Alasdair W. Clark

Lecturer
School of Engineering
University of Glasgow

Biography

Alasdair Clark received BSc degree in Applied Physics from the University of Strathclyde in 2004, and Ph.D. degree from the School of Engineering, University of Glasgow in 2009. Currently leader of the Bio-Nano-Plasmonics group at Glasgow, Dr. Clark's active research interests include solar energy-harvesting, molecularly-enabled metasurfaces, nanophotonic color, and DNA-origami.

Dual-color plasmonic pixels for high-density image patterning

We demonstrate a new plasmonic approach to high-density optical data storage; using dual-color plasmonic nano-pixels to encode two information sets into the same unit area using single arrays of two-state metal nano-apertures.

The ability to effectively separate discrete colors from white-light lies at the heart of how we record and view optical information; whether that be the arrangement of colored inks in painting and printing applications, or the spectral filters that enable many modern image display and recording technologies. In each case, color separation is typically provided by organic compounds; dyes and pigments that absorb and scatter particular wavelengths of light, leading to their distinct color profiles. Recently, structural color systems based on engineered nanophotonic materials have emerged as an appealing alternative to absorptive dyes [1]. Among these examples are color filters based on plasmonics. Plasmonic filters hold several dimensional and stability advantages over their micro-scale, dye-based counterparts. As a result, they have been positioned as new technological solutions for sub-wavelength color printing [1], RGB splitting for image sensors [2], anti-counterfeiting measures [3], and optical data storage [4]; thus representing one of the most promising, commercially relevant areas of current plasmonic research activity.

Here, we demonstrate a method for patterning full-color images and codes that exhibit polarization-dependent information states. Our individual pixels are comprised of asymmetric cross-shaped nano-apertures in a thin film of aluminum; each aperture engineered to exhibit 2 independent plasmonic color resonances that can be individually tuned across the sRGB spectrum. This enables us to encode 2 arbitrary information sets into the same unit area using the same array of nano-pixels. We show that using a standard optical microscope, color separation can be controlled down to 2x2 nano-pixels while retaining polarization selectivity. This defines our maximum data storage capability; each 2x2 pixel area acting as a 2-state data bit that can be read optically. The maximum data density we can achieve using this technique is approximately 1.46 Gb/cm^2, with the added ability to further encode each of those pixels using the full visible-color spectrum.

REFERENCES

[1] K. Kumar, H. Duan, R. S. Hegde, S. C. W. Koh, J. 6N. Wei, and J. K. W.Yang, "Printing Colour at the Optical Diffraction Limit", *Nature Nanotechnology*, 7, 557-561 (2012).

[2] S. P. Burgos, S. Yokogawa, H. A. Atwater, "Color Imaging Via Nearest Neighbor Hole Coupling in Plasmonic Color Filters Integrated onto a Complementary Metal-Oxide Semiconductor Image Sensor", *ACS Nano*, 7, 10038-10047 (2013).

[3] Y. H. Zheng, C. Jiang, S.H. Ng, Y. Lu, F. Han, U. Bach, J. J. Gooding, "Unclonable Plasmonic Security Labels Achieved by Shadow-Mask-Lithography-Assisted Self-Assembly", *Advanced Materials*, 28, 2330-2336 (2016).

[4] M. Gu, X.P. Li, Y. Y. Cao, "Optical Storage Arrays: A Perspective for Future Big Data Storage", *Light-Science & Applications,* 3 (2014).