Fiber-Optic Liquid Level Sensor Based on a Tapered Fiber Michelson Interferometer

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Abstract
A low cost, simple, and reflective in-line liquid level sensor based on a tapered fiber Michelson interferometer (TFMI) is proposed. In the study, the configuration, operation principle, experiment results and discussion for the proposed fiber-optic liquid level sensor are investigated. Experimental results show that the proposed TFMI sensor is extremely sensitive and linear in optical response. The liquid level sensitivity of about 0.383nm/mm can be achieved by the proposed sensor.

Many fiber optic liquid level sensors (FOLLSs) with hybrid and modified structures have been proposed [1-10]. These FOLLSs especially based on the in-line fiber interferometer have attracted much attention due to their miniature, lightweight, highly sensitive, corrosion-resistant, and especially non-electrical operation properties. Therefore, any parameters of the liquids are particularly suitable measured by a fiber sensor especially using in a storage tank of chemical or industry liquors.

A fiber-optic type of so-called continuous sensing the liquid level typically employs optical mode field reacted with the surrounding liquid by use of the well known long-period fiber grating: LPFG [1], bent side-polished plastic optical fiber [2], D-fiber [3], high-birefringence-fiber [4], fiber Bragg grating: FBG [5] and multimode fiber interferometer (MMFI) [6] have been reported. Another type sensing techniques are operated on the variation of mechanical pressure from liquid level change acting on the fiber sensor essence to make the optical signal changed. This type FOLLS with the configuration corporated the FBGs [7], and Fabry-Pérot Interferometer (FPI) [8] are measured the variations of reflection spectra to detect the liquid level have been also proposed.

In this study, we present a low cost, simple, and in-line liquid level sensor by using a tapered fiber Michelson interferometer (TFMI) which can be effectively fabricated by tapering a single-mode fiber (SMF), as shown in Figure 1. The TFMI have been applied to sensing the bending [9] and refractive index (RI) [10] and not yet utilized as a liquid level sensor. The new configuration of FOLLS based on the TFMI which is pasted onto a slice of uniform elastic-plastic to form a sensing element of bending cantilever, as shown in Figure 2. The bending curvature of the sensing element varies with the liquid level rising and makes the interference spectra shifts during the liquid level rises or drops.

Experimental results show that the proposed TFMI-FOLLS is very sensitive and linear in the optical response; a liquid level sensitivity of about 0.383nm/mm can be achieved.

References
Figure 1 Experimental setup of the proposed TFMI-FOLLS.

Figure 2 (a) Micrographs of the abrupt taper fiber made by a fusion splicer. (b) Configuration of the TFMI. W=45μm and L=0.5cm.

Figure 3 (a) Experimental reflection spectra of the proposed TFMI-FOLLS for various liquid levels (H). (b) Sensitivity of spectral shifts in the wavelengths dip of around 1620nm as indicated in the inset.

<table>
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<th>λ (nm/mm)</th>
<th>S1 (nm/mm)</th>
<th>S2 (nm/mm)</th>
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<tbody>
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<td>0.26</td>
</tr>
<tr>
<td>Dip2</td>
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<td>0.263</td>
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<tr>
<td>Dip3</td>
<td>0.095</td>
<td>0.383</td>
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Figure 4 Experimental results for wavelength shift with liquid level.