the larger one. We report the experimental dependence of the frequency shift as a function of power and demonstrate a good agreement with the circuit calculations. We also experimentally confirm polarisation sensitivity of the non-reciprocal interaction. All the experiments were performed in the dark to prevent parasitic illumination of the PDs.

The designed meta-atom opens exciting opportunities to impose a novel control mechanism over microwave signals. For example, a chain of such elements supports two initially independent magnetoinductive waves with orthogonal polarisations, which can propagate along the chain without direct interaction: one of the waves only drives the sequence of PD-SRRs while the other one only drives the sequence of the LED-SRRs. However, by varying power of wave transmitted with the LED-SRR polarisation, we will launch an optical feedback onto the chain of PD-SRRs and thus alter its dispersion characteristics despite the lack of coupling between the two subsystems in the linear regime. This feedback mechanism is promising for applications in signal processing and filtering, as well as for tuning and sensing.

9125-38, Session 9

Static and dynamic properties of third harmonic generation in fishnet metamaterials

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The angular dependence of third harmonic generation in fishnet metamaterials and its transient properties on the subpicosecond time scale were studied.

The proposed fishnet metamaterial was defined by e-beam-lithography and lift-off technique on a SiO2 substrate. It represents a multilayer structure of Au-MgO-Au films 20-35-20 thick. The structure has a period of 500 nm in both lateral directions.

Spectroscopy of the linear absorption for different angles of incidence with the angle varying from 0 to 50 degrees was carried out. The normal incidence IR absorption spectrum demonstrates an absorption peak at 1.54 ?m corresponding to the excitation of the magnetic plasmon mode, which position is blue-shifted as the angle of incidence is increased. For the nonlinear measurements a setup based on an optical parametric amplifier (OPA) was used operating at wavelengths of 1.49, 1.54, 1.56, and 1.60 ?m and having an average output power of 3 mW focused to a 300 ?m spot from the air side of the sample. The OPA was pumped by a Nd:YAG laser with a pulse duration of 5 ps and a repetition rate of 5 kHz. The resulting fluence took values up to 700 ?J/cm2 in the plane of the sample. The sample was placed on a six-axis positioning stage so that during the angular spectroscopy the beam was always focused into the same spot. The forwardly propagating third harmonic generation (THG) signal pulses were detected by a photomultiplier tube and gate-integrated by an oscilloscope. We used the p-p polarization configuration—illuminating with p-polarized light and selecting only the p-polarized part of forward propagating light before the detector. For all measurements spectral filtering before the detector was used for picking up the desired wavelength. The averaged THG signal from the pure SiO2 substrate measured outside the metamaterial area was at least one order of magnitude lower than that from the metamaterial area. Contributions from the substrate were therefore safely neglected.

For investigation of transient properties we use pump-probe technique. A laser beam from a femtosecond fiber laser with a central wavelength of 1.56 μm and pulse duration about 180 fs is split by the polarizing beam splitter into two channels, one of which allows us to bring time delay between two pulses by a mechanical translator. The average power of laser beam in two channels was up to 20 mW that corresponds to peak intensities up to 25 kW/cm2. Laser beams from two channels were focused by the objective lens onto the sample with waist about 25 μm and behind it were collected by the lens to the photon-multiply tube. To increase the ratio of signal to noise we use the lock-in technique with two modulation frequencies in two channels. It allows us to measure at summary frequency for separating only mutual influence of two pulses. Using the additional filters we determined that the spectral position of the detected signal corresponds to the triple frequency of the pump radiation.

9125-39, Session 9

Frequency-resolved optical gating of one-dimensional plasmonic crystals

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The resonant interaction between the surface charge and the electromagnetic field of the light constitutes the surface plasmons polaritons and gives rise to its unique properties [1]. Oscillations of such nature allow one to use plasmonic nanostructures as devices that control the optical radiation on micro- and nanoscale. Femtosecond-scale polarization state shaping has been experimentally found recently in optical response of a plasmonic nanograting by means of time-resolved Stokes polarimetry [2] based on the intensity autocorrelation scheme that is the most common technique to examine ultrashort pulses because it is easy to set up and use. But the information of the electric field phase is lost in such a measurement. Frequency-Resolved Optical Gating (FROG) which was invented by R. Trebino et al. [3] is one of the technique for retrieving both the amplitude and phase of the field.

In this work ultrafast dynamics of surface plasmons in one-dimensional plasmonic crystals is studied experimentally by using FROG technique.

Several techniques can be used to excite surface plasmon. One of them is a periodic perforation of the metallic surface. One-dimensional perforated metal film fabricated by laser interference lithography is used to study the excitation of surface plasmon-polaritons. The sample is 50-nm-thick gold film sputtered onto the grating of the of 0.8-?m-thick photoresist on a quartz substrate. The reflectance spectra show two pronounced minima corresponding to the edges of the plasmonic band gap (792 nm and 842 nm), the distance between them increases with increasing the incidence angle.

For measurements of the surface plasmon dynamics the technique of frequency-resolved optical gating (FROG) was used. Spectrograms were measured for the pulses normally reflected from the sample. The wavelength was chosen near edges of the band gap (792 nm and 842 nm). The spectrograms show very distinctive peculiarities for the case of surface plasmon excitation configuration: for p-polarized incident light there are significant changes as the pulse width and spectral characteristics at wavelengths near edges of the plasmonic band gap. The features are associated with resonant excitation of surface plasmon polaritons. The amplitude and phase of the pulses are extracted from the spectrogram series. The phase sensitivity of the technique allows us to reconstruct non-symmetric plasmon-assisted reshaping of the femtosecond pulses.

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