A comparison of whispering gallery modes in plasmonic and silicon waveguides

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***Abstract*—We designed and fabricated a millimeter plasmonic chip, which can excite whispering gallery modes on plasmonic waveguide coupled with corrugated disk resonator. Such whispering gallery modes show spoof localized surface plasmons effect. The Q-value as high as 268.3 (octupole) was experimentally obtained. A further comparision of whispering gallery modes on silicon waveguide with disk resonator was also demonstrated.**

I. INTRODUCTION

Recently the high Q-value terahertz sensors have attracted a great deal of attention. Due to their applications for food safety, biomedical detection and security instrument. Recently, planar terahertz chips by excited whispering gallery modes(WGMs) were proposed to accomplish low loss propagation and resonator for integration. Such chips have widely used in bio sensing because the sharp whispering gallery mode is sensitive to the refractive index of the material and such chips only needs a small amount of sample. In this submission, the WGMs can be excited by the interaction between plasmonic waveguide and corrugated disk resonator. Fundamental and higher order sharp WGMs were observed in the transmission coefficient spectrum. A further comparision of whispering gallery modes on silicon waveguide with disk resonator was also demonstrated.

II. RESULTS

The bilateral symmetric corrugated metallic structures are illustrated in Fig.1 [1]. The plasmonic waveguide port 1 and 2 can be used as signal input and output port, respectively. The spacing between the plasmonic waveguide and corrugated disk resonator is g. The width and periodicity of the grooves are denoted as a=0.5d, $p=\frac{2\pi R}{N}$, where N=20 is the total number of grooves. The height of waveguide is h.The dimensions mentioned above are R=1200µm, r=600µm, h1=500µm, h2=450µm, and p=380µm. 0.5µm-thick Gold layer was coated on the quartz substrate with 200µm-thick and loss tangent of tan(δ)= 0.0004 by conventional lithography. The transmission coefficient S21 was measured by 50-75GHz frequency band Agilent N5245A vector network analyser.

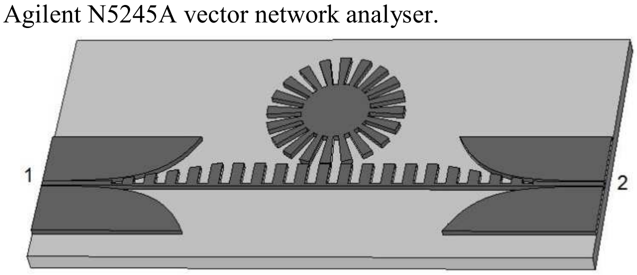

Fig. 1 Plasmonic waveguide with corrugated disk resonator

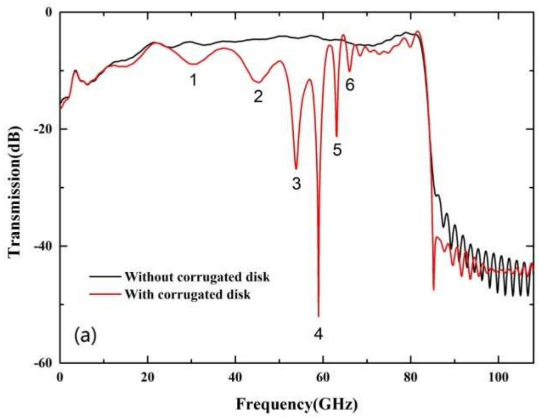

Fig. 2 The transmission coefficients S21

With the corrugated disk, the six main dips are generated in transmission spectra. Each of dip corresponds to a different mode. The modes 3-5 were appeared clearly in the transmission spectra. The experimental resonance frequencies are 53.7GHz, 59.2GHz and 63.3GHz, respectively. And the experimental transmission coefficient (dB) can reach -28.9dB,-39.8dB and -18.1dB, respectively. In experiment, the Q-value of octupolar mode has been observed as high as 268.3.

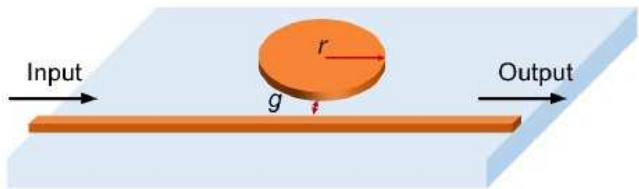

Fig. 3 Silicon waveguide with disk resonator

Another example that can excite WGMs is based on the silicon platform (Fig.2) [2], with the ridge is 500 µm wide and 340 µm high, over the slab with thickness of 130 µm (substrate). The gap (g) is 50 µm. The radius of the disk is r = 3 mm. Agilent N5227A PNA network analyzer and a set of WR-5.1 140–220 GHz VNA extenders was used to characterize the device transmission performances. The result of WGM with Q-factor of 201 is obtained for the E_x^{11} mode. For the E_y^{11} mode, the transmission spectrum shows that WGM with Q-factor of 305 at f= 194.6 GHz.

REFERENCES

[1].L. Chen, et al, "Spoof Localized Surface Plasmons Excited by Plasmonic Waveguide Chip with Corrugated Disk Resonator," *Plasmonics* 12, 947–952 (2017).

[2]. J. Xie, et al, "Terahertz integrated device: high-Q silicon dielectric resonators," *Opt. Mater. Exp.* 8 50-54 (2018)