Краткий научный отчет проекта РФФИ 14-29-0812014 (2014-2016), рук. А.В.Царев
(на английском языке)

The comparative analysis and optimisation of optical switches and modulators for radio photonics on the basis of electrooptical polymers, head by Dr.A.Tsarev

The contribution of various factors influencing on operation of the rib polymer waveguide electrooptical (EO) modulator with capability to pass the high level of optical power (up to 100 мВт) has been studied. It is shown that for correct calculation of performances of the traveling wave EO modulator it is necessary to consider a heterogeneous poling of a electrooptical polymer by electrodes of the modulator, a microwave dispersion of a polymer permittivity and a finite conductivity of the electrodes, and also the effect of the possible tunnel coupling between the shoulders of the Mach-Zehnder interferometer. Numerical calculations and structure optimization are fulfilled taking into account all these factors for the electrooptical Mach-Zehnder modulators on the basis of a multimode interference (MMI) and the coupled waveguides. It is shown that the insertion of additional insulating strips (especially from High-K dielectrics with the high permittivity, for example from MgO) provides the considerable (up to 2.8 times) reduction in driving voltage and increase (2.4 times) the RF bandwidth compared with a case of the analogous electrooptical modulator, but without these strips.

All these are owing to the two complementary effects:

(a) Shifting of a maximum of an electric field in the area of the rib waveguide during the polymer poling by driving electrodes of the modulator. It provides the peak value of electrooptical coefficient in the area of optical mode propagation in the rib waveguide and, thereby, it leads to reducing (to one and a half times) of the driving voltage on comparing with a case of the standard modulator in the same electrooptical polymer.

Appropriate decreasing of the microwave velocity provides the best matching with the group velocity of the guided optical mode propagating in the modulator that leads to broadening of operating frequency range. It magnifies the relative (on comparing with a case without dielectric strips) efficiency of electrooptical control which grows with the operating frequency and with increasing of electrode length of the travelling wave EO modulator.

The proposed construction of the EO modulator on the base of the High-K dielectric and the high quality polymer DH-80 (with the effective electrooptic constant 80 pm/V) have a half-wave voltage (Vpi) from 0.8 to 2.2 V (for the frequencies from 1 to 100 GHz)/

Let us note that joint utilization of MMI dividers 1x2 and 2x2 provides the working point of the electrooptical modulator without the additional electrical fine-tuning. And the working driving voltages for switching between states «0» and «1» decreases in 2 times (equally to +/- Vpi/2). Besides, the possibility of simultaneous usage of two optical outputs in a regime of the signals difference is twice to increase the measured optical power as well as decreases the noise. The EO modulators on the basis of MMI are very technological and our calculations show that they are capable to provide - 35 dB signal suppression in a state «0».

For the compensation of the technology tolerance of the EO modulator with the power dividers on the basis of the directional couplers and also for reducing of parasitic coupling effect of power between shoulders in the Mach-Zehnder interferometer, is offered to use additional driving electrodes locating in the area of the directional couplers. The last provides the additional fine-tuning of the division ratio, necessary for optimal operation the EO modulator with the high level of suppression of a spurious signal up to -50 dB.

The results obtained in this project, reveal the new possibilities to decrease of driving voltage of electrooptical modulators to level of order of 1 volt (especially on frequencies of order of 100 GHz) that can lead to qualitative changes in an electronic components for the radio photonics since will allow to use low-voltage RF electronic components, which are more power effective and low-cost and in comparison with that are used at the present time.