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オンデマンド・マイクロジェットを用いた光学レンズの形成

Producing Micro-Optical Lenses using Micro-jet Drop-On-Demand

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Abstract. MEMS (Micro-Electro-Mechanical System) is the integration of mechanical elements, sensors, actuators, and electronics on a silicon substrate through the micro fabrication technology, in general. Another MEMS formation technology is proposed in this study. The improved drop-on-demand ink jet heads are used and the Memes are formed on the plastics and silicon substrate. The transparent ultraviolet curing resins are injected from the drop-on-demand head to the plastics panel for the micro lenses formation.

Keywords : MEMS(Micro Electro Mechanical System), マイクロ光学レンズ(Optical-Micro lenses), オンデマンド微小ジェット(On demand micro-jet), 液晶用バックライト (Back light for liquid crystal devices)

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Keywords: MEMS, On demand micro-drop, Optical micro-lenses, Back light

Abstract. MEMS (Micro-Electro-Mechanical System) is the integration of mechanical elements, sensors, actuators, and electronics on a silicon substrate through the micro fabrication technology, in general. Another MEMS formation technology is proposed in this study. The improved drop-on-demand ink jet heads are used and the Memes are formed on the plastics and silicon substrate. The transparent ultraviolet curing resins are injected from the drop-on-demand head to the plastics panel for the micro lenses formation.

Introduction

MEMS technologies have been exposed to the attention recently. The representative example of MEMS technology is the semiconductor technology. MEMS is produced using the exposure and the etching technologies of the semiconductor technology.
MEMS is formed on the silicon substrate using the micro fabrication technology of the semiconductor. Another MEMS formation technology is proposed in this paper. The drop-on-demand system is one of the ink jet printing technologies. This technology is the method that spews the ink from the inkjet head by the trigger of outside and prints. This inkjet method is used for the formation of the micro mechanisms. However, it is necessary that the head is improved because the medium discharged from the head is the plastics or metallurgy genus, and keeps the head and the medium to the high temperature.
The micro lenses for the back light of the liquid crystal display are produced by the improved on-demand-drop jet head. The transparent ultraviolet curing resins are injected to the plastic panel and the micro lenses are formed on the panel. The small quantity of the resins makes the desired dimension lenses by repeating the jet drop and irradiating the ultraviolet ray. In this study, the following researches are practiced and the optimum conditions are clarified in the respect of the micro lenses formation high-reproducibly and stably.

(1) The clarification of the lenses curvature change by the resin materials and the drop head control parameters.
(2) Optimization of the resin spewed conditions from the nozzle of the drop head.

Drop-on-demand jet

There are three types of the ink jet printing. They are the continuous delivery type, the drop-on-demand type and the bubble jet type. The bubble jet printing is very popular and is used for the precise color printing and the photo printing. But the control of the individual bubble is difficult. The on-demand-drop is applied to the forming the MEMS because of controlling the jet easily. Fig. 1 shows the on-demand-drop. It is called ODMD (On-Demand-Micro-Drop). The data pulse The piezoelectric device of the jet head is supplied with the voltage power in proportion to the data pulse, and the medium of the head is spewed from the nozzle of the head tip by the impulsive deformation of the piezoelectric device.

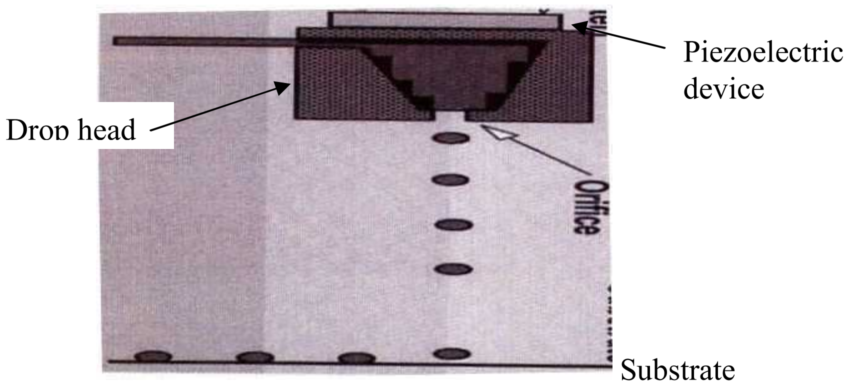

Fig. 1 The conceptual scheme of ODMD (On-Demand-Micro-Drop)

In this study, the epoxy resin of the liquid is used as the medium, and the micro lens of about 100 μm is formed. The viscosity of the epoxy resin of the liquid is high in the ordinary temperature. The delivery from the drop head is difficult for the viscosity. The head is retained in the high temperature in order to solve the problem of the viscosity. The drop head is retained at the 60° C and the resin medium can be discharged.

The experimental equipment is shown in Fig.2. The central is a part of the drop head and The epoxy liquid is spewed on the plastic board. The dropped liquid balls are hardened by UV irradiation device in the right hand part of the experiment equipment.

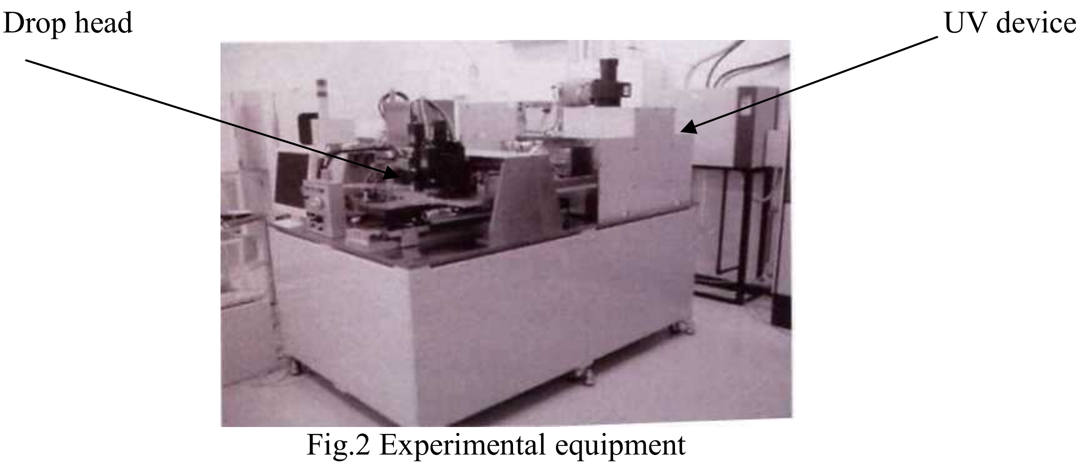

Fig.2 Experimental equipment

Experiment

The example of the micro lenses formation in spewing the epoxy resin liquid on the epoxy resin board is shown in Fig. 3. The lenses from big one to small one can be formed by the drop frequencies of the epoxy resin from the drop head. However, the height and diameter of the formed lenses slightly vary even in the equal size lens. The reason of this dispersion is that the optimum conditions of the parameters which affect the drops of the epoxy resin are not being obtained. The shape of one lens is shown in Fig.4. The shape of the lens is slightly different in X axis and Y axis. This is also the cause of the above dispersion. The experiments of the enormous quantity are required for the optimization of the conditions, if the experiments intend to be practiced on the combination of the parameter conditions. The technique of the Quality Engineering may be used in order to solve this problem. The optimum conditions of the parameter can be confirmed using the Quality Engineering experiment and analysis.

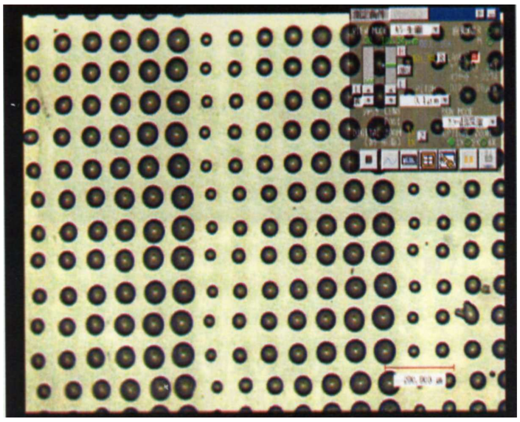

Fig. 3 Experimental example of optical lenses

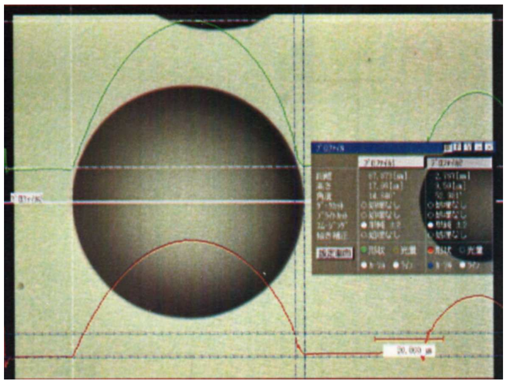

Fig. 4 Shape of one lens

Optimization of parameter conditions

The experiments are carried out using the L_{18} orthogonal array and the evaluation is carried out for data at S/N ratio and sensitivity. The parameters in the experiment are shown in Table. 1. The experiments using the orthogonal array and the evaluation using S/N ratio and sensitivity is the technique of the Quality Engineering. It is called the parameter design. The S/N ratio and sensitivity are calculated from the next equations as the data of the experiments on the NO.1 row of the orthogonal array.

$$SNratio(\eta) = 10\log(S_\beta - V_e)/rV_e \quad (1)$$

$$Sensitivity(S) = 10\log(S_\beta - V_e)/r \quad (2)$$

Where, $$V_e = (S_T - S_\beta)/(2-1) \quad (3)$$

$$S_T = y_{11}^2 + y_{12}^2 \tag{4}$$

$$S_\beta = L^2 / r \tag{5}$$

$$L = M_1 y_{11} + M_2 y_{12} \tag{6}$$

$$r = M_1^2 + M_2^2 \tag{7}$$

The SN ratio (η) and Sensitivity (S) are calculated using these equations.

Table.1 Parameters and levels

Parameter	Level 1	Level 2	Level 3
A. Room temperature	20°	25°	————
B. Head temperature	40°	50°	60°
C. Head gap	0.5 mm	1.0 mm	1.5 mm
D. Curing time	50 min	80 min	100 min
E. UV exposure time	5 min	10 min	15 min
F. UV gap	100 mm	120 mm	150 mm
G. Head voltage	18 V	22 V	24 V

Table.2 Array NO.1 data

Drop frequency	M_1	M_2
Array NO.1	y_{11}	y_{12}

The SN ratio and Sensitivity calculated from the orthogonal array experiments are shown in Fig. 5 and Fig.6. It is shown that the dispersion of the data is small if the SN ratio is high, if not; the dispersion of the data from the orthogonal array is large. The sensitivity means the height of the lens. If the sensitivity is high, the parameter of the experiment condition generates the large high lens.

The combination of the best level of the parameters becomes A_2, B_2, C_1, D_3, E_1, F_3, and G_1. In these parameters, the effects of C, D, E, F, are large. The height of the lens may be changed by adjusting the parameter of the Sensitivity which does not affect the SN ratio. The height of the lens is adjusted by changing the temperature of the drop head. It is possible to change the lens height from 8.18 micron to 8.73 micron for one drop by choosing the level of the parameter B(head temperature).

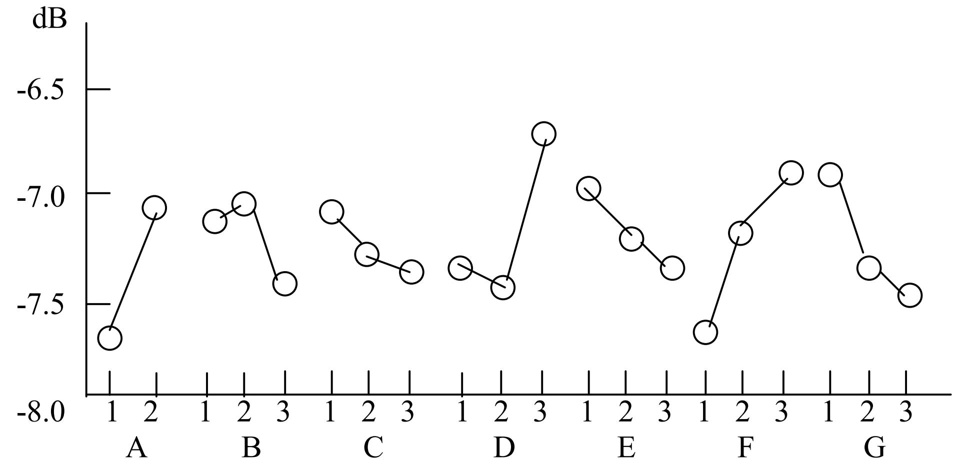

Fig. 5 SN ratio and parameters

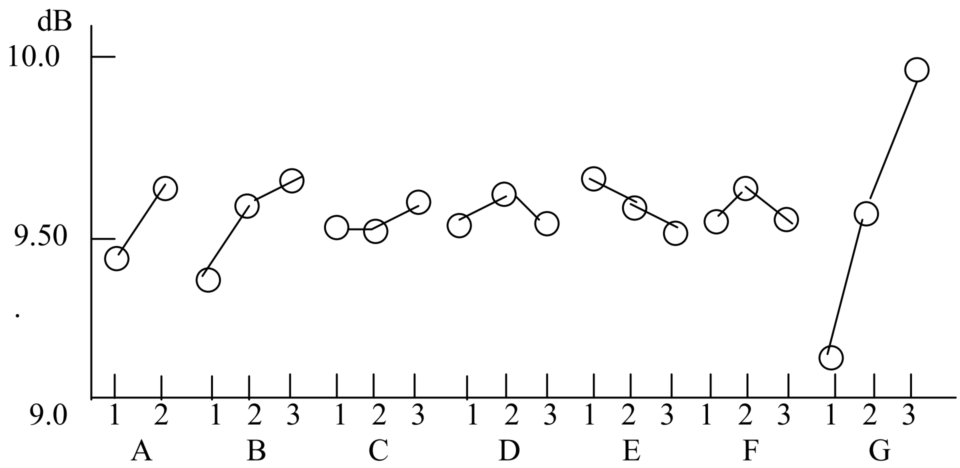

Fig. 6 Sensitivity and parameters

Application to the back light of the liquid crystal device

The back light is used in the liquid crystal display. The principle of the back light is shown in Fig.7. The light from the LED is guided to the light guide board and the light from the light guide board is transmitted to the liquid crystal. As shown in Fig. 8, the liquid crystal device can displays the screen using reflected light such as the solar light in the outdoor and in the indoor using transmitted light from the light guide board. The micro lenses are formed on the light guide board and it is possible to get the higher brightness back light. It was required that the luminance of the back light was uniform on the display until now and that the brightness of the back light was high. However, it is required that distribution of the luminance on the display is Gaussian distribution at present. The luminance distribution of the back light using the results of the study can satisfy the demand.

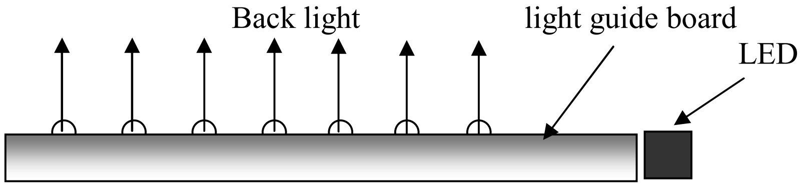

Fig. 7 Composition of the back light

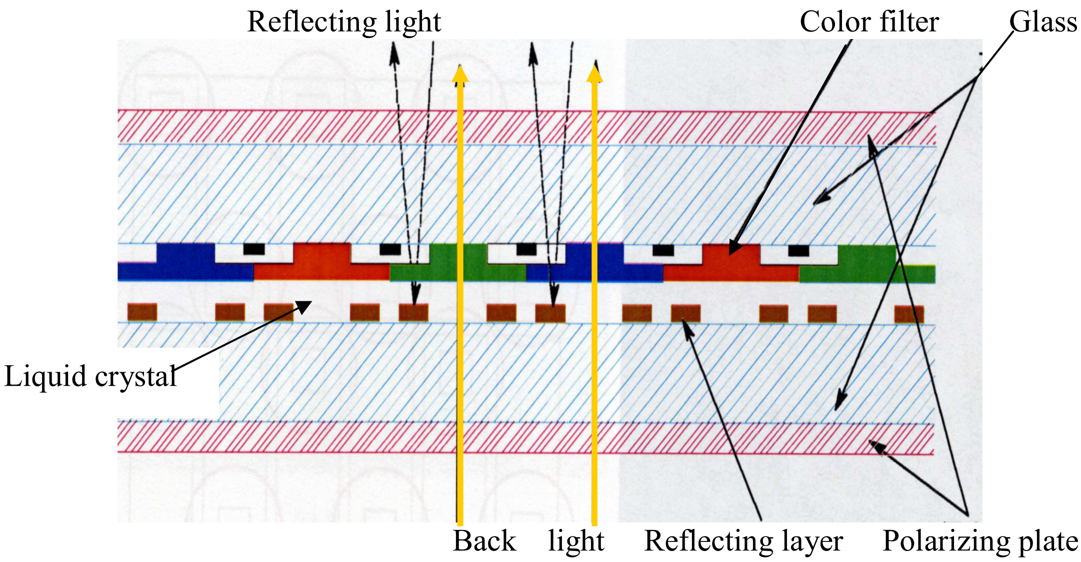

Fig. 8 Back light of the liquid crystal device

Conclusions

The plastic resin liquid was dropped using the improved ink jet head and the formation of MEMS was proposed using the head. As an example of the MEMS production, the formation of the micro lenses were taken up and the application to the back light of the liquid crystal device was shown. The production of the MEMS using metallic solution is also possible by the result of the study.

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