Precise Shape Measurement Method Using Scattered Light

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Abstract- It is shown in the paper that the shape and the contour of the objects can be detected high-precisely using the scattered light. The simulation of the scattered light using the simulation software at first pursues the possibility of the high precise measurement. The possibility of the high-precise measurement is confirmed in the simulation. The simulation results are verified by the experiments next. It is shown that the precise micron meter order measurement is possible using the scattered light from the results of the simulation and the experiment. The method is applied to the inspection of the end shape on the polishing process of the optical fiber and the practicability of the method is confirmed. This method presets the industrial applications like the measurement of the shape of the products.

1. Introduction

There are two methods of the measurement using the scattered light. One is a measuring from the reflected light of the measuring object illuminated by the light. The other is a measuring from the light of the measuring object itself. The high precise shape measurement is possible by putting the light on the object for the measurement and detecting the reflected light. Using this measuring method, the object shape can be measured at the accuracy of the nanometer order theoretically. In this paper, the method of detecting the light from the measuring object itself is investigated. The shape measurement after polishing the tip of the optical fiber is taken up as the concrete application of the scattered light in the study. The coaxial cables, microwaves, and optical fibers are used as the communication medium in the communication system. The optical communication system increases rapidly as the communication medium. The optical fiber can carry the large capacity of the communication in the multimedia age. The connection and separation means for the optical fiber is necessary for the maintenance and operation in the optical communication system. The optical connector is used for the connection and separation of the optical fiber. The tip shape of the optical fiber is exactly controlled in order to reduce the loss of the connection and to maintain the reliability of the connection in the optical connector. The tip shape of the optical fiber is possible by the scattered light from the optical fiber itself. It is shown that the high-precise measurement by the scattered light is possible.

2. Measurement Principle

The principle of the measurement is shown in Figure 1. The light is discharged from the surface of the measuring object body. The discharged light reaches the light received side as the scattered light. The surface shape of the measuring object can be estimated from the intensity distribution of the scattered light on the light received side. Concretely, the scattered light is received in PDs (Passive Diodes) from the tip of the optical fiber and they measure the strength and weakness of the electric signals in PD. The electric signals form the tip shape of the optical fiber.

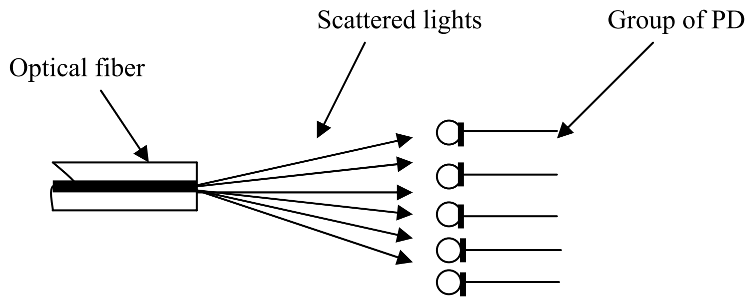


Fig 1.Principle of measurement

3. Simulation

3.1 Simulation method

The strength and weakness of the light scattered from the end face of the optical fiber can be detected in PD. The processed shape of the optical fiber end is measured by the strength and weakness of the current in PD. The simulation confirms the effectiveness of the measuring method. As shown in Figure 2, the simulation is carried out using the green lens instead of the optical fiber. The scattered light from the green lens is detected in the receiver part. The scattered light of the receiver will detect the tip shape of the green lens. The simulation was carried out. The scattered light was detected on the receiver.
But, the scattered lights were not the same shape of the green lens tip. As the results of the trials and errors, the slit is formed in the front of the green lens. The tip shape can be detected in the receiver part by the formation of the slit. It was found that the shape measurement became possible by forming the slit in right after of green lens. Such composition of the test equipment was made and the experiments were practiced. Fig 3. shows an example of the simulation.

3.2 Simulation results

In the simulation, the quality of the tip shape of the optical fiber is taken up. The green lens is made to be optical fiber and the slit is installed in the front of the green lens. The light that the green lens radiates passes through the slit and reaches to the light reception side. The examples of the simulation results are shown in Figure 4 and Figure 5. The simulation result shown in Figure 4 satisfies the standard shape of the processed optical fiber. The shape is symmetry for X and Y axes. Figure 5 has not satisfied the standard shape of the optical fiber tip. The shape is asymmetry for Y-axis. The deviation exists in the center of the optical fiber tip.

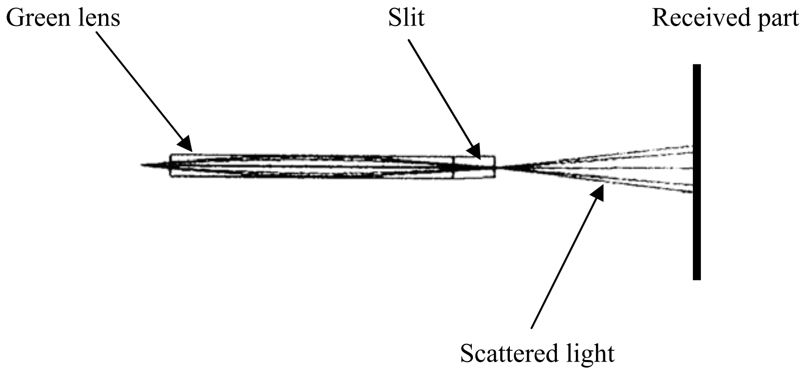


Fig 2.Simulation

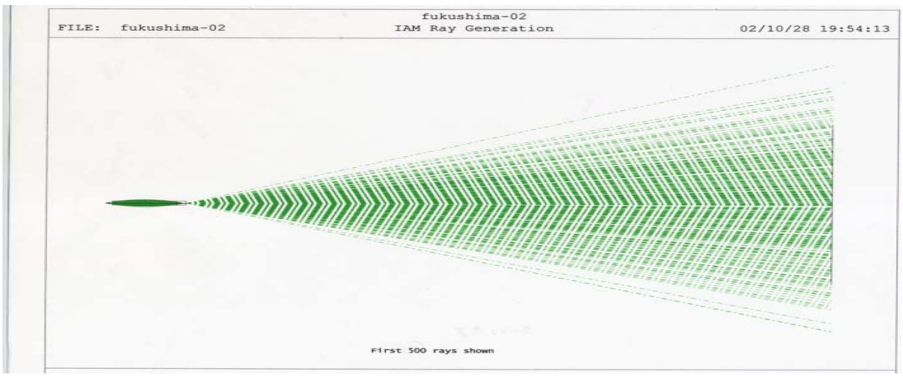


Fig 3. Example of Simulation

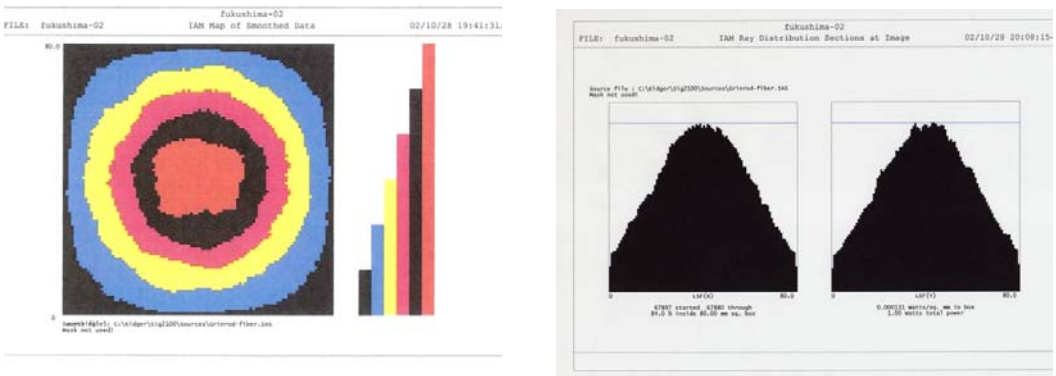


Fig 4. Result of Simulation (Good Contour of Optical Fiber)

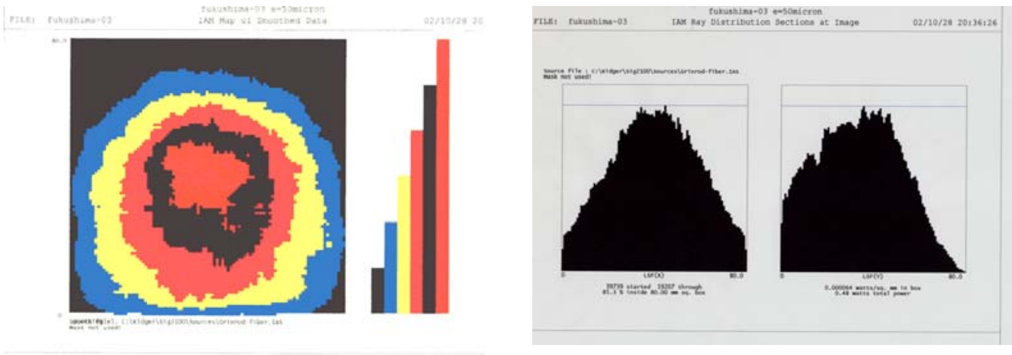


Fig 5. Result of Simulation　(Bad Contour of Optical Fiber)

4. Experiments

4.1 Experimental device

Figure 6 shows the experimental device. The experimental device consists of the part that retains the polished ferrule, the part that moves the slit and the part which retains PD. Using this experimental device, the results of the simulation are confirmed.

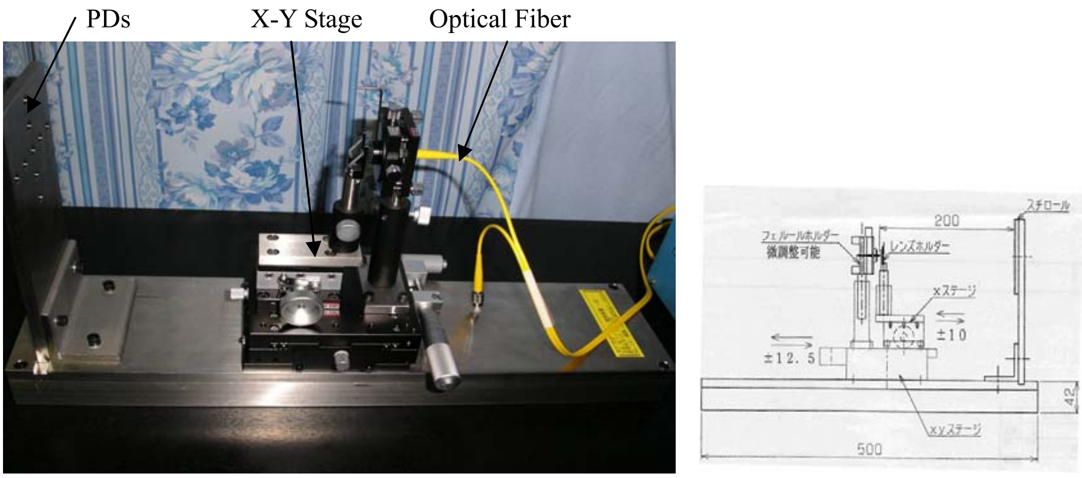


Fig 6. Experimental Equipment

4.2 Results of experiment

The experimental results are shown in Figure 7 and Figure 8. Figure 7 shows the standard shape of the processed optical fiber. This result is well correspondent to the simulation result of the standard product shown in Figure 4. The result shown in Figure 8 is correspondent to the result of the simulation shown in Figure 5. The tip shape of this optical fiber becomes the standard outside.

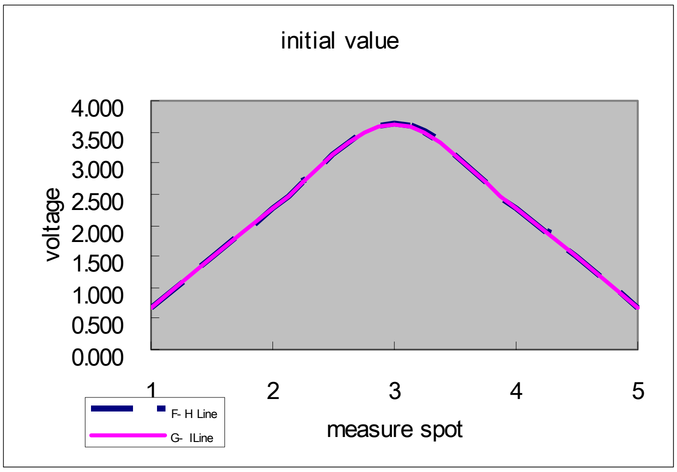


Fig 7. Experimental Result (good processing)

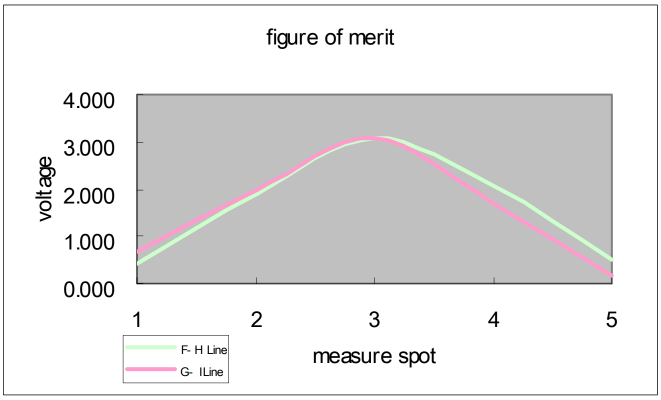
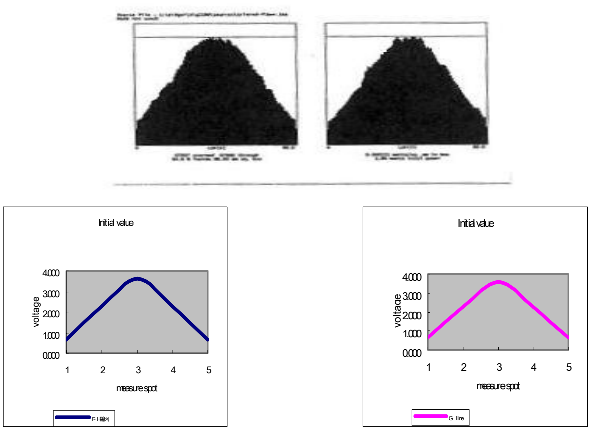
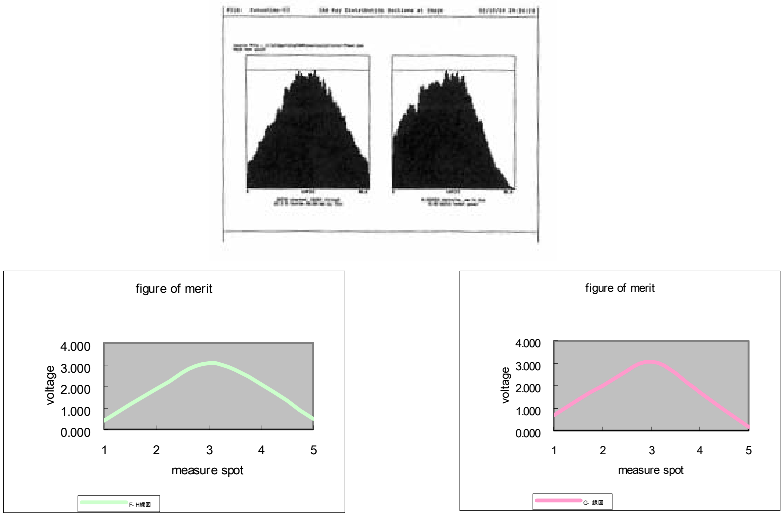


Fig 8. Experimental Result (bad processing)



X-axis Y-axis

Fig 9. Comparison of Result between Simulation and Experiment (good processing)



X-axis Y-axis

Fig 10. Comparison of Result between Simulation and Experiment (bad processing)

Figure 9 shows the comparison of the results between the simulation and the experiment on the good processing of the fiber tip. Figure 10 shows the case of the bad processing. Both cases show the good coincident between the simulation and experiment.

5. Conclusions

The precise shape measurement method using the scattered light was proposed in the paper and the simulation and the experiment confirmed the effectiveness of the method. The method was applied to the measurement of the processing shape of the optical fiber in the optical connector in order to confirm the practicability. In the examination of the simulation, the possibility of the measurement was found by the slit that was formed close to the tip of the optical fiber. The experimental device was constituted on the basis of the simulation results and simulation results ware confirmed by the experiments. The small, low-cost and high-precise measuring device will be realized using the proposed method and it is also possible to be included in the product line.

References

[1] L. V. Henriquez, “Study of surface quality in FDM rapid prototyping process”, Proceedings of Cars & Fof 2004, pp.337 - 348 , 2004.

[2] F. Bitte, H. Mischo, “3D Surface inspection with a DMD based sensor”, IMEKO 2000 , Proceedings Vol. 2, pp . 157-162, 2000.