Linear and nonlinear THz spectroscopy of materials and metamaterials

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Abstract—We report on our activity in time-domain terahertz spectroscopy. We perform broadband (0.2 – 18 THz) or nonlinear (with THz fields amplitudes up to 400 kV/cm) tests of material properties of chalcogenide glasses and transparent conductive oxides. Also we address design and characterization of different polarization-controlling devices, whose performance is based on the principles of metamaterials functioning.

Keywords—terahertz spectroscopy; metamaterial; nonlinear; broadband; polarization; chalcogenide glass

I. INTRODUCTION
Progress in new methods for generating and detecting terahertz (THz) radiation [1] has spectacularly increased the interest of its applications in a variety of fields, e.g. in spectroscopy of organic tissues, chemical compounds, proteins and solid materials. We report on our activity in time-domain THz spectroscopy (TDTS) developed in two main directions.

II. TIME-DOMAIN SPECTROSCOPY OF MATERIALS
The first one is the extreme TDTS of natural materials (in our case – chalcogenide glasses and transparent conductive oxides), which includes either a broadband (0.2 – 18 THz range) or nonlinear (with THz fields amplitudes up to 400 kV/cm) tests of material properties. The broadband analysis reveals the breakdown of the universal power-law dependence of the absorption coefficient due to atomic vibrations observed at low THz frequencies in disordered materials, and transition to localized vibrational dynamics for some compounds at higher frequencies [2].

The tests on terahertz-field-induced third-order (Kerr) nonlinear optical properties of amorphous chalcogenide glasses (As$_2$S$_3$ and As$_2$Se$_3$) allow retrieving nonlinear THz coefficients, which are comparable to those at the optical frequencies [3].

III. TIME-DOMAIN SPECTROSCOPY OF METAMATERIALS
The second direction is connected with advances in THz metamaterials and metasurfaces. The ability of metamaterials to manipulate electromagnetic waves makes them natural candidates to be probed as THz optical components. We report on design and characterization of different polarization-controlling devices, for example, universal polarizers, filters, rotators, absorbers, whose performance is based on the principles of metamaterials functioning [4-7]. The theoretical findings and modeling results are in full consistency with measurements. Advances in fabrication of free-standing membranes and multilayer metal-dielectric structures [4, 5] will be covered as well.

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REFERENCES