Metasurfaces for generating high-order optical angular momentum modes

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We investigate a new approach to solve the critical challenge of packing more data channels in optical transmission links to achieve densities orders of magnitude higher than current ones. Spatially, this can be achieved by increasing the optical modes that light can propagate through an optical fibre. These modes can exist simultaneously within a fibre and act as parallel data channels.[1]
An exciting category of modes is the one carrying optical angular momentum (OAM) since they are better isolated from each other, thus reducing the modal crosstalk.[2] This category also contains a much higher number of modes than different categories of modes. However, they are challenging to obtain and couple into a fibre.

Here, we present our initial simulations and experiments showing that metamaterials can be used to transform a standard fundamental mode into an OAM mode having a relatively high order number, L. Using this approach, we can transform the light coming from single-mode fibres, the most used type nowadays, into OAM ones with L=5-7. The obtained conversion efficiency of the metasurfaces was -6 dB for L=5 and 6 and -8 dB for L=7. The insertion loss is approximately 0.5 dB. The modal crosstalk was measured at -15 ~ -16 dB in the fibre.
In Figure 1, we show (a) the fabricated metasurface for OAM mode L=5 and (b) the generated OAM beam after interference with a Gaussian one to demonstrate the characteristic spiral phase front and the correct number of lobes.

Further research aims to increase the coupling efficiency and decrease the crosstalk, especially when light is not normally incident onto the fibre. This aspect is essential due to the necessity to couple several modes into one fibre. Thus, each of these modes will come from a different direction.

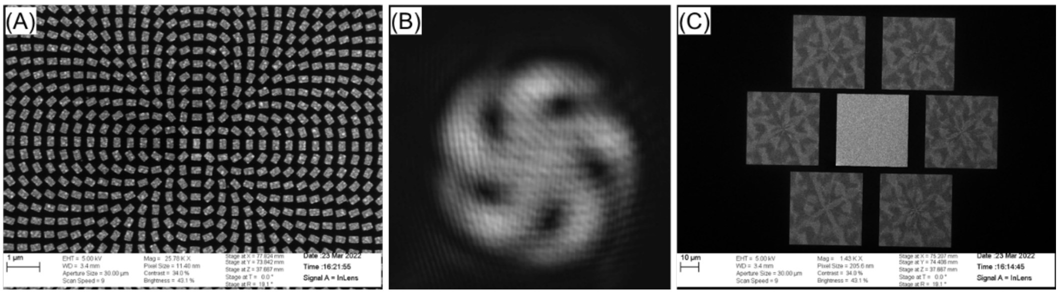

Figure 1. (A) SEM image of a metasurface generating an L=5 OAM beam from a Gaussian-shaped one. (B) interferogram of the L=5 beam with a Gaussian one, showing the correct number of lobes and their shape, (C) a set of 7 metasurfaces positioned to match a 7-core single-mode fibre. Each metasurface converts a fundamental mode into an OAM with a different high-order number to be launched in a multimode fibre.

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