Multidimensional screening anti-counterfeiting: shapes and images

Multidimensional anti-counterfeiting technique, which could display diverse images depending on different readout conditions, provides an unparalleled approach to improve the information security and holds great potential in practical applications. Although it has been achieved by varied wavelength, polarization and spatial dimensions, it is still a challenge to realize multidimensional screening anti-counterfeiting by simple fabrication process and readout methods.

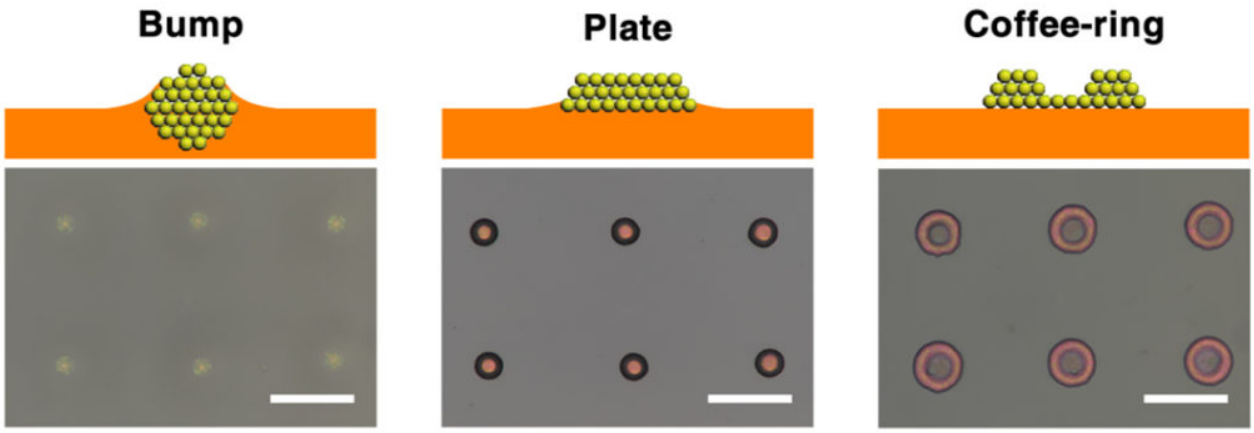

Fig. 1. Three kinds of PC dots shaped as bump, plate and coffee-ring, respectively.

Photonic crystal (PC) widely exists in nature, such as butterfly's wing, opal, beetle's back and shell. It has a periodic optical nanostructure and shows lots of unique optical properties, such as presenting rainbow colors, reflecting light with specific wavelength, and enhancing the fluorescence intensity. Based on these properties, the PCs have been widely applied in optical fiber, sensors and anti-counterfeiting labels. Self-assembly of nanoparticles is a simple method to construct PC. Through inkjet printing, the patterning PC image can be easily obtained.

In our study, the solution contained nanoparticles and fluorescence molecules was printed on poly(dimethylsiloxane) (PDMS) substrate with different rheology and three kinds of PC dots, shaped as bumps, plates and coffee-rings were obtained (Fig. 1). Differently shaped PC dots can reflect light to different directions because of their various surface morphologies. Besides, the difference in fluorescence enhancement of three kinds of PC dots was induced by different photonic band gaps (PBGs) due to compact degree of assembled nanoparticles. Therefore, obvious optical difference of three kinds of PC dots can be observed from microscope images from four different lighting conditions: lighting from top, lighting from side, under excitation with high power and under excitation with low power. These results mean three kinds of PC dots could be

distinguished by their optical difference under four lighting conditions. We further applied this discovery into the anti-counterfeiting field.

Accordingly, a novel quick response code composed of differently shaped PC dots was fabricated, which could display four images depending on different lighting conditions, and thus four-dimensional screen anti-counterfeiting was achieved (Fig. 2). The differently shaped PC dots were sequentially integrated into this pattern by controlling the rheology of PDMS substrate. The information was encoded and stored by the differently shaped PC dots, and readout from the images under different lighting conditions according to the optical differences in reflection and fluorescence enhancement.

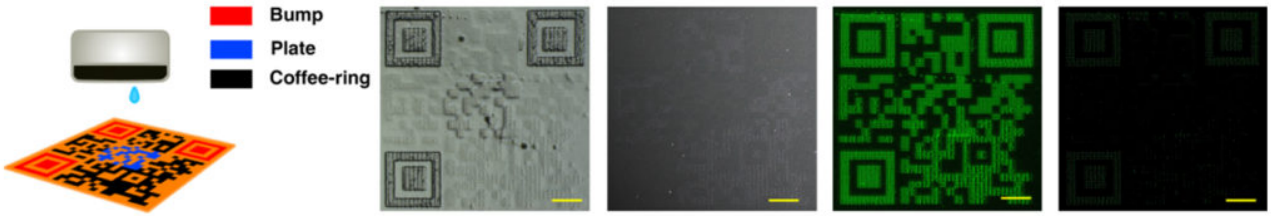

Fig. 2. Four-dimensional screening anti-counterfeiting QR code that shows four different images under different lighting conditions.

This strategy, including controllable shapes of inkjet-printed PC dots and multidimensional screening anti-counterfeiting depending on different light conditions, is easy, fast and low-cost. This work provides a new avenue to improve the encoding dimension and diversification of information storage and anti-counterfeiting screening.

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Publication

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