Reflectivity spectra of GaAs/AlAs Distributed Bragg Reflector in the MIR Calculated by the Transfer Matrix Method

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Photonic structures play an important role in tailoring the emission properties according to the requirements of a specific application. There are applications demanding vertically emitting lasers operating in mid-infrared (MIR), as e.g., some of the optical gas sensing schemes. In that context distributed Bragg reflectors (DBRs) are typically used. The DBRs constitute of many pairs of alternating layers of two high-refractive-index contrast dielectric/semiconductor materials, which in epitaxial structures need to be lattice matched to the substrate to avoid strain accumulation. For this purpose it has been proposed a standard and technologically mature material - GaAs/AlAs. It is technologically demanding as the DBR need to be much thicker than for the shorter wavelengths resulting in longer growth process during which precise control of layer thicknesses needs to be maintained. In this case, only the thickness of each layer needs to be up-scaled for the longer wavelengths.

Our work aims at calculating reflectivity spectra of DBR structures designed for the MIR range by employing the transfer matrix method. The structure contains GaAs/AlAs DBR. The transfer matrix method is based on considering the amplitudes of electric field during the propagation of an electromagnetic wave through the structure and includes propagation within a material of a given refractive index and thickness, as well as reflection and transmission at each of the interfaces. By using the common notation, the light propagation in the whole structure can be represented by a 2D array called a transfer matrix [1-4]. The method was implemented in Python and used to calculate the reflectivity spectra of the DBR. Through such simulation, we are able to match the values of thicknesses of layers and types of materials of such a structure before fabrication in order to optimize its design. This is a crucial contribution to the self-consistent design-fabrication-measurement of optical properties loop and allows for broad range parameter study to understand the sensitivity of the reflectivity spectrum on the structural parameters.

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