24-bit/16 million structural true colors through extraordinary optical transmission of subwavelength Ag holes

Bing-Rui Lu, Jianan Deng, Li-Jin Gong, Yifang Chen

Nanolithography and Application Research Group, State key lab of Asic and System, School of Information Science and Engineering, Fudan University, Shanghai 200433, China

lubingrui@fudan.edu.cn, yifangchen@fudan.edu.cn

Plasmon resonance induced transmissive/reflective structural color in metal films is capable of achieving full color spectrum without UV degradation, which may lead to broad applications in photonic circuit components, optical data storage, macroscopic color holograms, chemical sensors, color filters and displays, and anti-counterfeit measurements. Although substantial basic study in both proof-of-concept and nanofabrication techniques have been reported, the depth of the generated structural colors remains a challenge. So far the demonstrated color palette are based on the precise dimensional definition of the nano structures. This offers a relatively wide range of the output color with the sacrifice of the certainty of the output color. For example, a 5 nm difference of the hole radius, which can be a common margin during the nanofabrication, can cause a dramatic shift in the output color. Therefore it is of essential significance to find a new method to obtain with certainty a wide color range for a realistic structural color picture.

Based on our earlier work on structural color through subwavelength Ag hole arrays, we demonstrate a new concept of constructing a much wider range of the color depth by configuring the R-, G- and B-colors with 256 grey scales to obtain 24-bit/16 million true colors. As depicted in Fig. 1, The grey scale information of each color is extracted from the reference picture, and each color pixel consists of the three primary colors in the extracted grey levels, which are determined by the numbers of the -R, G-, B-color unit. An electron beam lithography system JEOL 6300FS is used to fabricate the nano holes in the PMMA resist on a quartz substrate, followed by a thermal metal deposition of Ag. The thickness of the Ag defines the mode of the color, with 60 nm for the transmission and 300 nm for the reflection. The sizes of the holes are investigated and compared in Fig. 2 and 3. A realistic color rendering in both modes of a painting is fabricated in Fig. 4 and 5.

We conclude that in this new method of RGB color configuration to obtain 24 bit/16 million true color depth is a promising alternative for future consumer products in color display, sensing, imaging and non-toxic color printing.

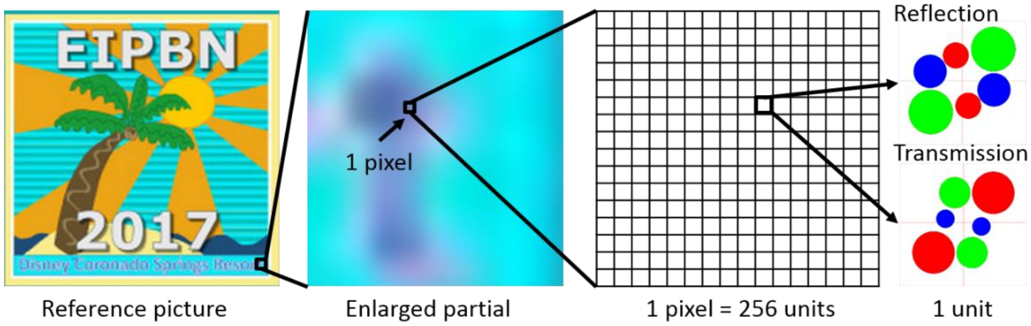

Figure 1. The 256 grey scale of each color pixel can be defined by the total number of units taken in the 16 by 16 array of the double-hole color unit for each of the RGB colors.

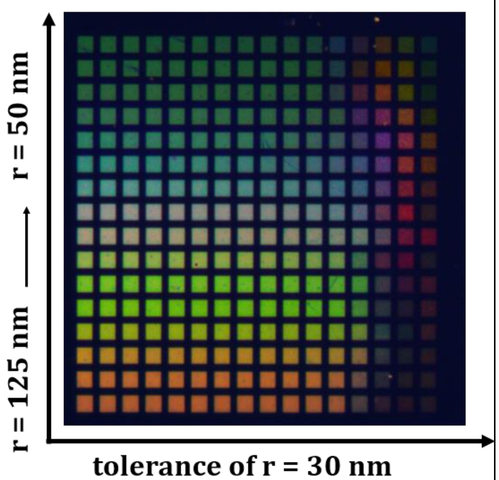

Figure 2. In the transmission mode, the subwavelength Ag hole arrays in various dimensions to form different colors with high tolerance of >30 nm.

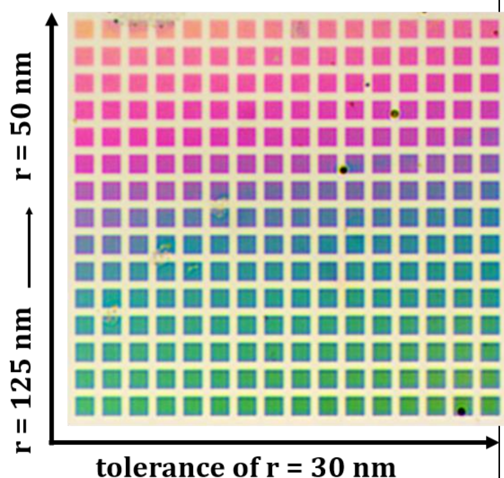

Figure 3. In the reflective mode, the subwavelength Ag hole arrays in various dimensions to form different colors with high tolerance of >30 nm.

Figure 4. The realistic color rendering of a traditional Chinese painting in the transmission mode. The height of the picture is 1 mm.

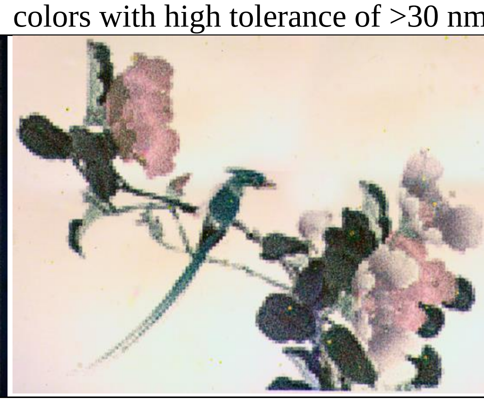

Figure 5. The realistic color rendering of a traditional Chinese painting in the reflection mode. The height of the picture is 1 mm.