,2]. It was reported that the quality of SPP is dependent to different copper thickness and if the film is oxidised or not. In this study, 3 different thickness of 30 nm, 40 nm and 49 nm of copper were used using Kretschmann configuration. This study aims to compare different of thickness of copper films, and the effect of oxidising the films. While explain the magnitude of SPP and its launching angle.

EXPERIMENTAL METHODS

Simulation Methods The experimental findings were compared to the simulation results using MATLAB®, which adapts the thin film matrix methods.

Experiment Surface plasmon polariton from copper film were measured in from the reflectivity through an arcylic prism. This is done by mounting the copper coated glass film on a plastic prism namely the Kretschmann configuration[2]. The reflection angle was determined by the angle where the reflected passed, and the mirror symmetry of the prism allow this to be happened. Plots of normalised reflectivity versus incident angle were identified for different copper films under each conditions. Furthermore, a second experiment session was aimed to measure the launching angle after the copper films were exposed under air for 2 weeks. The coating would become copper oxide (CuO).

RESULTS AND DISCUSSION

The launching angles were identified where the minimum reflectivity was located.

Thickness	Simulation		Experiment	
	Cu	CuO	Cu	CuO
30 nm	45.05°	49.84°	$47 \pm 0.5°$ $48 \pm 0.5°$	$46 \pm 0.5°$
40 nm	45.01°	49.22°	$47 \pm 0.5°$	$47.5 \pm 0.5°$
49 nm	44.79°	49.03°	$53 \pm 0.5°$ $54 \pm 0.5°$	$46 \pm 0.5°$

Table 1 shows the findings of the launching angles between different thickness and after the copper film has been exposed under air for 2 weeks (i.e. CuO column).

The findings shows the launching angle differs between simulation and experimental results. The 30 nm and 40 nm thick copper films differ by approximately 4%, while the 49 nm thick copper film differs by 20.5% between theoretical and experiment al results. The launching angles of the oxide samples were midway between the simulation results of both Cu and CuO.

The qualitative results agreed with simulation and literature from Takagi et. al.[2]. The minimum reflectivity of the Cu samples agreed with simulation. While its range is dependent to the thickness for both Cu and CuO samples, agreed from the findings from Takagi et. al.[2]. The findings suggests that SPP may require more energy to penetrate thicker films. In addition, the findings implied that electromagnetic energy dissipates into the CuO film.

CONCLUSION

Surface plasmon polariton was observed from copper thin films using the Kretschmann configuration. Through MATLAB® simulation and laboratory experiments, thick copper (oxide) films were observed with less minimum reflectivity at the launching angle, then the thinner layers. While the CuO sample absorbs more at the launching angle than Cu films, further research should explore the absorbed energy in CuO films. The results from different coating conditions show a potential research direction on producing a photonic circuit, nano-lasers and nanoscale chemical and biological sensors.

REFERENCES

1. Pitarke, J., Silkin, V., Chulkov, E. and Echenique, P. (2006). Reports on Progress in Physics, **70** (1), pp.1-87.
2. Takagi, K., Nair, S., Watanabe, R., Seto, K., Kobayashi, T. and Tokunaga, E. (2017). *Journal of the Physical Society of Japan*, **86** (12), p.124721.

ACKNOWLEDGMENTS

The author would like to thank Syed Salim Aljunied and Lindon Drake for their wisdom and guidance during the collaboration in the laboratory.