Chiral polarization response of a nanophotonic device

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1. Introduction

Nanophotonic devices are becoming increasingly important for enabling the controlled and efficient production of photons in well defined modes of optical resonators and waveguides. A particular class of such devices which has seen extensive application in recent years is that of evanescently coupled waveguides which can be used to create fiber-coupled single photon sources or to couple light to other nanophotonic systems. However, evanescent coupling typically results in equal intensities coupled to either port of the waveguide, leading to a 50% if it is desired to send photons to a particular receiver.

Recently, it has been noted that nano-waveguide modes exhibit strong chirality – that is their forward and backward propagating modes have near-orthogonal circular polarizations. This allows deterministic channeling of photons to either output port, and thus deterministic coupling of distant spins coupled to the same waveguide. For this reason, nanowaveguides are expected to play an important role in future quantum networks.

Here we report a fundamental experimental characterization of such a device, including its polarization response over the entire Poincare sphere, along with measurements of scaling behavior of the response. We also discuss possible applications to detection of single and multiple emitters on the waveguide surface.

2. Method and results

Experimental method

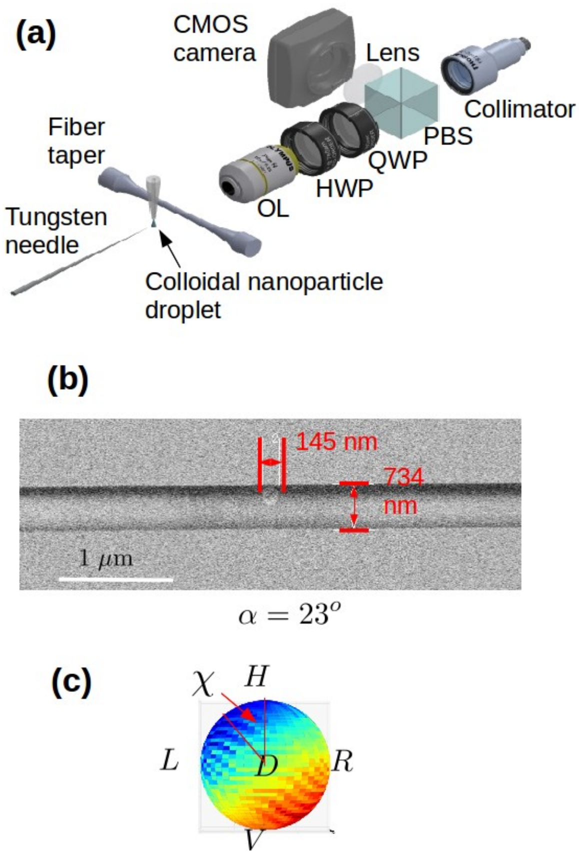
As a nanowaveguide, we use an optical nanofiber. A single gold nanosphere on the nanofiber surface acts as an optical antenna, re-radiating incident light while preserving its polarization. By controlling the incident light polarization state over the entire Poincare sphere, the two-port polarization response of the nanofiber may be measured. (Figure 1(a)). This response is defined as the intensity at either output port of the fiber as a function of the polarization state.

Results

Single gold nanospheres are deposited from a colloidal solution onto the nanofiber surface with a success rate close to 50%. Figure 1(a) shows an example of such a deposition. The sample may then be used to measure the polarization response of the nanofiber. Figure 1(c) shows the polarization response for one output port for the sample shown in Fig. 1(c). The angle χ indicates the rotation of the response function away from the vertical.

The parameter χ can be used to define the chirality of coupling to the nanofiber guided modes. χ also obeys a simple, one parameter scaling function, with the practical result that measurements of χ for any nanofiber radius / illumination wavelength or particle position α can be described by a single curve [1].

Finally, we note that the position of the minimum of the polarization response function on the Poincare sphere can give information about whether single or multiple particles are responsible for scattering the input light, giving a new method for quantitative detection of nanoparticles.



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References

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