Optimizing geometric factors of nano-hole arrays for Label-free bio-detection

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Surface plasmons have received great attention due to their extraordinary optical characteristic. The interaction between metallic thin films consisting of subwavelength nanostructures and lights causes plasmonic resonance. This phenomenon is able to be utilized for many applications such as color filters, image sensors, and plasmonic microscopies [1-2]. Recently, many kinds of nanostructures have been developed for label-free bio-detection [3-5].

In this study, we investigated the contribution of geometric factors to detecting resolutions and found optimized conditions for high sensitivity. To do this, structural color filters (SCFs) composed of 2-dimensional nano-hole arrays were formed on 150 nm-thick aluminum films as following a quadrate arrangement. The hole diameter and spacing varied from 120~220 nm and 260~400 nm with 10 and 20 nm steps respectively. Then, the solutions of collagen and bovine serum albumin (BSA) diluted to 20 $\mu g \cdot ml^{-1}$ with phosphate buffered saline (PBS) were dropped on SCFs to evaluate the role of geometric factors. As a result, improvement of detecting resolution occurred when both hole diameter and spacing increased.

In addition, human embryonic kidney (HEK-293) cells were prepared to confirm the detecting ability of fabricated SCFs and their resolution. Based on the result from simple proteins, in this step, we tried to distinguish nucleus and cytosol from the cell. Owing to their characteristic dielectric constants which are different from each other, it was also expected that the positions of plasmonic resonances are different. This difference makes distinguishable transmission for each unit pixel of optical microscope images. Therefore, instead of complex spectra analysis, color coordinates such as '*Hue*' and '*Lab*' spaces were used. Both parameters presented coordinates which distinguish nucleus and cytosol areas.

According to the result, geometrically optimized SCFs and analyzing method based on color coordinates show possibility that they are suitable candidates for label-free and real-time in-vitro bio-detection.

References

[1] C. Genet and T. Ebbesen, Nature, 445 (2007) 39-46
[2] Y. Gu, L. Zhang, J. K. Yang, S. P. Yeo and C.-W. Qiu, Nanoscale, 7 (2015) 6409–6419
[3] A. G. Brolo, R. Gordon, B. Leathem and K. L. Kavanagh, Langmuir, 20 (2004) 4813–4815
[4] A. Kausaite-Minkstimiene, A. Ramanaviciene and A. Ramanavicius, Analyst, 134 (2009) 2051–2057
[5] E. Kazuma and T. Tatsuma, Nanoscale, 6 (2014) 2397–2405

Figures

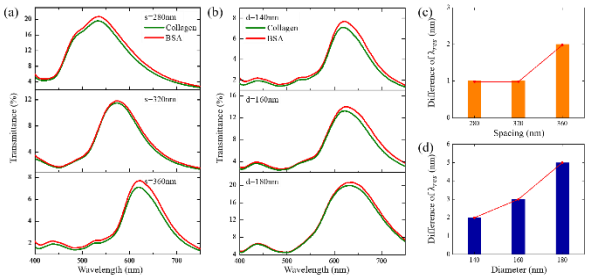

Figure 1. Measured transmission spectra of SCFs with increasing (a) spacing and (b) diameter after proteins were dropped. The difference of the resonance wavelengths are plotted on (c) and (d).

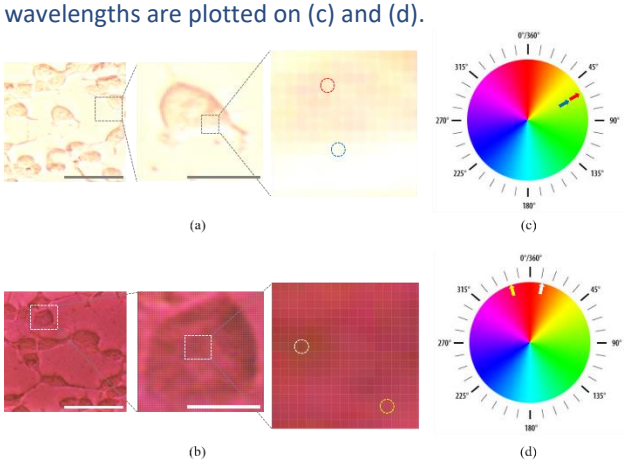

Figure 2. (a-b) OM images of the glass substrate and SCF with HEK-293 cells. (c-d) '*Hue*' color spaces of nucleus and cytosol areas.