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Modal Composition of a Terahertz Pulse in a Parallel-plate Waveguide Partially Filled with a Nonlinear GaSe or DAST Crystal

Prof. A. S. Nikoghosyan[1], Prof. V. R. Tadevosyan[1] and A. A. Pogosyan[2]*

[1]Department of Radiophysics and Electronics, Institute of Physics, Yerevan State University, Armenia

[2]Master's Student in Physics, Yerevan State University, Armenia

Abstract

A numerical analysis of terahertz (THz) pulse propagation in a metal parallel-plate waveguide partially filled with a nonlinear crystal (PPNW) is presented. A femtosecond laser generating a linearly polarized optical pulse with a duration of 100 fs is employed for both pumping and detection of broadband THz pulses. Terahertz radiation is generated via optical rectification of the optical pulse in a nonlinear crystal that partially fills the waveguide cross-section. Nonlinear crystals such as GaSe and DAST are considered efficient frequency converters in the THz range.

The modal composition of the THz pulse in the waveguide is analyzed numerically using MATLAB and COMSOL Multiphysics. The analysis is performed for two types of optical–THz interaction, namely eoo and eee, using both experimental and modeled refractive indices in the THz frequency range.

It is shown that decreasing the crystal thickness between the waveguide plates leads to an expansion of the single-mode propagation bandwidth of the THz pulse spectral components. In particular, for a GaSe crystal with both thickness and height equal to 0.1 mm, the fundamental TE_{10} mode spans the frequency range from 0.2 to 3 THz, while reducing the thickness to 60 μm extends this range up to 5 THz. These results provide guidelines for optimizing single-mode THz generation and propagation in hybrid waveguide structures.