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Forming technology of random patterns in large areas by roll to plate indentation process using micro abrasive grain tool

Tae-Jin Je[1, 2], Ji Young Jeong[1, 2], Seung Hwan Moon[1], Je-Ryung Lee[1], Dae-Hee Choi[1, 2], Eun-chae Jeon[1, 2]

[1]*Dept. of Nano Manufacturing Technology, Korea Institute of Machinery and Materials , Korea*
[2]*Dept. of Nano-Mechatronics, University of Science & Technology(UST), Korea*

Email: jtj@kimm.re.kr

Abstract

Regular micro patterns are applied to increase light luminance for the devices. However, viewing pattern on the screen with the images and total reflection are considered as the problems. Random patterns have advantages such as increasing light diffusion and light efficiency by aperiodicity of the patterns. The roll to plate indentation process, using micro abrasive grain tool, has advantages such as easy processing and less processing time for the forming of random patterns. In this study, the formability, indicated by such characteristics as pattern size and ratio of the random patterns, in accordance with the changed indentation force, is analysed. An indentation forming machine was designed and manufactured for the purposes of this study. And, electrodeposited diamond wheel of 1000 mesh with nickel bond was used. In results of forming random patterns, the average size and ratio of the patterns were increased in accordance with the increasing force because width of the diamond grains increases according to the indentation depth. Accordingly, the depths obtained during the experimental results were compared to the ideal indentation force when pattern ratios were equal to area of experimental indentation area. Through this procedure, the usefulness of the roll to plate indentation process using a micro abrasive grain tool to form large area random patterns was confirmed.

Keywords: Random pattern, Roll to plate indentation, Micro abrasive grain tool

1. Introduction

Regular micro patterns of optical film for increasing light luminance has problems that are easily viewed to the eyes by a regularity property and decreasing light efficiency by total reflection.[1] However, random patterns has advantages such as increasing the light diffusion and the efficiency.[2] Conventional manufacturing technologies for random patterns have been studied, and include such techniques as the chemical etching, and ultra precision machining using a multi-axis milling.[2-4] These technologies require complicated processes and long processing time when these technologies are applied for large area molds. Accordingly, the roll to plate indentation process using a micro abrasive grain tool was studied to form micro random patterns on a large area. Then, aspects of formability such as pattern size, ratio and depth of patterns is analysed in accordance with the indentation load.

2. Roll to plate indentation process

A schematic drawing of the roll to plate indentation process using a micro abrasive grain tool is provided in Fig. 1. This process is one in which the tool is rotated and indents on the plate material. Then, the grain shapes of the tool surface are duplicated on the material surface. In this process, size and ratio of patterns were expected to be controlled by changing the size and ratio of the grain. The total processing time can be reduced by having a wider width and faster rotation of the tool.

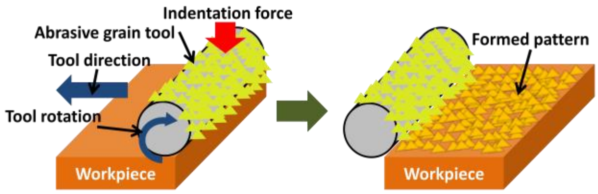

Figure 1. Roll to plate indentation process using abrasive grain tool.

3. Roll to plate indentation forming system and conditions.

The roll to plate indentation forming machine uses the load cell (10 ton) for the measurement of indentation force.

Electrodeposited diamond wheel having 1000 mesh with nickel was used as a tool in this study. The tool surface is shown as Fig. 2. Average size and height of the grain are 28 ㎛ and 10 ㎛. Randomly distributed diamond grains on the tool surface are expected to form random patterns effectively.

The experimental conditions for analysing the formability are shown in Table 1. Indentation force is increased from 10 kgf to 100 kgf for each forming random-pattern.

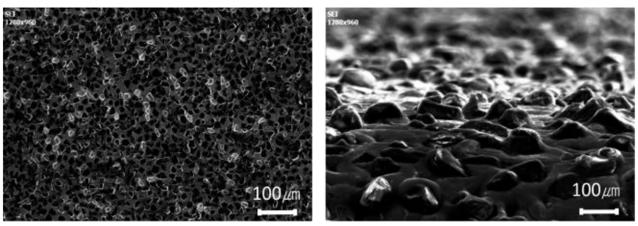

Figure 2. Distribution and height of the grains of electrodeposited diamond wheel of 1000 mesh with Ni bond.

Table 1. Forming conditions of random-patterns

Workpiece	64 Brass (Surface roughness 20nm, 60 HV)
Tool	Electropdeposited diamond wheel (1000 #)
Indentation force	10 – 100 kgf

4. Results and discussion

4.1. Pattern size and ratio according to indentation force

The formed results of random patterns at 10 kgf and 100 kgf of the indentation force are shown as Fig. 3. Average size and ratio of the patterns at 10 kgf are 11.8 ㎛ and 1.7 %. At 100 kgf, average size and ratio are 21.2 ㎛ and 9.5% ㎛. The analysis results such as those for the size and the ratio of the random patterns are summarized in the Fig. 4. As the indentation force is increased, the size and ratio of the micro-random patterns tend to increase.

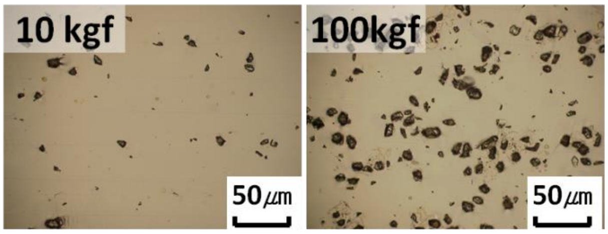

Figure 3. Forming results of random patterns at 10 kgf and 100 kgf.

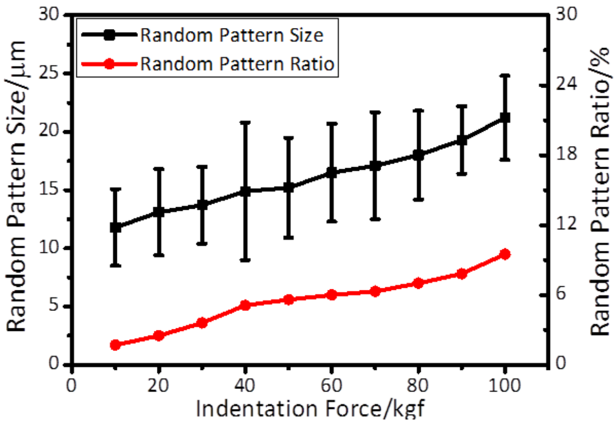

Figure 4. Change of random pattern size and ratio according to the indentation force.

4.2. Indentation force according to depth and ratio of patterns

Experimental depths of the random patterns are calculated by using the diameter of the tool, because the heights of diamond grains are supposed to be uniform. The ideal depth of the pattern can be calculated according to the projected area of indentation area, which is equal to the diamond grains area of the electrodeposited diamond wheel. Then, these values were compared to those for the change of the ideal depths, with results as shown in Fig. 5. The indentation forces required to form random patterns are a maximum of nine times higher than the experiment results. This is attributed to the irregular grain height. Accordingly, higher indentation force is required indentation of all diamond grains or having regular heights tool is required.

Ideal indentation force according to changed pattern ratio can be determined by considering the relationship between the strength of the workpiece and its area; this relationship is calculated using the width of the tool and the contact width between the tool and the workpiece. The measured force is higher than the ideal force by more than 6 % of the ratio of random pattern area as shown in Fig. 6. The Ni layer on the diamond grain of the electrodeposited wheel was expected to generate this phenomenon because of it increase of the indentation area.[5] When these problems is ameliorated, the roll to plate indentation process using a micro abrasive grain tool is expected to be effective in application to the manufacture of random patterns in molds having large area.

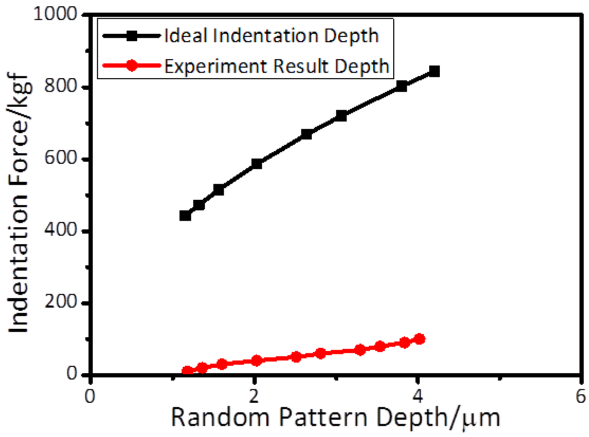

Figure 5. Analysis of the Indentation forces according to the ideal depth and the calculated depth of the random patterns.

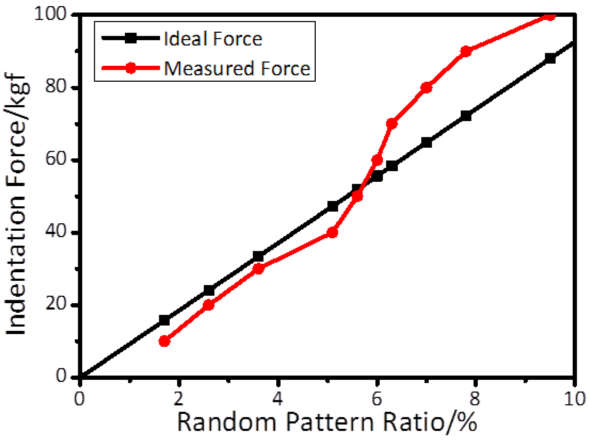

Figure 6. Analysis of the Indentation forces according to the ideal depth and the calculated depth of the random patterns.

5. Conclusion

In this study, forming micro random patterns were conducted by roll to plate indentation process using micro abrasive grain tool. Formability, such as the size and ratio of the random patterns, was found to increase in accordance with the increasing of the indentation force. Problems were found such as irregular height of the grain and Ni layer on the grain in this process. To effectively utilize this process, these problems will be ameliorated.

References

[1] Jeon E c, Je T J, Lee E S, Park E S, Lee J R, Choi H j, Chang S h and Choi S K 2013 *Inter. J. Prec. Eng. Manuf.* **14** 1113-16
[2] Shin J W and et. al 2014 *J. Org. Elec.* **15** 196-202
[3] Dong C, Gu Y, Zhong M, Li L, Sezer K, Ma M and Liu W 2011 *J. Mater. Process.Technol.* **211** 1234-40
[4] Kobayshi Y and Shirai K 2008 *Inter. J. Prec. Eng. Manuf.* **9** 34-38
[5] Zhang Y, Tani Y, Murata J and Hashizume T 2014 *Japan. J. Solid. Mech. Mater. Eng.* **80** 1-12