금속 박막의 광학상수를 측정하기위한 광섬유 센서

Optical fiber sensor for measuring the optical constants of metal films

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A fiber-to-planar waveguide coupler is of great interest for optical communication systems and many sensor applications because this in-line component offers distinguished features including low insertion loss, low back refraction, and good mechanicalstability. Through the use of the coupler as a channel drop filter, modulator, polarizer, refractometer and various sensors have been successfully demonstrated.[1,2]

In this work, we have proposed a fiber optic sensor for evaluating optical properties of a metal film based on the fiber-to-PWG coupler. Herein a thin metal film is employed as a cladding of PWG. The optical device considered in the current study consisted ofa side-polished single-mode fiber covered with a multi-mode PWG with a metal cladding,as shown in Fig. 1. For a simple analysis, the single-mode fiber was replaced with an equivalent PWG, and then the device is modeled as a one-dimensional multilayer PWGas shown in Fig. 2. The device is divided into input, output and coupling section. The normal mode theory is adopted to calculated transmission from input section to output section. The structural parameters considered to be constants in the analysis, s, tp, and L, were 4.0 μm, 10.0 μm , and 1.2 mm, respectively. The refractive index for each layer is denoted in Fig. 2. The Fresnel reflections at the two interfaces and material dispersion were not taken into account. First, we have calculated the wavelength responses of TM polarization for various dielectric constants of the metalwhose values are given as complex. For example the complex dielectric constant represented as $Kr + j\ Ki$ of Al, Au, Ag and Ni are about -154-j30.0, -108-j7.4, -81-j5.0, -26-j37.2 around 1310nm wavelength, respectively.[3] Here, tmis assumed to be optically infinite.

The experimental results presented in Fig.3 shows the wavelength selectivity as well as resonance position of the coupler also strongly depended on the kind of metals used for cladding of the PWG. The thickness of the polymer layer which inferred from the resonance peaks of the device with no metal layer(i. e. air superstrate) is 11.1μm. The relevant coupling length (L) is 1.0 μm under s=4.0 μm. The *Kr* and *Ki*of the employed metals have been obtained in a such way that both measured resonance position and resonance depth(extinction ratio) are coincide with those of the theoretical results. The Fig. 4 shows the calculated wavelength responses of the device under experimental condition exploiting the acquired dielectric constants of the metal claddings The obtained dielectric constants of the metals which are written in Fig. 4 except NiCr are similar with results of reference. This result implies that the unknown optical constant of a metal like NiCr ally can be determined at a concerning wavelength.

In conclusion, the fiber-to-PWG coupler as a spectral sensor for measuring the optical properties of metal films were investigated experimentally and theoretically. It is demonstrated that the coupler is a useful tool to evaluate the optical properties of the metal film through the monitoring the wavelength responses.

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[2] W. G. Jung, S. W. Kim, K. T. Kim, E. S. Kim, and S. W. Kang, High-sensitivity temperature sensor using a side-polished single-mode fiber covered with the polymer planar waveguide, *IEEE Photon. Technol. Lett.*, 13 , 1209-1211 (2001)
[3] M. A. Ordal, L. L. Long, R. J. Bell, S. E. Bell, R. W. Alexander Jr, and C. A. Ward, Optical properties of the metals Al, Co, Cu, Fe, Pb, Ni, Pd, Pt, Ag, Ti, and W in the infrared and for infrared, *Appl. Optics*, 22 , 1099-1120 (1983).

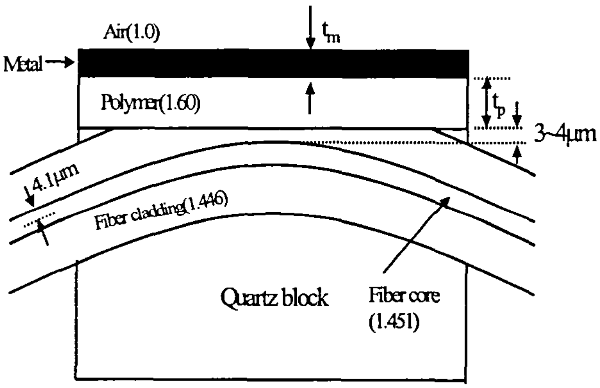

Fig. 1. Proposed sensor structure.

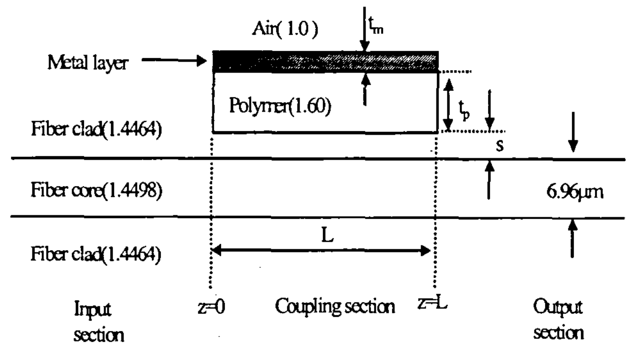

Fig. 2. Equivalent modeling of sensor

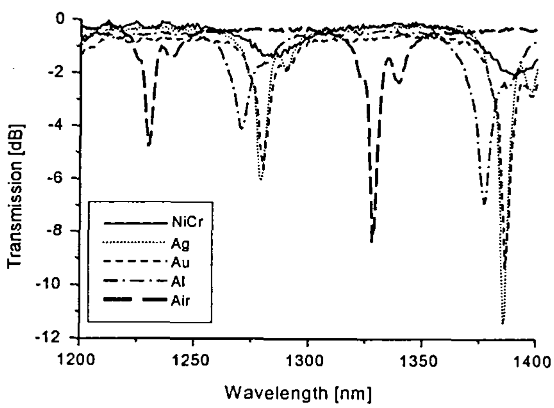

Fig. 3. Spectral responses of sensor for various metal clads.

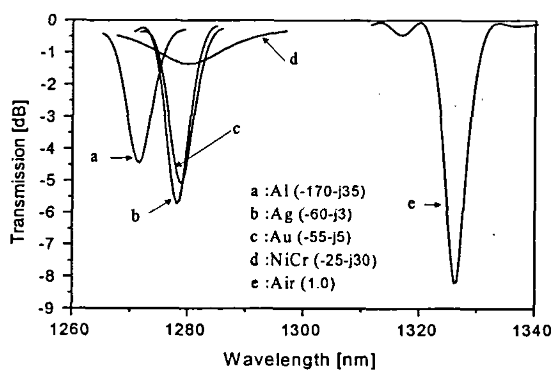

Fig. 4. Theoretical results for experimentor conditions.

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