Measurement of nanometer displacement by using the optical interferometer based on only a 3x3 optical fiber coupler

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The optical interferometric system implemented based on optical fiber has the disadvantage of poor stability. For the case of acquiring nanometer scale displacement, the sensitivity depends heavily on the initial phase of the system. In a conventional interferometric system based on a 2x2 interferometer, having two input ports and two output ports, the interference signal varies sinusoidally with optical path-length difference (OPD). Thus, for the case of such a small displacement measurement, the initial phase or the operating point affects the sensitivity of the system. Unfortunately, the optical fiber-based system easily suffers from the drift of OPD even in a laboratory condition. To mitigate this issue, various studies have explored solutions, such as adding modulators to the interferometer and keeping the operating point at a constant phase. However, this approach often introduces complexity to the system and needs for additional equipment. In response, we have developed an optical interferometer using a 3x3 optical fiber coupler, creating a system that is impervious to changes in the initial phase drift. The slow drift of the system can be measured and compensated with the inherent phases of the 3x3 interferometer, thus the fast sensing signal can be measured with any initial phase without hurting the sensitivity. We present the optical interferometric system implemented solely with a 3x3 optical fiber coupler. With this, the minute displacement of the surface induced by ultrasound wave could be successfully measured. It means the ultrasound wave used for the non-destructive diagnostic of the structure in a harsh environment can be measured remotely in a safe place.