Evaluation of Measurement Properties Depending on Optical Coupling of Whispering Gallery Mode (WGM) Resonance – Based Diameter Measurement

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The micro-Coordinate Measuring Machine (CMM) is used for dimensional measurement of micro-parts, and the diameter of micro-CMM's probe sphere is crucial for the measurement accuracy and it needs to be known accurately. Various methods for measuring microsphere diameter are being developed, and these typically involve contact measurement using micro-CMM, Scanning Probe Microscopy (SPM), or other universal measurement tools, which often requires calibration with standards with known dimensions. In our previous study, we have proposed a method for measuring microsphere diameter using Whispering Gallery Mode (WGM) resonance. This method involves coupling a laser into the microsphere using a tapered optical fiber, measuring the wavelength at resonance, estimating the WGM mode number, and subsequently deriving the microsphere diameter by searching the solutions of the WGM dispersion equation. From a theoretical standpoint, this proposed method doesn't require calibration with standards due to the application of the strict WGM dispersion equation, which can uniquely determine the exact diameter. To ensure measurement accuracy with this method, two main factors need to be considered: the accuracy of the resonance wavelength measurement and the accuracy of the WGM mode number estimation. We have developed an accurate measurement method for WGM resonance wavelength and proposed a mode number estimation method. However, we don't have information about the actual mode inside the microsphere because the electric field is invisible, and thus the accuracy of the mode number estimation method can't be ensured. To make it clear t hat how the WGM electric field is distributed inside the microsphere, we proposed a method to measure the WGM electric field distribution on the microsphere surface with a Scanning Near-field Optical Microscopy (SNOM) probe. In this study, we use the SNOM probe to measure the 2-dimensional WGM electric field distribution, and then we can obtain the information about the WGM optical coupling, which determines the mode numbers and the location of the WGM excitation. Based on the evaluation of the measurement properties, we can verify the accuracy of the mode number estimation method, and we can also know the position and range of WGM, which depends on the optical coupling of tapered optical fiber and microsphere. Furthermore, we can adjust the position of the tapered optical fiber to guide the WGM excitation in different planes inside the microsphere, achieving the measurement of the microsphere diameter distribution. The above work can significantly contribute to the accurate dimensional measurement of micro-CMM for micro-parts.