Investigation of electromagnetic interactions in a composite system of a dielectric photonic-crystal nanocavity and a metallic nanostructure (III)

[Introduction] We have studied dielectric-metal-hybrid systems consisting of a photonic crystal nanocavity (PCC) and metallic meta-atoms, where both electric and magnetic components of light can be controlled in sub-wavelength range. Recently, it is demonstrated that a PCC and a split ring resonator (SRR) interact through magnetic dipole, and a PCC and metal BAR interact through electric dipole [1-2]. In this work, we demonstrate that polarization of the light emitted from PCC can be controlled into circular polarization by utilizing sub-wavelength interaction with a SRR and a BAR simultaneously.

[Structure and Results] Figure 1 shows the two hybrid systems investigated, each of which consists of a L3 type PCC, a metallic BAR, and a SRR. In both systems, BAR is placed at the electric antinode position of PCC, and SRR is placed at the magnetic antinode position of PCC. We chose the design parameters of meta-atoms (BAR: $t_1 = 280\text{nm}$, SRR: $t_2 = 220\text{nm}$), so that their resonant wavelengths are positively and negatively detuned from that of PCC by about HWHM of meta-atoms. Therefore, when excited by the light which is on-resonant to PCC, the phase of BAR and SRR shows $\pm \pi/4$ difference with the excitation light. The light emitted from both meta-atoms, which are placed within the wavelength from PCC, are expected to be superimposed to exhibit circular polarization. The calculated snapshots of the near-field electric field distributions and polarizations of radiation at three different timings are shown in Fig.2. It is seen in the figure that the excitation of BAR ($t_a$) has $\pi/2$-phase lead compared with that of SRR ($t_b$). The polarizations of radiation at individual timings are shown in the insets. Due to the difference of rotation angle of SRR, structure A shows RHC (Right-Hand Circular) polarization while structure B shows LHC (Left-Hand Circular) polarization. Such nano-scale RHC, LHC implementation would be promising for micro-bio sensing to distinguish optical chirality. Other polarization states can be also implemented by expanding this method. Further details will be discussed at the conference. [Ref.] [1] 李他・秋田良 31a-ZR-7(2011), [2] 李他・秋田良 13a-PA5-1 (2012)

![Fig.1. Configuration of each hybrid system, labeled A has BAR+0 SRR, labeled B has BAR+180 SRR, and resonance spectrum of each cavity element; SRR and BAR resonances are detuned from that of PCC.](image1)

![Fig.2. Calculated near-fields ($E_y$) including radial polarization at certain time steps ($t_a, t_b, t_c$); Extracted field component from each excited meta-atoms have radiation delay while spinning in RHC (Labeled A) and LHC (Labeled B) direction.](image2)