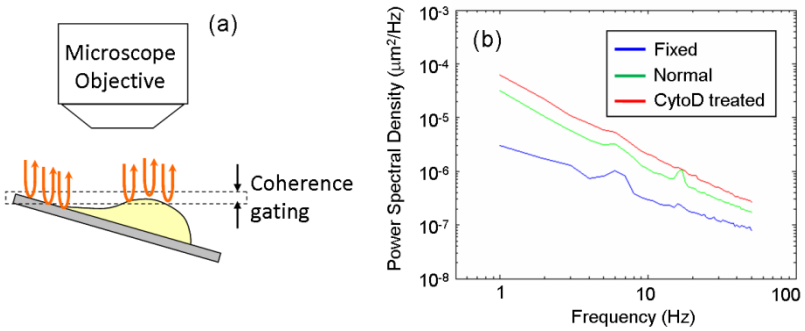

Fig. 5. Setup and results of the cell membrane fluctuation measurement. (a) Location of coherence gate; the sample is tilted to simultaneously acquire membrane fluctuations as well as background phase from the coverslip. (b) Power spectral density of membrane fluctuations as a function of frequency for three different populations: blue, formalin fixed; green, normal; and red, Cytochalasin-D treated HeLa cells.

4. Conclusion

We have proposed and demonstrated, for the first time, a quantitative reflection phase microscope based on *en-face* optical coherence tomography and off-axis digital holography. The setup utilizes a diffraction grating in the reference arm to provide the desired angular tilt to the reference beam for off-axis interferometry. The full-field illumination allows single-shot phase measurement of multiple points on the surface of interest and enables the use of self phase-referencing method to reject common-mode noise inherent in interferometric setups using a separate reference arm. In our full-field reflection phase microscope, the self-phase referencing suppressed phase detection noise down to as low as 21 $picometers / \sqrt{Hz}$. With such high phase sensitivity, we were able to resolve thermal motion of the cell surface in the field of view, which was on the order of 100 picometers to 150 nanometers. A potential application of the full-field reflection phase microscope is to use the membrane fluctuations to estimate the mechanical properties of cell membrane; these variations in cell membrane mechanical properties can serve as non-invasive biomarker to study pathophysiology of general cell types [13]. Another future direction includes full-field and multi-cell imaging of cellular electromotility, including cell membrane motion driven by the action potential in single mammalian cells [26].

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