課題番号　　：F-13-HK-0041
利用形態　　：機器利用
利用課題名（日本語）　：
Program Title (English)　：Plasmonic-photonic hybrid for ultra-fast optical switching application
利用者名（日本語）　：
Username (English)　：Worawut Khunsin
所属名（日本語）　：
Affiliation (English)　：RIES-Hokkaido University

1. 概要（Summary）

This project entails the use of plasmonic nanoantennas and optical microring resonator. Near-field interaction between the nanoantenna and the ring resonator in such hybrid structures is investigated. In this report, we discuss its fabrication processes towards the realization of the hybrid structure. In brief, the hybrid structure necessitates three lithography steps, involving the writing of the markers, the ring resonator and, finally, the placement of the nanoantenna in close proximity to the ring resonator.

2. 実験（Experimental）

The 3-step lithography process employs an ultra-high precision electron beam lithography system from Elionix (ELS-F125) and high performance positive resist ZEP-520A to achieve high-resolution structures and high-precision placement required. The structures are fabricated on Silicon-on-Insulator (SOI) substrate.

The first lithography step is used to define a set of markers necessary for sub-10nm precision placement of the nanoantenna next to the ring resonator achieved in the second lithography step. For all the three lithography steps, the exposed patterns were developed in methyl isobutyl ketone (MIBK) solution. Inductive-coupled plasma (ICP) etcher was used to etch the top silicon layer to obtain the ring resonator. Lift-off step is employed in the first and third lithography steps to fabricate the markers and the plasmonic nanoantennas.

3. 結果と考察（Results and Discussion）

Fig. 1(a) shows the fabricated structures of the ring resonator. The structure is designed to have the operating wavelength at the telecommunication window around 1.55 μm. The fabricated structure shows high fidelity, achieving ring radius of 3.0 μm and width of 0.7 μm, although further investigation is needed to achieve precise control over the gap between the ring and the straight waveguide. Fig. 1(b) shows a successful overlay exposure required in the third lithography step, tested here with two sequential exposures of nanoantennas that are oriented orthogonally with each other: the first exposure is marked with red and the second (overlay) exposure is shaded in blue. The designed gap size and vertical displacement of the horizontal antenna with respect to the center position of the vertical antenna are 8 nm and 66 nm, respectively. The resulting structure reproduces exceedingly well the designed values, achieving the gap size of 5 – 10 nm and the vertical displacement of ca. 60 nm.

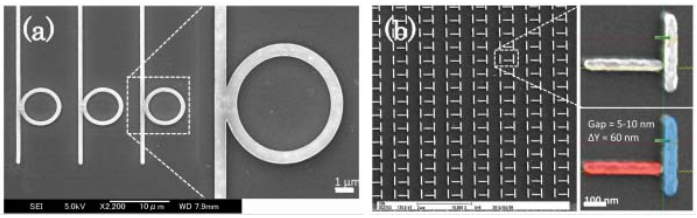

Fig. 1. SEM images of (a) Ring resonator (scale bar = 1 μm) on SOI substrate, and (b) the overlay exposure of two sequentially exposed and orthogonally oriented nanoantennas (scale bar = 100 nm). Red and blue shades denote the first and the second exposure, respectively.

4. その他・特記事項（Others）

なし

5. 論文・学会発表（Publication/Presentation）

なし

6. 関連特許（Patent）

なし