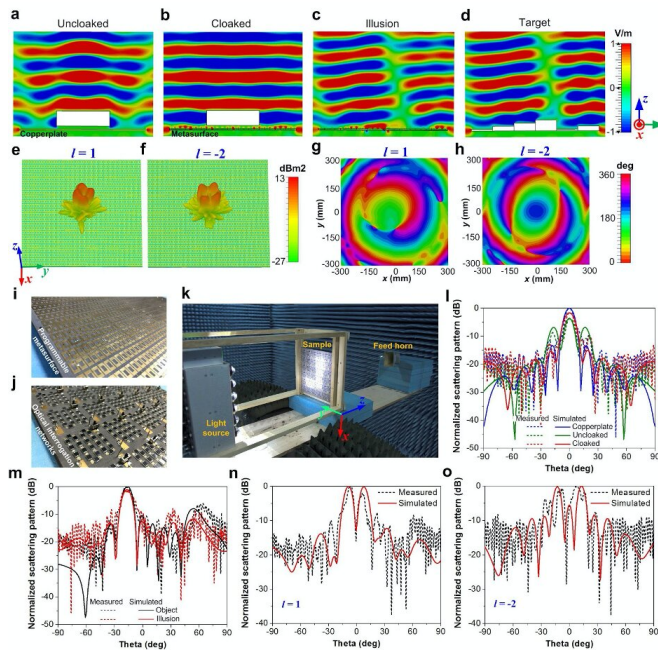


An optically driven digital metasurface to bridge visible light and microwave communications

30 March 2020, by Ingrid Fadelli



The proposed optically interrogated digital platform (OIDP) and its performance. a,b, Simulated electric field intensity distributions of the E_y component on the y - z plane at 5.8 GHz for the unclocked case (a) and the cloaked case (b). c,d, Simulated intensity distributions of E_y electric field component on the y - z plane at 6.5 GHz of the metasurface (c) and target (d). e,f, Simulated 3D vortex beams with $l=1$ (e) and $l=-2$ (f) modes at 6.5 GHz. g,h, Simulated phase distributions of E_y electric field component on the x - y plane of vortex beams with $l=1$ (g) and $l=-2$ (h) modes. i,j, Photographs of the top programmable metasurface (i) and bottom OINs array (j). k, Photograph of the microwave measurement setup. l, Measured and simulated 2D scattering patterns for the unclocked case, cloaked case and copperplate at 5.8 GHz. m, Measured and simulated 2D scattering patterns of the planar metasurface and target ladder at 6.5 GHz, respectively. n,o, Measured and simulated 2D scattering patterns of the vortex beams with $l=1$ (n) and $l=-2$ (o) modes at 6.5 GHz. Credit: Zhang et al.

Coding, digital, and programmable metasurfaces are engineered surfaces that can be used to manipulate electromagnetic waves, [first introduced by Prof. Tie Jun Cui and his colleagues in 2014](#). Due to their many advantageous characteristics, these artificial structures have recently become the focus of a number of research studies.

In addition to realizing the functions they are programmed to complete, programmable metasurfaces can control [electromagnetic waves](#) and [digital information](#) simultaneously. This unique feature allows them to act as a bridge between physical and digital worlds. Despite this favorable quality, most coding, digital and programmable metasurfaces developed so far are quite complex and require a vast amount of bulky hardware components.

Researchers at Southeast University in China have recently developed a new optically driven digital metasurface that can be programmed to implement electromagnetic functions. The structure they created, presented [in a paper published in Nature Electronics](#), could help researchers to overcome some of the limitations of digital metasurfaces introduced in previous studies.

"Most existing digital coding and programmable metasurfaces require electrical wires, complex control circuits and bulky power supplies," Wei Xiang Jiang, one of the researchers who carried out the study, told TechXplore. "To solve the problem, we tried to find a way to remove these electrical wires and complex control circuits."

Back in 2015, [Jiang and his colleagues fabricated a light-controlled transformation-dc device](#) based on a resistor network, embedded with light-sensitive semiconducting resistors. In their new study, they used the same concept of light control at the core

of this device to design and realize an optically driven programmable metasurface.

"The main objectives of our work were to eliminate the cross-talk between the DC signal and microwave signal, and to realize non-contact remote programmable meta-systems," Wei Xiang said. "To realize a specific function, we first need to design visible light illumination patterns, which will be converted to the voltages biased to the metasurface elements by the optical interrogation network. Then, the metasurface will generate specific microwave reflection phase distributions and realize different functions in programmable way."

The optically driven artificial structure developed by Wei Xiang and his colleagues has 6 x 6 subarrays, each containing 4 x 4 metasurface elements based on electronic varactors. These elements are combined with an optical network made of photodiodes that can convert visible light patterns into voltages and ultimately produce specific microwave reflection phase distributions.

In contrast with digital and programmable metasurfaces introduced in previous studies, the new metasurface can operate within a broad range of bandwidths and can be programmed remotely. This means that it does not require wires and other bulky power sources.

"The most important features of our programmable system include light weight, small size, and wireless tuning," Wei Xiang explained. "Moreover, we can use the light intensity to control the microwave phase, which could be of value in developing hybrid electronic-photonic devices and systems for more advanced electronic and [communication systems](#)."

The optically driven system proposed by this team of researchers can ultimately act as a bridge between visible light and microwave communications. In the future, it could enable the development of lighter, more advanced electronics and communication devices.

So far, Wei Xiang and his colleagues have demonstrated the capabilities of their metasurface

by programming it to perform three key functions: external cloaking, illusion, and dynamic vortex beam generation. However, the same structure could also potentially be programmed for a variety of other applications.

"We are now planning to start investigating a visible light and [microwave](#) hybrid communication system based on the fabricated optically driven programmable [metasurface](#) that can convert the [light](#) signal to the [microwave signal](#)," Wei Xiang added.

More information: Xin Ge Zhang et al. An optically driven digital metasurface for programming electromagnetic functions, *Nature Electronics* (2020). [DOI: 10.1038/s41928-020-0380-5](https://doi.org/10.1038/s41928-020-0380-5)

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