ISSN 0735-2727, Radioelectronics and Communications Systems, 2015, Vol. 58, No. 8, pp. 378–383. © Allerton Press, Inc., 2015.
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Amplitude and Phase-Frequency Characteristics of the Magneto-Optical Modulator Based on the Bimorph Element in the Mode of Magneto-Mechanical Oscillations[1]

I. V. Linchevskyi[1*] and A. V. Skripets[2]

[1]*National Technical University of Ukraine "Kyiv Polytechnic Institute", Kyiv, Ukraine*
[2]*National Aviation University, Kyiv, Ukraine*
**e-mail: igorvl2009@gmail.com*

Received in final form December 15, 2014

Abstract—This article presents the theoretical calculations of spatial distribution of the amplitude and phase characteristics of the Stokes vector for a magneto-optical modulator based on the magneto-optical crystal in the framework of a bimorph plate of rectangular shape for the fundamental mode of magneto-mechanical oscillations. The geometry of the magnetic fields and the direction of light propagation relative to the crystallographic axes provide the occurrence of linear and quadratic magneto-optical effects with respect to the magnetic field. It has been shown that due to the phase delays of voltages, which are excited in the bimorph plate in the frequency range of fundamental acoustical mode, the elements of the Stokes vector of the output radiation obtain spatially dependent amplitude variations within 10% range and phase variations within the range of π.

DOI: 10.3103/S0735272715080063

INTRODUCTION

A magneto-optical light modulator based on the bimorph element allows one to obtain a two-dimensional distribution of the rotation angle for the polarization plane using the light beam cross-section [1]. This distribution is achieved by the alteration of magnetization of the magneto-optical crystal (MOC) in the case of shear deformation in the bimorph structure of the modulator. On the other hand, in order to provide the conditions for magneto-mechanical oscillations in a bimorph structure the magneto-optical crystal is placed in a constant (polarizing) and in an alternating magnetic field with the given frequency. In this case the direction of the magnetic fields must be parallel to the plane of a bimorph plate. As a result, the light, which propagates through the magneto-optic crystal, obtains constant and variable ellipticity, which varies with the frequency of the alternating magnetic field. Therefore, in addition to the modulation, which is caused by the Faraday effect, in the considered modulator there is the polarization component caused by the Cotton–Mouton effect.

In the process of magneto-mechanical oscillations of bimorph element in addition to shear deformations there occur compression-tension deformations, which also result in corresponding additional variations of the magnetization. In [1, 2] the calculation and investigations of oscillations of bimorph plates have been carried out taking into account only their amplitude-frequency characteristics. However, the oscillations in the frequency range of magneto-mechanical resonance are inevitably accompanied by the phase-frequency responses of voltages with respect to the exciting force. Consequently, due to the deformations distribution in the volume of the bimorph element the polarization characteristics of a modulator across the light beam cross-section in addition to the amplitude-frequency distribution will also be characterized by phase-frequency distributions in the frequency range of magneto-mechanical resonance.

The purpose of this work is the investigation of peculiarities of spatial distribution for the amplitude and phase polarization characteristics of the light modulator based on MOC in the framework of a bimorph rectangular plate in the frequency range of the fundamental mode of magneto-mechanical oscillations.

[1] This research was performed as part of R&D work s/r No. 0114u003916.