Synchronous detection technology optics surface microstructure Research and characterization methods

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Abstract. The total integrated scattering method for non-contact measurement technology, will not damage the surface of the sample, the instrument has a simple structure, low cost, high speed, high accuracy, less susceptible to environmental factors and other characteristics, has been widely used on the quality of the actual detection of the optical processing.

Introduction

Ultra-precision optics manufacturing technology plays an important role in the implementation or development of a number of national projects or major weapons systems. Ultra-precision optical components manufacturing system, composed of ultra-precision optical machining, ultra precision optical detection and ultra-precision optical surface treatment and other aspects. Particular note is that from the perspective of the manufacturing system , with the continuous improvement of manufacturing capacity, synchronous detection surface microstructure of ultra-precision optics problems have become the bottleneck of the development of manufacturing technology limitations.

Synchronous detection optical element large aperture surface microstructure mainly mechanical stylus measurement, optical measurement, optical measurement method stylus. However, these methods are complex operations, such as lack of time-consuming measurements.

This paper presents the total integrated scattering method is very suitable for the detection of high-quality large-diameter optical surface microstructure. This approach can not only compensate for the lack of the detection methods, but also helps perfect scattering techniques combined with scanning force microscope.

Research

By studying the mechanism of sub-surface polishing, mathematical modeling, it is concluded that the relationship .between the surface roughness and the sub-surface structures. Realize the synchronous detection, On the detected data analysis, process optimization experiments. Experimental device to verify by testing the experimental device consists of a sample positioning system, a spatial filter, precision goniometry arms, lock-in amplifier, the control part of the system and data acquisition systems and other components. General use of radiation sources, mechanically compensated by the sample positioning system, each of the local radius of curvature, lighting vertical illumination of the sample surface. Deal with the partial compensation to the actual detection angle scattering angle by software. Sample precision positioning system fixed in the center of the goniometry arm, and detection system fixed to one end of the arm, and by the angle detector can be a resolution of 0.01 degrees 360 degree rotation around the sample. This arrangement includes 12 orders of magnitude, it can meet the microstructure detect ultra-smooth surface.

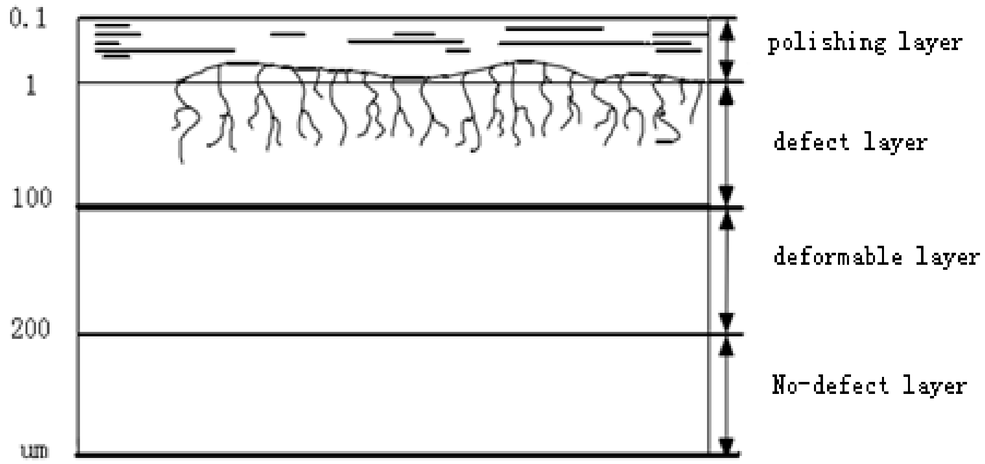
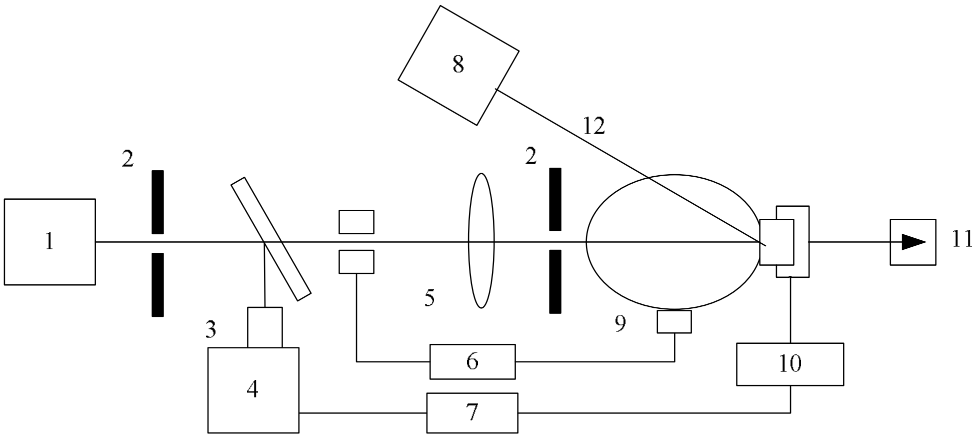


Figure 1: Subsurface damage figure

Various ancillary structures circuits and electronic control systems, respectively, after the detector signal high-gain low-noise preamplifier access to dual-channel lock-in amplifier, you can get a reference signal and scattering the incident optical signal amplified . Lock-in amplifier output analog signal by the A / D converted directly into the computer for processing to obtain the total integrated scattering information. Digital lock-in amplifier, the system more reliable easier. The rapid development of surface roughness measurement precision made increasing demands; the phase shift interference microscopy system can achieve nanoscale resolution ultra-smooth surface roughness analysis of nanotechnology. Stop system can reduce the effects of stray light. The total integrated scatter diagram shown in Figure 2:

The advantage of the scatterometer is simple, convenient, no contact with the sample surface without damage. Space optical wide spectral imaging system, the focal length and an increasing demand for large diameter, the substrate surface microroughness scattering loss is an important factor, which seriously affect the film surface scattering loss specular reflectance. Bennett and Porteus developed the theory of scalar scattering medium rough surface reflectivity radar Davies and apply it to the visible realm, Tomas and Daniel under special conditions related to the application of the simplified theory, gives the total integrated scatter (TIS) relatively simple conversion between the loss and the surface roughness (rms).



1.He-Ne laser 2. Aperture 3. photocell 4 digital voltmeter 5 focusing system
6. Lock-in amplifier 7. Computer 8. Reflected light absorption tube
9 photomultiplier tube 10. Scanning circuit 11. Transmissive light absorption
12.analyzer arm cylinder
Figure 2: The total integrated scatter diagram

Mathematic Model

Establishment of comprehensive statistical sample surface basic characteristic parameters - relations with all its root mean square roughness scattering total integration between the reflection direction, so that the total integral scattering method has become a convenient measure the rms surface roughness methods. The theory starting from Kirchhoff diffraction, diffuse scattering occurs deduced on the film surface that part of the light. Total score for the film to define the scattering surface scattering (diffuse) light surfaces reflect light (specular and diffuse reflection and) the ratio between the two. According to the scalar scattering theory, in the conditions of q **pp** l , satisfy the relation between total integral scattering andσ:

$$TIS \approx (4ps\ \cos q_0/l)^2 \qquad (1)$$

If the direct application of the theory of scalar scattering resulting formula:

$$s = (l/4p\ \cos q_0)\sqrt{TIS} \qquad (2)$$

Wherein s means square surface roughness q_0 meanslight incident angle,TIS means the total integrated scattering, drawn s , since its structure limits the sphere, it can not collect the scattered light from all angles within a solid angle of 2π, and therefore the total value derived is smaller than the actual surface roughness. Based on the analysis, pointed out that the measured can be corrected to make it closer to the actual value of the surface roughness, through preliminary experiments, can be an ideal value after correction.

LambroPoulos obtained based on the median crack sharp indenter platen and lateral crack depth theoretical calculation based on the indentation fracture mechanics theory and ideal plastic material expansion Hin holes respectively.

For the median crack depth for the indentation load suppression, sharpness of the indenter angle, the elastic modulus of the material, as the material hardness, fracture toughness of the material, as one yuan dimensionless constant stress field of the indentation on the elastic component crack depth correction coefficient bit values between 1/3 and 1/2.

Experimental light output power of 10mW He-Ne laser, wavelength 632.8nm, P polarization, use a large laser output power is to enhance the signal to improve the sensitivity of the system. The use of P-polarized light is scattered to the need to build the model.

When a monochromatic parallel light is projected onto the roughened surface, which reflected light can be divided into two parts, one part is specular, diffuse part of the light or scattered light, and the sum of the two hemispheres called the total reflected light or the reflected light. If set to the total reflected radiation, the scattered radiation, specular reflected radiation, the angle of incidence, the rms roughness of the sample,

The rapid development of surface roughness measurement precision made increasing demands, the phase shift interference microscopy system can achieve nanoscale resolution to ultra-smooth surface roughness analysis of nanotechnology. The preparation of the software system, real-time measurement of the sample surface roughness, can satisfy the requirements of nanoscale roughness measuring performance.

For a smooth optical surface, the scattering signal is very weak, in order to improve the measurement accuracy, the key is to try to suppress the noise reduction system. Integrating sphere system noise including the external stray light, air dust inside the integrating sphere , light scattering noise current of the photomultiplier tube. In addition, the stability of the system will largely affect measurement accuracy. According to the above principle, the experimental apparatus based on the total integrated scattering method, shown in Figure 3:

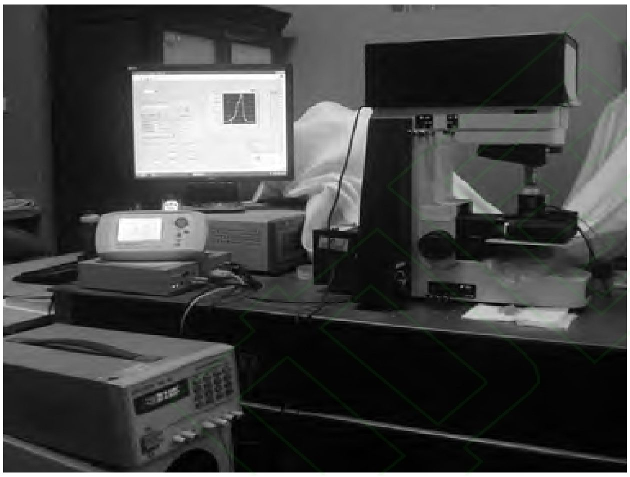


Figure 3: Experimental device

Summary

(1) Verify the processing under the same conditions, the process of polishing an optical component affect the size of the diameter of the abrasive grains on the surface roughness of the test piece, the surface roughness and the processing of the specimen and abrasive particles into a certain diameter proportional relationship; verify the SSD / SR (subsurface damage / surface roughness) scale model of forecasting method, that the greater the surface roughness of optical components, the deeper the depth of sub-surface damage. The measurement object optical components for ultra-smooth surface, probing depth of 100μm, vertical measurement resolution of 0.1nm.

(2) The total integral scattering method that can detect parts of the surface roughness and subsurface damage conditions, this method does not damage the surface of the part is, through data processing, analysis can also damage parts of the surface at different depths within the range of the measured distribution.

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