Micro Prism Array Machining on Large Area of Brass Foil for Making Roller Imprinting Mould

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Abstract

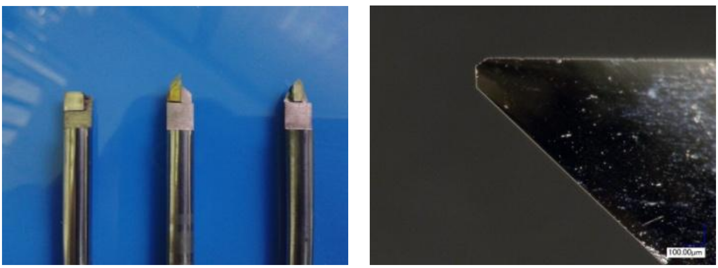
Roller imprinting is one of the most important technologies for micro/nano fabrication of large area flexible electronics due to high throughput, large-area and low-cost. But making a roller mould with micro-optical structures is very challenge especially for those applications in micro-optics, electro-optics, flexible electronics, organic photo-electronics, plate panel displays, back-light units, e-papers, etc.

1 Introduction

Currently, large area flexible electronics are becoming one of the most promising emerging technologies, which has been projected that by 2015 the market could grow to greater than $100B with products such as flexible displays, sensors, energy modules, lighting systems, RF networks, and smart packaging. Roller imprinting is one of the most important technologies for micro/nano fabrication of large area flexible electronics due to high throughput, large-area and low-cost. But making a roller mould with micro-optical structures is very challenge especially for those applications in micro-optics, electro-optics, flexible electronics, organic photo-electronics, plate panel displays, back-light units, e-papers, etc. Laser writing has been used for the fabrication of roller mould directly but the surface quality and shape are not good enough for optics applications [1, 2]. Lithography method is capable to produce nanometer to micrometer features but limited to 2D and 2.5D structures [3]. Ultra-precision horizontal drum lathe can be used to directly cut a roller mould with 3D micro structures achieving nanometer scale surface roughness and submicron feature accuracy but very costly and time-consuming [4, 5]. A new method for making roller imprinting mould, i.e. micro machining of large brass foil with micro prism array and wrapped it onto a sleeve to form a roller mould, has been developed in this paper. However, to scale up the machined moulds with micro structures to large area is extreme challenge. So far no study has been reported on micro structure machining of large metal foil.

2 Methodology for Large Area Micro Machining

A new methodology has been proposed for large area micro machining of brass foil, of which a customized single crystalline diamond endmill is applied onto a conventional Roders 3-axis CNC high speed milling machine to perform micro machining enabling to achieve optical surface quality. Fig. 1 shows the customized single crystalline diamond tools used in this study. A brass foil was hold by a vacuum plate holder, where the porous ceramic plate has numerous micro holes with a diameter between 10 to 20µm in so as to eliminate material deformation caused by cutting forces. Fig. 2 shows the schematic diagram of micro prism array on a brass foil for making the roller imprinting mould, where the pitch is 400±10µm, sag size is 79±1µm and prism angle is 60°. The size of brass foil used is 350×500mm and its thickness is 200µm, of which the machined area is 300×500mm. The machining conditions are listed in Table 2. The machined surface roughness and prism array profile of brass foil were measured using a portable Zeiss Surfcom and a Taylor Hobson stylus profilometer, respectively.



(a) Full view (b) Close view of used tool

Figure 1: Customized single crystalline diamond endmill

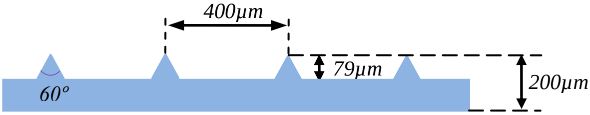


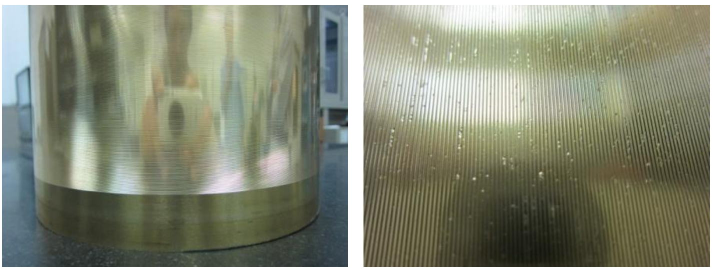
Figure 2: Schematic diagram of micro prism array on a brass foil

Table 1: Micro machining condition for brass foil

Spindle speed N (rpm)	Feed rate V_f (mm/min)	Depth of cut a_p (µm)	Coolant
32000	1000	20	Oil-air mist

3 Results and Discussion

Micro milling of brass foil mould was conducted on a Roders high speed milling machine with the customized diamond endmill. Fig. 3 shows the machined brass foil flexible mould with micro prism array structure, which can be folded and rounded: (a) rounded brass foil mould and (b) close-view of micro prism array structure. The machined brass foil surface roughness and micro prism array profile was measured, where its pitch is 399.4µm and sag size is 80µm as shown in Fig. 4. Table 2 lists the measured surface roughness of the machined prism array, of which the average surface roughness achieved is about 60nm in R_a. The used single crystalline diamond cutter is showed in Fig. 2 (b), of which there is no obvious tool chipping and tool wear observed and likely it can be continuously used. The experimental results indicated that optical quality micro prism array can be achieved on a large brass foil using a conventional milling machine with single crystalline diamond tools, which can used to make a roller mould for imprinting applications.



(a) Rounded brass foil (b) Close view of micro structure

Figure 3: Micro milled brass foil master mould

Table 2: Measurement of machined surface roughness

Measurement	1	2	3	4	Average
Surface Roughness (Ra)	64nm	56nm	59nm	63nm	60.5nm

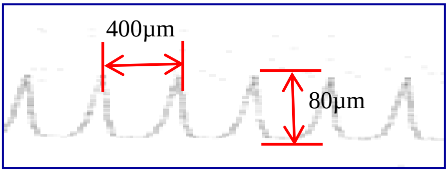


Figure 4: Measured micro prism array profile

4 Conclusions

Micro machining of large area on a brass foil has been conducted using a conventional 3-axis CNC milling machine with the customized single crystalline diamond endmill. Optical quality micro prism array structure has been successfully achieved on the brass foil with a large area of 300mm×500mm, of which uniformed micro prism array with a pitch of 400µm and sag size of 80µm are produced with an average surface roughness R_a of 60nm. The machined brass foil with micro prism array is flexible, which can be rounded as a master mould for the roll-to-roll manufacturing application.

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