

Modulated Amplitude Ultrasonic Vibration Cutting of Microstructured Surface with Image-Display Function

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Abstract

Roll-to-roll machining with structured rollers has been widely used for mass production of optical functional structured surfaces. In this paper, a hybrid slow-tool-servo (STS) and ultrasonic vibration machining (UVM) strategy is developed to generate microstructures with image display function on rolls. STS diamond turning is used to produce periodic diffraction gratings on the roller, which can display red, green and blue respectively. By modulating the amplitude of elliptical ultrasonic vibration cutting in the direction of cutting depth, a fast-linear motion axis with micron stroke can be realised to chisel concave pyramid pits on the STS machined gratings using sharp diamond tool with tool angle of 127° and clearance angle of 35° .

Since a colour can be displayed by the three primary colours with different proportions, the colour of a picture can be realized by the superposition of the diffraction grating structure that displays the three primary colours and the pyramid pits that generated by UVM with base frequency of 41.5kHz can be used to accurately control the percentage of the primary colours gratings by quantitatively destroy the grating surfaces. The proportion of the diffraction grating destroyed is controlled by controlling the depth of the pyramid whose maximum adjustment range is $2.5\mu\text{m}$.

For demonstration, the Mona Lisa image was generated on a roller as shown in Fig. 1. A gray-scale analysis will be used to decide the percentage of the three primary colours in each pixel. The generation of image on roller is realized by modulating the amplitude of ultrasonic vibration cutting and the linkage of machine tool slow tool servo. Imperfectly, colour of the image has not been produced since poor diffraction effect of grating structures, which possibly due to the mismatch of blaze angle and pitch.

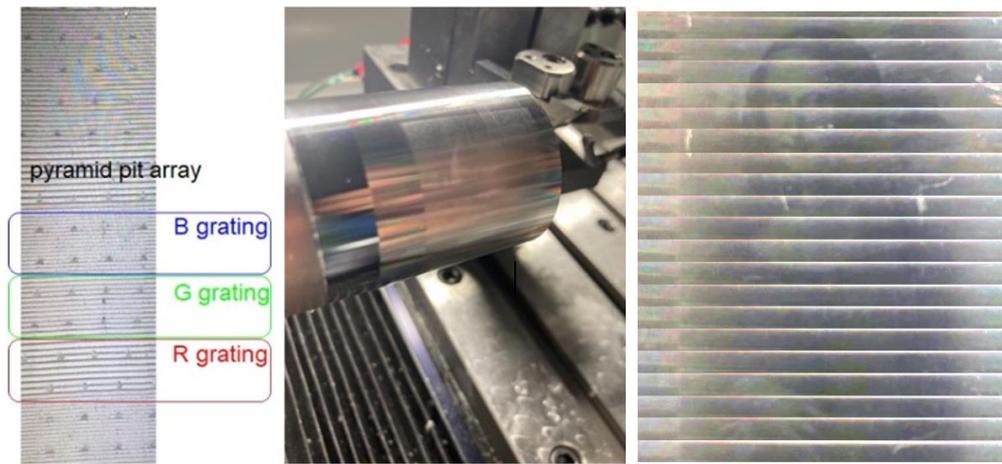


Fig 1: Surface microstructures with image-display function.