Epsilon-Near-Zero Grids for On-chip Quantum Networks

Realization of an on-chip quantum network is a major goal in the field of integrated quantum photonics. A typical network scalable on-chip demands optical integration of single photon sources, optical circuitry and detectors for routing and processing of quantum information. Current solutions either notoriously experience considerable decoherence or suffer from extended footprint dimensions limiting their on-chip scaling. Here we propose and numerically demonstrate a robust on-chip network based on an epsilon-near-zero (ENZ) material, whose dielectric function has the real part close to zero. We show that ENZ materials strongly protect quantum information against decoherence and losses during its propagation in the dense network. As an example, we model a feasible implementation of an ENZ network and demonstrate that information can be reliably sent across a titanium nitride grid with a coherence length of 434 nm, operating at room temperature, which is more than 40 times larger than state-of-the-art plasmonic analogs. Our results facilitate practical realization of large multi-node quantum photonic networks and circuits on-a-chip.

Cryogenic characterization of titanium nitride thin films

It is well known that noble metals are not compatible with silicon fabrication processing due to their low melting point, and that their plasmonic behaviour suffers from the material losses at visible wavelengths. As an alternative, titanium nitride has been highly investigated in order to overcome these challenges. High temperature characterization of TiN films has been performed, showing its CMOS compatibility; however, information on intrinsic losses at lower temperatures is still lacking. Here we experimentally investigate the optical properties of a 100 nm TiN film under low temperatures down to 1.5 K. From the reflection measurements we retrieve the dielectric constant and analyze plasmonic applications possibilities.
Optical properties of titanium nitride films under low temperature

Transition-metal nitrides represent a class of materials receiving growing interest due to their high melting points, providing compatibility to Si platforms, as well as similar optical properties to noble metals such as gold or silver [1]. However, most of quantum photonics platforms operate at low temperatures, meaning that the optical properties of these materials are expected to change. In this paper, we report the measurement of the reflection spectrum of a 100 nm thick film of titanium nitride (TiN), submitted to cryogenic temperatures. By fitting the data to the Drude-Lorentz model and using the transfer matrix method [2] we were able to retrieve its permittivity, as depicted in Fig. 1. From the permittivity curves we also extracted other properties, such as the quality factor of localized surface plasmons and surface plasmons polaritons [3]. We hope that these results will facilitate the design of metamaterials and other devices aiming integration of TiN with quantum devices.

Epsilon-Near-Zero Systems for Quantum Optics Applications

The Epsilon-Near-Zero (ENZ) supercoupling effect allows electromagnetic radiation to be fully transmitted through narrow distorted channels. ENZ materials are also able to control emission and interaction of quantum emitters. Here we propose the combination of both properties in order to facilitate distant quantum emitters interaction and form what we call an ENZ network for quantum applications. We show that such systems present very low losses and are able to coherently transmit radiation, making possible to excite other emitters or nanoparticles with high efficiency.
Determination of viscosity through terminal velocity: use of the drag force with a quadratic term in velocity

A correction to the term with quadratic dependency of the velocity in the Oseen’s drag force by a dimensionless factor is proposed in order to determine the viscosity of glycerin through the measurement of the terminal velocity of spheres falling inside the fluid. This factor incorporates the effect of the container’s wall over the movement of the spheres, analogously to the correction of the Stoke’s force by the Landenburg factor, and permits to make the Oseen’s force compatible with the experimental data for the drag coefficient up to Reynolds number near 30. Admitting a proportionality relation between these factors, the viscosity coefficient turns into a linear coefficient in the relation between the parameter that corresponds to the viscosity that would be determined if only the Stokes’ force was considered and the product of the terminal velocity by the diameter of the spheres. The experiment with steel spheres falling inside tubes of different diameters showed values for the viscosity coefficient of glycerin compatible with the expected, for the temperature range worked. This method might be applied to Reynolds number of order of ten of the sphere’s motion, relaxing the restriction of working with Reynolds numbers inferior to 0.5 for the determination of the viscosity through the Stokes’ method.

Laguerre-Gauss beam generation in IR and UV by subwavelength surface-relief gratings

The angular momentum of light can be described by the states of spin angular momentum, associated with polarization, and orbital angular momentum, related to the helical structure of the wave front. Laguerre-Gaussian beams carryorbital angular momentum and their generation can be done by using an optical device known as q-plate. However, due to the usage of liquid crystals, these components may be restricted to operate in specific wavelengths and low powersources. Here we present the fabrication and characterization of q-plates madewithout liquid crystals, using processes of e-beam lithography, atomic layerdepositions and dry etch techniques. We exploit the phenomenon of formbirefringence to give rise to the spin-to-orbital angular momentum conversion. We demonstrate that these plates can generate beams with high quality for the UV and IR range, allowing them to interact with high power laser sources orinside laser cavities.
Verification of Malus's Law using a LCD monitor and Digital Photography

An alternative laboratory experiment for verifying Malus's Law, as well as understanding concepts of photometry, polarization and image formation on liquid crystal displays using low cost materials is proposed. The experimental setup could be introduced to any undergraduate curriculum using readily available tools, such as a digital camera, polarizer removed from a cell phone and a LCD laptop screen. A fairly amount of photometric data was collected and analyzed by an astronomical image processing software resulting in a successful verification of Malus's Law.
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**Activities:**

**Optical properties of titanium nitride films under low temperature**
Period: 30 Jan 2019 → 31 Jan 2019
Larissa Vertchenko (Guest lecturer)
Department of Photonics Engineering
Degree of recognition: National
Documents:
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**Related event**

**Danish Optical Society Annual Conference 2019**
30/01/2019 → 31/01/2019
Copenhagen, Denmark
Activity: Talks and presentations › Conference presentations

**Quantum emitters in Plasmonic Epsilon-Near-Zero Medium**
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Larissa Vertchenko (Guest lecturer)
Department of Photonics Engineering
Degree of recognition: Local
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**Related event**

**Danish Optical Society Annual Conference 2017**
09/11/2017 → 10/11/2017
Lyngby, Denmark
Activity: Talks and presentations › Conference presentations