

課題番号 : F-20-UT-0089  
利用形態 : 機器利用  
利用課題名(日本語) :  
Program Title (English) : Vibrational strong coupling in a plasmonic nanogap patch antenna cavity  
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キーワード/Keyword : リソグラフィ・露光・描画装置、Lithography, Plasmonics, Vibrational Strong Coupling

### 1. 概要 (Summary)

Vibrational strong coupling (VSC) of vacuum field and molecular vibrations offers promising applications in cavity-modified chemistry and ultrasensitive spectroscopy. In this project, gap surface plasmon cavities were fabricated to realize VSC at the nanoscale. Our nanocavity offers VSC comparable to microcavity but with drastically reduced number of molecule, which can open the ways for nanoscale chemistry.

### 2. 実験 (Experimental)

#### 【利用した主な装置】

超高速大面積電子線描画装置 (ADVANTEST F7000S+VD02), LL 式高密度汎用スパッタリング装置 (芝浦 CFS-4EP-LL i-Miller), 高精細電子顕微鏡 (HITACHI Regulus 8230).

#### 【実験方法】

Positive EB resist (ZEP-520A) was spin-coated on a CaF<sub>2</sub> substrate and patch nanoantenna arrays were defined by EB lithography (ADVANTEST F7000S+VD02) followed by development in ZED-N50 and MIBK. On top of the patterned resist, 50-nm Au layer was deposited with a 5-nm Ti-adhesion layer (CFS-4EP-LL i-Miller), and lifted off by ZDMAC. The SEM image (HITACHI Regulus 8230) of the fabricated antennas is shown in Fig. 1(a). A thin layer of the PMMA polymer followed by 80-nm Au layer was then spin-coated above the antennas.

### 3. 結果と考察 (Results and Discussion)

The reflectance spectra for the fabricated sample is shown in Fig. 1(b). The resonance dip of the gap surface

plasmon resonance is split into two dips due to the coupling with C=O stretch vibrations of the PMMA molecules. The splitting ( $\Omega$ ) of 108 cm<sup>-1</sup> satisfies the criterion for the strong coupling regime (red curve).

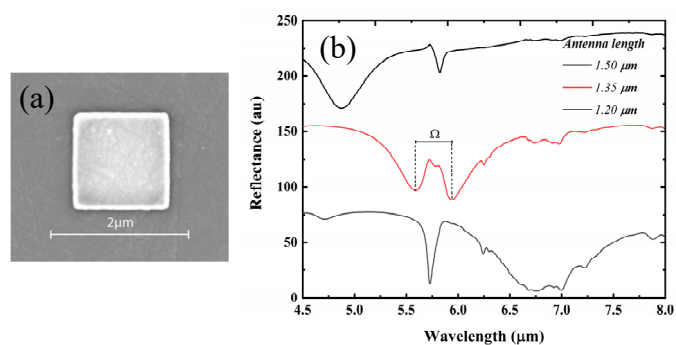


Fig. 1 (a) The SEM image of the fabricated patch antenna. (b) The reflectance spectra for the PMMA filled gap surface plasmon cavity for different antenna length.

### 4. その他・特記事項 (Others)

We would like to greatly acknowledge M. Fujiwara, E. Lebrasseur and A. Mizushima for the technical supports.

### 5. 論文・学会発表 (Publication/Presentation)

1. G. Dayal, I. Morichika, and S. Ashihara, under review (2021).
2. G. Dayal, I. Morichika, and S. Ashihara, The 67th JSAP Spring Meeting 2020, 14p-B414-4 (2020/3/14).

### 6. 関連特許 (Patent)

N/A