335. Title:Theoretical investigation of terahertz amplifier by carbon nanotubes within transmission line metamaterials
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Abstract:Terahertz (THz) power amplification in coplanar waveguide composite right left-handed transmission line (CPW CRLH TL) metamaterials with carbon nanotubes (CNTs) has been investigated. The negative differential resistance (NDR) behavior of the CNTs with appropriate DC voltage bias, which can be characterized as the feature of the Gunn-type oscillator, Esaki-like diode, or field effect transistor (FET), is used to provide the THz loss compensation/gain. From introducing gaps in the central signal line and short-circuited stubs connected between the CPW central signal line and the ground are used to realize the left-handed (LH) series capacitance CL and LH shunt inductance LL, respectively. The equivalent circuits model approach and effective medium method are employed to study the propagation constant γ = α + jβ of the CNT-based active THz metamaterials, which are validated by three-dimensional (3D) full-wave finite element (FEM) and circuit model co-design. Results indicate not only the negative attenuation constant α (gain) provided by CNTs but also the negative phase constant β (backward wave propagation with anti-parallel phase and group velocities) by artificial TL configuration at THz frequency region. This planar structure could be used to design tunable THz devices with different DC bias voltage and also easily extended to two-dimensional (2D) and 3D active microwave, IR, or optical metamaterials at room temperature.