NANOPHOTONICS

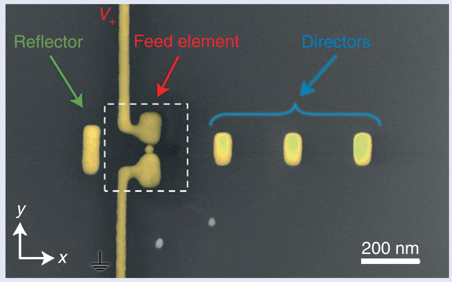
Integrated optical antenna

Optical Yagi–Uda antennas — a nanometre-scale design of the famous radio-wave TV antenna seen on rooftops around the world — could be a useful light source for future applications involving on-chip optical data communication. Consisting of a reflector, an active feed element and directors, the Yagi–Uda antenna acts as a highly directional emitter of electromagnetic waves. However, to date, experiments with optical versions have relied on the use of a separate bulky light source to feed the antenna, and a fully integrated miniature system would be preferable.

Now, René Kullock and co-workers from Universität Würzburg in Germany have done just that and developed an electrically driven, integrated system that offers directional emission of infrared light (pictured) (*Nat. Commun.* **11**, 115; 2020).

The antennas were fabricated on a glass plate by focused ion beam milling of chemically grown single-crystalline gold microplatelets. The size and the positions of the reflector, the feed element and the directors were determined by numerical simulations such that the forward-to-backward ratio became high for light emission around 870 nm. The feed element with a gap of around 25 nm in the middle was electrically connected via kinked gold wires to avoid optical field disturbance.

Light with a broad spectrum around 830 nm was generated via antenna-enhanced inelastic tunnelling of electrons over the antenna feed gap where a single gold particle was placed. To exactly place one particle into the antenna gap, the German scientists employed feedback-controlled single-particle dielectrophoresis. A water droplet containing gold particles was placed on top of the antenna structures and an a.c. electrical signal was used to move a gold particle to the region with the highest field gradient, that is, the feed gap.



Electroluminescence from the antennas was measured by applying a d.c. voltage of up to 1.8 V and collecting the emitted light via a high-numerical-aperture objective lens. In order to experimentally estimate the forward-to-backward ratio, the emission pattern of the electroluminescence was recorded by back focal plane imaging for various antennas and calculated. The obtained forward-to-backward ratio was estimated to be in the range of 6.5–9.1 dB, equivalent to that of Yagi–Uda antennas for radio-frequency waves.

"This work paves the way for optical on-chip data communication that is not restricted by Joule heating but also for advanced light management in nanoscale sensing and metrology as well as light-emitting devices", concluded Kullock. ❐

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IMAGING

Graphene light-field camera

A new light-field imaging scheme, employing stacks of transparent graphene photodetectors, has been demonstrated, providing a path to greatly simplify the otherwise complex three-dimensional imaging.

Khurram Shehzad and Yang Xu

Painters of the Renaissance struggled to depict true colours, light and the three-dimensional (3D) nature of the objects in their paintings. To depict true colours, they would often use expensive pigments, while to get the authentic light values, painters such as Vermeer are believed to have used camera obscura. Modern colour cameras have solved these problems and can now record 2D projections of a 3D object with accurate colour and light value. However, such 2D projections provide little or no information about the depth of objects within the scene. Painters and photographers have long been fascinated by the idea of realizing 3D images that not only depict colour and brightness, but also depth information.

Now, writing in *Nature Photonics*, Miao-Bin Lien and colleagues report a simple yet effective and potentially revolutionary scheme of employing thin transparent graphene photodetector stacks to image 3D objects more accurately[1].

Most of the recorded images on our phones, cameras and computers are 2D projections of a 3D object. However, there is an increasing commercial and academic thrust to develop a means to capture the complete representation of a 3D scene. Current 3D object imaging techniques employ complex set-ups and suffer from performance deficiencies. Light from a 3D