폴리머 크래딩을 이용한 저손실 표면플라즈몬 광도파로 개발
Development of low-loss surface plasmon waveguides by using polymeric cladings

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Abstract

We investigate characteristics of gold and silver metal strip waveguides based on long range surface plasmon polaritons (LRSPPs) along thin metal strips embedded in a polymer for practical applications at the wavelengths of 1.31 and 1.55 um. Guiding properties of the metal strip waveguides are theoretically and experimentally evaluated. In addition, surrounding technologies such as the development of TM-mode laser, coupling properties, as well as high-speed digital signal transporting experiments will be explained for board-to-board optical interconnections by using the LRSPP waveguides.

Transmission of high-capacity digital information by means of optical interconnection (OIC) has been considered as a promising technology to solve the predicted transport limit (2.5 Gbps per channel) of copper lines on integrated circuits.[1] OIC can offer decreased interconnect delays and provide the higher bandwidth, with resistance to an electromagnetic interference and a low power consumption. Since these are key issues in computers or mobile devices, several optical technologies such as planar optical circuits, silicon photonics, and photonic crystals have been developed, and recently plasmonic circuits have been proposed as an emerging technology.[2] The plasmonic waveguides support anti-symmetric and symmetric guided modes depending on their mode field distributions. The former is tightly bound to the metal strip, meaning that the evanescent decay lengths in the dielectric are less than half of the wavelength. Since this feature can provide photonic circuits with length scales much smaller than the diffraction limit of the light waves, plasmonic devices in nano structures have been actively studied [3]

On the other hand, the symmetric guided mode has also unique properties of long-range propagation with relatively low loss. Many functional devices, such as optical attenuators [4], filters [5], couplers [6] and switches [7] have been demonstrated for integrated optical applications. However, the LRSPP waveguides themselves for the OIC applications have attracted less attention due to their larger propagation loss than in dielectric multi-mode waveguides. As is common in most nascent technologies, the propagation loss is improving. In recent progress, we have reduced the propagation loss down to 0.6 dB/cm in the LRSPP waveguide. In addition, LRSPP waveguides can provide various mode field diameters depending on the metal strip thicknesses and widths. This is a distinct advantage in the point of view that we can control the light coupling efficiency between the waveguides and the light sources or the detectors. Furthermore, the fabrication of LRSPP waveguide is simpler than that of dielectric multi-mode waveguides, where one needs deep etching or imprinting for patterning the thick cores. Instead, the thin metal core strips can be easily made by vacuum deposition on a pre-defined surface by photolithography. The metal cores are also compatible with flexible polymer claddings and substrates, which is an important requirement in flexible printed circuit boards, and also have good mechanical stability in repeated bending due to the thin film nature of the metals. Thus, plasmonic waveguide is a candidate for cost-effective and suitable transmission lines for OIC.

The limit of data rate in the light transport in an optical waveguide depends on modal delay and dispersion. The modal delay in multi-mode waveguides is the main origin of the limit. However, LRSPP waveguides support just one mode in cm-length scale that their data rates are not constrained by the modal delay. The dispersion of LRSPP waveguides is strongly depends on their interface geometry, but the dispersion effect is to be minor as is in case of the single mode fiber transmissions.

In this presentation, we will show the characteristics of our developed LRSPP waveguides. In addition, surrounding technologies such as the development of TM-mode laser, coupling properties, as well as high-speed digital signal transporting experiments will be explained for board-to-board optical interconnections by using the LRSPP waveguides.

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