CHAPTER V
CONCLUSIONS

Optical coherence tomography (OCT), based on a Michelson interferometer with a low coherence light source and a vertical scanning interferometry (VSI) technique, is a method for constructing a surface profile of material. In this research, a light beam was set as a parallel beam, instead of a focusing beam, in order to reduce the time-consuming process. Because coherence length (L_C) is a success key of a measurement accuracy in this OCT method, L_C of an 830-nm superluminescent diode (SLD), used as a low coherence light source in this research, was first defined. For determining L_C of this SLD, light intensity signals from a plain mirror, used as a sample, was analyzed by a discrete Fourier transform (DFT) and noise filtering with a Butterworth window. The result showed that L_C of our SLD was 22 μm. That meant this light source could clearly extract a layer of multi-layer material, which was at least 22 μm thick.

To confirm our experimental system and signal analysis method, a surface profile of step-height standard plate was constructed by applying both two signal analysis methods, a discrete Fourier transform (DFT) and a continuous wavelet transform (CWT). It found that the surface profile, constructed by CWT, was more closed to a real sample surface profile than the one constructed by DFT. Therefore, CWT was more efficient method than DFT for analyzing interferogram, detected by the Michelson interferometer with SLD. A depth of this step-height standard plate was also calculated from the surface profile, constructed by CWT. It was 2.064 ± 0.064 μm, which differed from the one reported by a step-height standard plate manufacturer.

Next, surface cross-sections of three stainless steel plates (Sample No.1, No.2 and No.3) were defined by analyzing the interferograms with both DFT and CWT. For cross-sections of Sample No.1 and No.2, constructed by CWT, their uncertainty ranges of root-mean-square roughness (R_q) overlapped with the ones calculated by phase-shift interferometry (PSI) mode of 3-D Non-Contact Surface Profiler SP-500 Series from Toray Engineering Co., Ltd. But the uncertainty ranges of R_q did not overlap with the ones calculated by PSI mode of SP-500 Series for cross-sections of Sample No.1 and No.2, constructed by DFT. These results confirmed that CWT had more efficiently than DFT for analyzing the interferograms of our system. In contrast, the uncertainty ranges of R_q for Sample No.3 cross-sections, analyzed by both DFT and CWT, did not overlap with the ones calculated by PSI mode of SP-500 Series because of the difference in analysis method and more surface roughness of this sample.

In PSI mode of SP-500 Series, light beam was focused to twenty small areas of sample surface. By comparing with our OCT method, measuring area, covered by parallel beam, was 4 lines of 25 × 4000 μm, which was larger than the area, measured by PSI mode of SP-500 Series. In case the smooth surface sample, such as Sample No.1 and No.2, the size of measuring area had no effect on R_q because values of surface roughness in almost every different area were close together. For Sample No.3, its surface was rougher than the others, then, the size of measuring size affected to its R_q. The smaller measuring area brought to smaller R_q than the larger one. Therefore, R_q, calculated from larger area, was suitable to represent the roughness of the whole sample surface.

By analyzing the interferogram of OCT with CWT, surface profiles of Sample No.1, No.2 and No.3 with and without cover slide, used as transparent material, were also constructed. The results showed that the surface profiles of these three samples with and without cover slide could be constructed and there were consistencies between surface profiles of these three samples with and without cover slide in the same area. Then, R_qs of these three samples with and without cover slide were also calculated. R_q of Sample No.1, calculated in PSI mode of SP-500 Series by focusing light beam to twenty small areas of sample surface, was closed to the one calculated by our OCT method in 500 × 500 μm surface area. In contrast, R_qs of Sample No.2 and No.3, measured in both methods, were totally difference. It was implied that surface of Sample No.1 was less roughness than the others. The result also showed the difference between R_q of these three samples with and without cover slide. The difference of these R_q was caused by air gaps between a contact surface of cover slide and stainless steel. It was also caused by an accuracy of a refractive index of these cover slides.

Finally, the OCT method was applied for measuring thickness of a transparent material, which was a cover slide in this research. Positions of a reference surface with and without transparent sample were first extracted by OCT with CWT analysis method. The reference surface, used in this research, was a stainless steel plate. The thickness of the cover slide sample was calculated by applying Eq.(2.32) with different positions from the first step and the refractive index of cover slide. Thickness of cover slide sample were also compared with the one measured by a length measuring instrument ULM RUBIN 800 of MAHR METROLOGY. The result showed that thickness of cover slide, extracted by our OCT system, was significantly closed to the one measured by ULM RUBIN 800.

In this thesis, the OCT system with SLD and CWT analysis method could construct an inner surface of an object, covered by a transparent material without destroying the sample. Therefore, the OCT system is a suitable method for retrieving microscopic properties of material surface. With this method, low intensity light source, such as this SLD, was also proved that it was a proper tool for measuring the thickness of transparent material in micrometer scale.

In contradiction, because of the low intensity of SLD and a parallel beam technique, an efficiency of the OCT method can be reduced by reflected light from neighbor CCD pixel, the Newton's ring, scattering surface and the refractive index of transparent material. To increase the intensity of the OCT light source, a focusing beam method might be a better choice for getting more significant result. But the focusing beam method will trade with measurement time consuming. The high intensity of light source, such as a new model of SLD, is the second choice for retrieving the good results. Also, a higher resolution CCD camera will be applied as a new detector for increasing an accuracy of this OCT method in the future.