Development of Minimized-Assembly System for Camera Phone Lens Module

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Abstract

Since camera phone was first introduced in year 2000, the market is booming worldwide in recent years. Also, the high-resolution versions of camera phones become main stream trend currently. Lens module is one of the key parts to obtain good image quality. The lens module for camera phone is consisted of several parts, such as a holder, lenses, spacers and a shield. Improper assembly of these parts leads to image deterioration which is crucial defect for camera phone lens module. For example, the required assembly accuracy should be within 3 μm to acquire desired image quality. Also, each lens should be assembled in desired rotational direction for the best optical performance of the lens module. Therefore, not only mass production but also precise assembly of lens module becomes essential. In this study, we proposed the design of assembly system and developed in-line assembly system for camera phone lens module in order to meet the needs. Our developed system has the tack time of 3 seconds. 45 % of scale down compare to the previously developed assembly system was accomplished.

1 Introduction

Lens modules are made up of various types of parts, such as lenses, spacers, and a barrel. General composition of megapixel lens module is shown in Figure 1. The performance of camera phone lens module comes from proper assembly of the parts. These parts should be assembled in series with micron-level accuracy under clean room condition. Also, rotation direction of each lens should be matched to obtain best image quality. 5 megapixel lens module adapted one glass lens and two plastic lenses to ensure required resolution. But, recent model is only consisting of four plastic lenses for price reduction. Therefore, assembly process and lens orientation issues become more important.

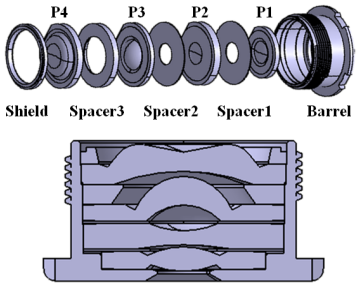

Figure 1: Composition of megapixel lens module

In order to cope with these needs, development of minimized-assembly system for camera phone lens module for mass production is essential.

2 Minimized-assembly system

2.1 Design of the assembly system

The assembly system is designed to assemble 8 megapixel lens module which consist of 9 parts: a holder, four plastic lenses, three spacers and a shield. Also, our developed system reduces assembly process to 6 steps by combining lens and spacer assembly together while conventional assembly operation needs 9 processes. Figure 2 shows one of the design of lens module assembly cells used in the system. The assembly system is designed to be four different cell cofiguration for easy maintenance and replacement during manufacuturing process. Each cell is designed to be almost the same construction. Accordingly, the one of the design of lens module assembly cell is introduce in this clause. The cell is manly consist of X and Y drive axis, vision system, pickers and trays. Barrels, spacers and lenses are supplied in tray unit. As mentioned before, one type of lens and spacer can be assembled in series in a assembly cell. Assembly process is like belows. Firstly, picker pick up a barrel and place it on assembly base. Mechanical guiding mechanism is introduced for barrel center alinment to shorten tack time instead of using vision system. Secondly, vision system reconizes gate direction to gather rotation infromation for disired assembly direction. Thirdly, lens picker picks up the lens and rotate the lens by refering the vision data. Fourthly, lens is assembled in the barrel. Finally, spacer is picked up and assembled in the barrel. Our developed assembly system also designed to cope with

model change of lens module which covers holder size of 6.0 ~ 9.0 mm and holder height of 5.0 ~ 8.0 mm. We checked the design errors, interferences during assembly process, and found optimized sequence using IGRIP. We also analyzed typical performance index, such as tack time, manpower and UPH (Unit per Hour) from simulation results for manual process, cluster type assembly system and our developed assembly system. Our developed system turned out to have the tack time less than 3 sec, manpower of 4 and 1,200 UPH which shows excellent performance compare to other processes. The economical efficiency analysis using AHP (Analytic Hierarchy Process) showed that significant NPV (Net Present Value) and ROI (Return on Investment) improvements are expected with 50% of investment costs of manual assembly process.

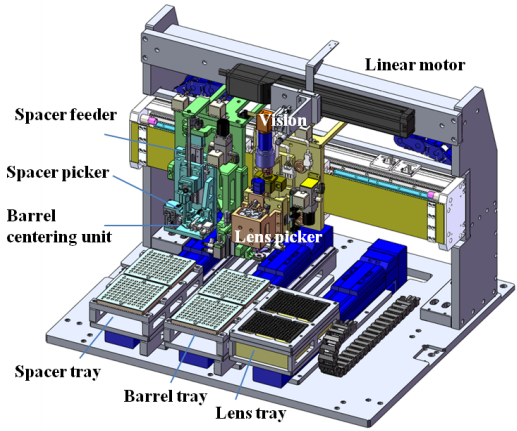

Figure 2: Design of lens module assembly cell

2.2 Developed minimized-assembly system

Entire assembly system is consist of four assembly cells. Figure 3 shows the example of the developed assemlby cell. Compare to machining process, assembly process needs more spaces because relatively long stroke is needed for assembling several parts. Despite this, we minized the lens module assembly cell to the size of 820 (W) × 700 (D) × 1800 (H). This is 45 % of scale down of the previous lens assembly system that we had developed. Each cell supplies 187 lenses and 100 barrels with continuous supply of spacers. Repeatability of drive axis used for assembly is 1 µm with maximum speed of 1 m/sec. Also, mechansim to cope with

lens model change is applied in the system. The system is now under operation in 5 megapixel lens assembly lines. The tack time of 2.87 sec is achieved by shortening alignment time using mechnical alignment, lens gate detection speed, and the proper process control.

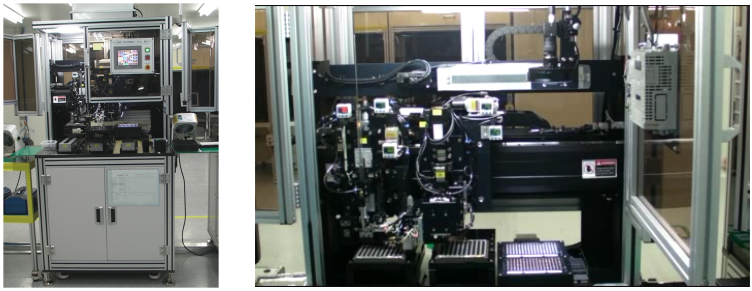

Figure 3: Developed lens module assembly cell

3 Conclusions

We developed minimized-assembly system for camera phone lens module. This system consists of four cells which perform lenses and spacers assembly. Cell configuration enables easy maintenance and replacement of the machines. The experimental results showed that the system has the tack time of 2.87 sec and downsized to 45 % of the previous assembly system. These can be achieved by minimizing alignment time, lens gate detection time, and assembling lens and spacer in one cell.

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