

Photochromic control of Fano resonance in multilayer structures

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1. Introduction

The Fano resonance is a resonant phenomenon that exhibits an asymmetric line shape caused by an interaction between a broad resonant mode and a sharp resonant mode. Over the past decade, many studies on the Fano resonance have been performed, in particular, in nanostructures made of metal, semiconductor or dielectric materials, due to its physical interest and potential applications such as sensors, switches and platforms for enhancement spectroscopy [1, 2]. However, towards the real applications, the nanostructures have some issues such as the high cost for fabrication, difficulties of analytical calculation or design. As one of the replacements, we have focused on the Fano resonance in simple multilayer structures, and demonstrated quite narrow and high- Q Fano resonances ($Q \sim 2800$) [3, 4]. Using the multilayer structure, it is easy to photo-functionalize the Fano resonance by merely doping photo-functional molecules into the layers.

Here, we report the response of the Fano resonance to UV light irradiation in multilayer structures containing a photochromic layer. We demonstrate drastic changes in the Fano line shape induced by UV light irradiation and an enhancement of absorption change by a factor of $\sim 10^2$ relative to that in a single photochromic layer.

2. Sample

As shown in Fig. 1, the sample is composed of 3 layers, a HLG (half leaky guided) layer, a spacer layer and a PWG (planar waveguide) layer. We used the polystyrene (PS) ($n \sim 1.6$) for the HLG and PWG layers and polyvinyl alcohol (PVA) ($n \sim 1.5$) for the spacer layer. The ATR spectra measured in the Kretschmann configuration

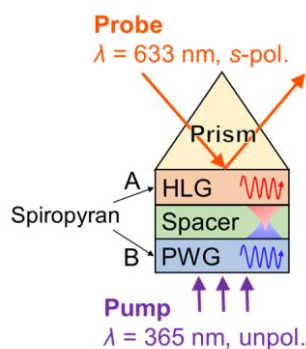


Figure 1. Sample structure

exhibit the Fano resonance, caused by the interference between a HLG mode and a PWG mode excited in the respective layers. To generate photochromic responses, spiropiran molecules were doped into the PS layer (photochromic layer); in Sample A (B), the photochromic layer was implemented for the HLG (PWG) layer. In the ATR measurements, a probe light ($\lambda = 633$ nm) was incident through the prism, and a pump UV light ($\lambda = 365$ nm) was incident from the air side in order to excite photochromic molecules.

3. Results and discussion

Figures 2(a) and 2(b) show the ATR results for Sample A and Sample B, respectively. In both of the ATR spectra, Fano resonances appear around the broad dip. With increasing the dose of pump light, the Fano line shape changed systematically from the convex downward to the convex upward for Sample A, on the contrary, from the convex upward to the convex downward for Sample B. The changes in the Fano line shape are caused by changes in absorption in the photochromic layers [5]. The mechanism of the photochromic change of the Fano line shape is discussed in detail in the presentation.

Figure 2(c) shows the comparison of the absorption change with the UV dose, in Sample B at 59.73 degrees and in a single photochromic layer. Absorption change is $\sim 10^2$ times larger in the Fano structure. This is due to the electric field enhancement inside the photochromic layer achieved under Fano resonance.

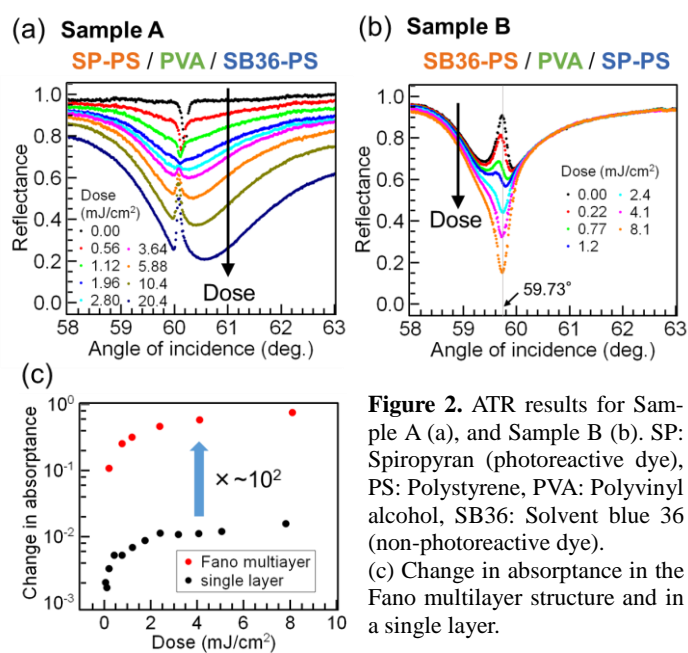


Figure 2. ATR results for Sample A (a), and Sample B (b). SP: Spiropyran (photochromic dye), PS: Polystyrene, PVA: Polyvinyl alcohol, SB36: Solvent blue 36 (non-photochromic dye). (c) Change in absorbance in the Fano multilayer structure and in a single layer.

References

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