A design f-theta lens for bio-medical system

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Abstract

According to the development of bio-technology, the requirements of metrology in biochip measuring become more precise and non-contact measurement like optical detector or ultra wave sensor is plenty used in this field. Laser scanning technology is used in examine biochip for its characteristic of non-contact measurement, high performance and good sensitivities. This paper emphasis on the lens designed for micro meter focusing scanning for bio-medical systems. The scanner exploits the functional advantages and the optical system has small spot size, great linearity and large depth of focus. The optical design of the scanning lenses is discussed and the scanner fabrication is introduced.

Introduction

Laser scanning technology is finding new applications as society moves from an industrial age to an information age. Laser scanner not only can be used to write information on a medium, as in machining, welding, printing and projection; but could be add in instruments for medical use for cell measurement. Considering the fluorescence scanner for reading gene microarray, there are 2 major approaches in the worldwide market. One, selected by PerkinElmer, Axon, Genomic Solution, BioRad, etc., is composed of laser light source and photo multiplier tube (PMT) and the other is composed of white light source and charged-coupled device (CCD) camera, involved by Alpha Innotech, Applied Precision, etc. These two approaches have its strengths respectively but the former solution with 2 laser sources, which costs around US$50,000 to 80,000, is more popular and cost effective so that this research is also based on it. The basic structure of this solution includes sample loader with moving stage, multiple fixed light sources, and con-focal fluorescence detection.

Mechanism and Specification Requirements

For the study of entire genomes expression or large sets of genes, bio-scientists perform blot hybridizations, where the gene-specific nucleotide sequences of probes are bound to membranes in arrays, to complete a fast and precise examination. One way to measure dot blots array of hybridizations is to detect their fluorescent images with laser scanning mechanism and to compare the fluorescent signal with the known control probes and RNAs or cDNAs.

As an image writing means for a printer or digital copier, there has been used a scanning optical system that scans a deflector that deflects a light beam emitted from a light source, and an imaging lens that makes the deflected light beam form an image on the scanning surface conventionally. In such a scanning optical system, when a polygon mirror is used as the deflector, an inclination error of the reflection surface of the polygon mirror (hereinafter

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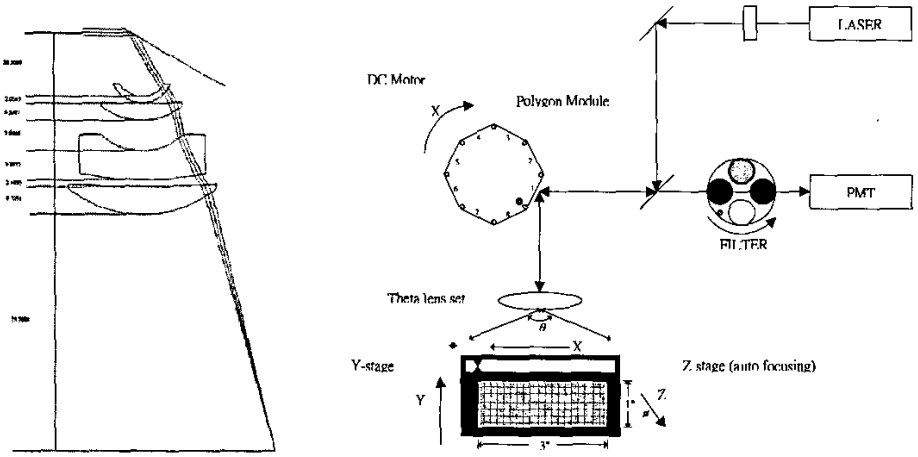
also referred to as "polygon reflection surface") often causes dislocation of one-line images that are formed on the scanning surface (i.e. uneven pitches between the one-line images). Moreover, the requirement of pixel size and linearity in the optical system used for biochip scanning is thousands times of the scanning system used in printer is invented in 1970s is close in micro meter scale.

For solving all the problem described above and raising the signal to noise ratio that make the field of scanning systems troubled, we try to use microarray scanning system with confocal technology to get higher performous than other scanning systems, shown as below.



Usually, the individual probe molecules on dot blots array are well arranged in order on a 22mmX75mm (or 1"X3") substrate with 80~250 dpi. That means the diameter of sample spot is about 25~500 m, popularly 100 m. To precisely calculate the fluorescent intensity of one spot, the spot needs to be divided to tiny pixels and summed up the intensity of all pixels. Thus, the scanner should provide higher resolution than spots. For example, for 100 m spot of micro-array, the suggestion pixel size is 5~20 m. It means the pixel resolution is 5000 dpi.

Considering the accurate measurement, scanning speed and manufacturing cost, we choose pre-objective scanning geometry using 12-face rotating polygon and one sphere lens set of f-theta lens to make the image height be as proportional to the scan angle with less than 5% error. Converting to scanning speed, it means scanning malposition is below 0.05 m per pixel.

Besides, other considerations include scanning along the 3" width, 5cm diameter of circumscribed circle of polygon, dual laser source (635 nm and 532 nm wavelengths) and 10cmX10cmX20cm opto-mechanism size.

The goal of Micro-array Scanner Systems is précising position, fast scanning, high sensitivity and resolution, and the proper dying for most visible light; for this requisite, this paper use optical design software CODE V to design a new optical system with polygon mirror to achieve the needs.

Conclusions

This paper has presented an optical scanning system which could focus in 5um and its scanning region is about 3 inch long. In a scanning optical system where a bundle of rays scans a surface to be scanned through an polygon mirror adding on a servo motor and an image forming optical system, the image forming optical system includes a positive front lens group having two lens elements and a rear lens group constituted by an elongated single

anamorphic lens element having a strong positive refractive power in the sub scanning direction. All the lens elements in the image forming optical system are made of a BK7 material, and the scanning optical system satisfies the conditions bio-scanner needs, including small spot size smaller than 5um, linearity is about 0.05um per dot, and large depth of focus.

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