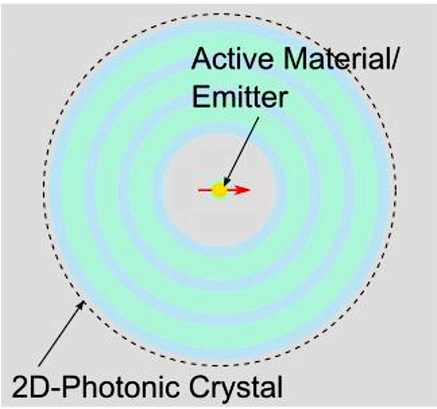
Technology Offer:

Near-Unity Efficiency: Novel Light Collecting Antenna for Quantum Technologies
Ref.-No.: 1629-6049-WT

The invention relates to a new concept for a high efficiency light antenna, namely the Truncated Omnidirectional Reflector (TOR). It is well suited for obtaining directional emission and efficient fiber coupling from various types of light sources like single photon emitters.

Especially in the fast-growing field of quantum technologies efficient collectors for solid-state single photon emitters are needed. Achieving collector efficiencies of more than 95% into the fundamental Gaussian mode, TORs can be used for coupling of photons into a single-mode fiber. As an example, long distance quantum communication can be improved significantly by the new technology.

The TOR's collection methodology is based on the implementation of a truncated 2D photonic crystal in combination with a metallic mirror. By appropriate sizing, large-angle emissions are suppressed and small-angle defect-modes are enhanced by the arrangement.



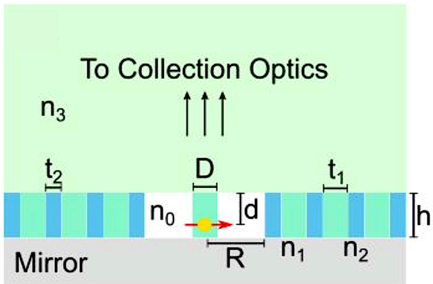


Fig. 2: Cross section of the device concept. The central cylinder as well as the photonic crystal are mounted on top of a mirror and truncated at height *h*.

Fig. 1: Top view of an antenna according to the invention. The concentric crystal is arranged around the light emitter.

Advantages

- >95% overlap with the mode of a single mode optical fiber
- Broadband operation possible
- Insensitive to emitter position
- Compatibility with the majority of emitters
- Fabrication by standard lithography techniques

Applications

- Quantum computation
- Quantum communication
- Optical microscopy
- Fiber coupled light sources

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Background

Efficient extraction of light into a well-defined spatial mode is of interest for various sorts of technology. For example, single-photon sources have been identified as central building blocks for quantum technologies and solid-state emitters are the natural choice. In order to achieve a high collector efficiency, current concepts are mostly based on the coupling of a single emitter to a specifically shaped nanowire or to a microcavity mode. Both methods are limited due to their manufacturing processes, being rather elaborated etching techniques. Recently reached photon extraction efficiencies of 66% are insufficient for future quantum technology applications.

Technology

A new antenna device (cf. Fig. 3) has been designed to overcome the aforementioned shortcomings. The newly developed TOR thereby enables near-unity collection efficiency of light from a light source in the center of the arrangement into the fundamental gaussian mode.
The TOR consists of a central cylinder (18) that contains the one or more light emitters (24). It is surrounded by a circular photonic crystal formed by two kinds of concentric and alternating rings (16) made of dielectric materials. To achieve the desired omnidirectional reflection, the refractive index of the central cylinder (18) needs to be lower than the one of the materials composing the 2D circular photonic crystal (16) around it. The entire structure is arranged on top of a metallic mirror (12).
To achieve optimal coupling of the light into a freely propagating beam, the photonic crystal and the central cylinder are truncated at a height 'h' (cf. Fig. 2). For example, more than 95% of the photons from an emitter/scatterer can be collected into the fundamental Gaussian mode using the antenna design. Additionally, the TOR is inherently broadband making the invention compatible with the vast majority of emitters available. Moreover, the TOR concept is very robust against displacements of the emitter position from the optimal position within the antenna. A TOR device according to the invention can be experimentally realized by using standard lithography techniques.

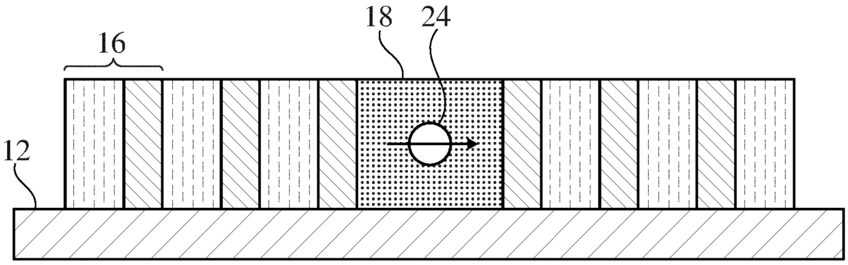

Fig. 3: Cross section of the device concept. The light emitter (24) in the is located within the central cylinder (18) and surrounded by the photonic crystal (16). A mirror (12) forms the base for the antenna.

Patent Information

PCT *(WO2022022830A1)*

Publications

W. Li *et al.* "*Truncated Metallo-Dielectric Omnidirectional Reflector: Collecting Single Photons in the Fundamental Gaussian Mode with 95% Efficiency*", ACS Photonics (2020)

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