광섬유 다발을 이용한 비접촉식 용액굴절계
Noncontact liquid refractometer using a fiber bundle

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Abstract

We have proposed and demonstrated noncontact refractometer incorporating a fiber bundle. The fiber bundle is composed of a TEC(thermally expended core) fiber and hundreds multimode fibers. The fiber is designed in such a way that the detected reflected optical power from a liquid is constant against the distance between fiber bundle and liquid surface. Low differactive characteristic of TEC fiber make it possible to increase the available distance between the fiber bundle and liquid surface, The obtained sensitivity, optical intensity variation by change of refractive index of liquid is 0.4.

I. Introduction

The measurement of the refractive index of liquid is an important in fields of material processing and food industry. The fiber-optic liquid refractometers using fiber grating[1], D-shape fiber[2], and side-polished fiber[3] have been extensively studied. All those sensors are invasive type. That is, the sensing region should be contact with liquid. If the liquids are toxic such as acids, those invasive type is no longer available for measurement of the refractive index.

In this paper, we proposed and demonstrated a simple fiber-optic noncontact liquid refractometer using a fiber bundle which is composed a single mode TEC(thermally expended core) fiber and several hundreds multimode fibers. The reflected optical power is a function of refractive index of liquid. The refractometer is designed in such a way that the detected reflected optical power from a air-liquid interface is constant against the distance between fiber bundle and liquid surface.

II. Operation principle and design concept

Optical source is launched into the TEC fiber and refracted light from the air-liquid surface is coupled into fiber bundle as shown in Fig. 1. The output optical beam of TEC fiber has smaller diffraction compared to that of standard single mode fiber. Therefore it allow to increase the distance between fiber bundle and liquids. Since the cross section area of fiber bundle is so wide that all reflected optical beam is within the end face of the fiber bundle.

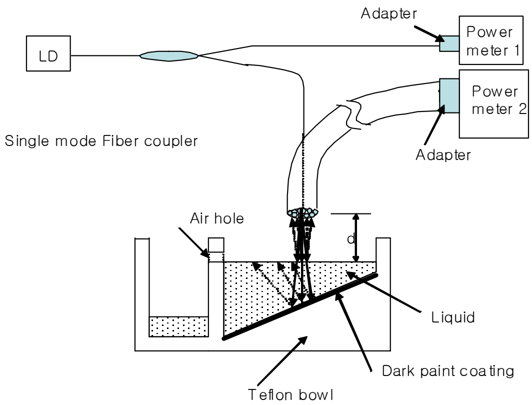
All optical power within fiber bundle surface can not reach photo detect because a part of light reflected at air-fiber interface and the light encountering fiber cladding and epoxy are lost. Only the light encountering fiber cores in fiber bundle can reach the photo detect. If the fibers are homogeneously distributed in cross section of fiber bundle the optical power captured by fiber cores is constant regardless of the distance.

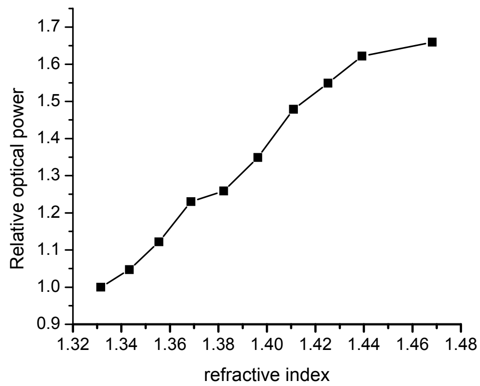
III. Experiment

The single mode fiber(SMF-28) for standard telecommunication is adopted for the fabrication of TEC fiber. A flame bushing method to expand the core thermally was used in this experiment. A single mode TEC fiber is located in center of the multimode fiber bundle. The fiber bundle consists of a single mode TEC fiber and several handled multimode fiber and its diameter is 2.0 mm. The fabricated fiber bundle is mounted on a stage. The light beam direction carefully adjusted to be perpendicular to surface of a liquid surface. Several liquid materials whose refractive indices to be measured were made of water-glycerin mixtures. The experimental results are shown Fig. 2. In this experiment, the water is used for reference material to measure the relative optical power. The detected optical power is increased as the refractive index of liquid is higher. The intensity variation to change of liquid refractive index, say, sensitivity is approximately 0.4. The key feature of the refractive includes no limitation in refractive index range.

IV. Conclusion

We have demonstrated non contact liquid refractometer based on a fiber bundle. The intensity variation to change of liquid refractive index is approximately 0.4.





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