3D Information Retrieving of Concealing Surface beneath Opaque Resin Layer by Fast-Fourier Low Coherence Interferometer

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Introduction

Retrieving of information beneath a layer, low coherence light, and analytical method are essential tools for interferometry. 2D image concealing under a light-scattering medium could be retrieved by applying a normalized contrast method on the interferogram from SLD Michelson interferometer [1]. and 3D profile of uncoated and coated surface under transparent thin layer could be produced by using a continuous wavelet transform with vertical scanning interferometry. The Halogen lamp is the light source. [2,3] In this research, 3D information on a surface, concealing beneath opaque resin layer, will be produced by using SLD phase difference interferometry with a Fast Fourier Transform, is less time on analysis.

Experimental detail

3D image is constructed from interference fringes of the sample surface and FFT analysis. The fringe is built by using SLD Michelson interferometer, as is in figure 1. The interference fringe is explained by distribution function which is

$$i(x, y) = a(x, y) + c(x, y)\exp(2\pi i f\ x) + c^*(x, y)\exp(-2\pi i f\ x).$$

FFT is applied for separating signal spectrum data at central frequency $A(f_0, y)$ and two terms of the signal spectrum shifted $C(f - f_0, y)$ and $C^*(f + f_0, y)$), according to following equation;

$$I(f, y) = FFT[i(x, y)] = A(f_0, y) + C(f - f_0, y) + C^*(f + f_0, y).$$

Next, inverse FFT was applied to just only data of signal spectrum shifted $C(f - f_0, y)$ to calculate phase distribution from;

$$\phi(x, y) = arctan\left(\frac{Im[c(x, y)]}{Re[c(x, y)]}\right)$$

Finally, the height distribution $h(x, y)$ of the surface beneath the thin layer, which its refractive index is n can be calculated from:

$$h(x, y) = \frac{\lambda_0}{4\pi(n-1)}\phi(x, y).$$

The samples used in this research are listed as following: SN-sample is prepared by engraved the 'CU'-mark on a steel gauge box by laser etching and other samples are coated with an opaque resin.

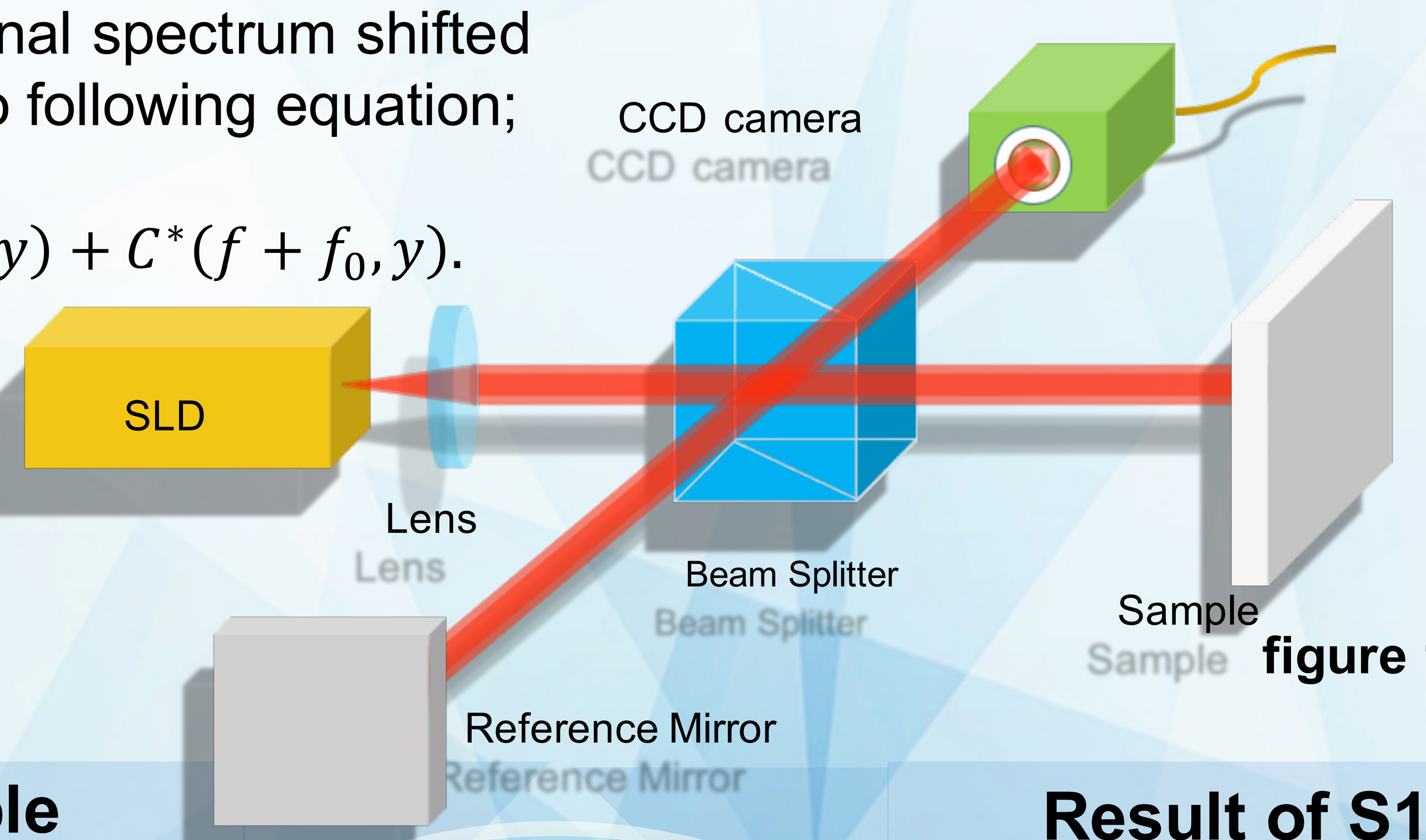
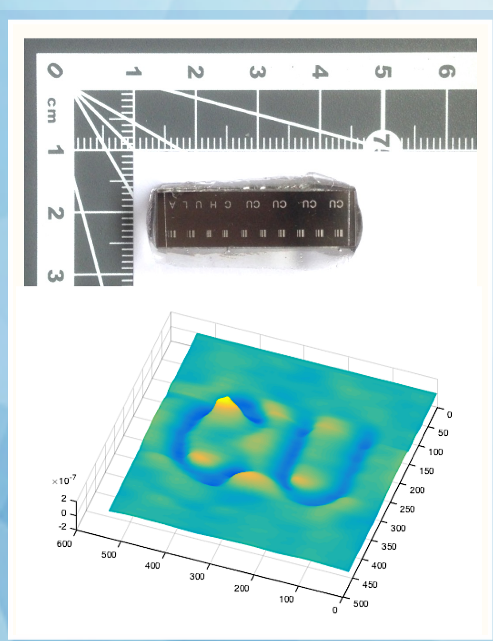


figure 1. SLD Michelson interferometer

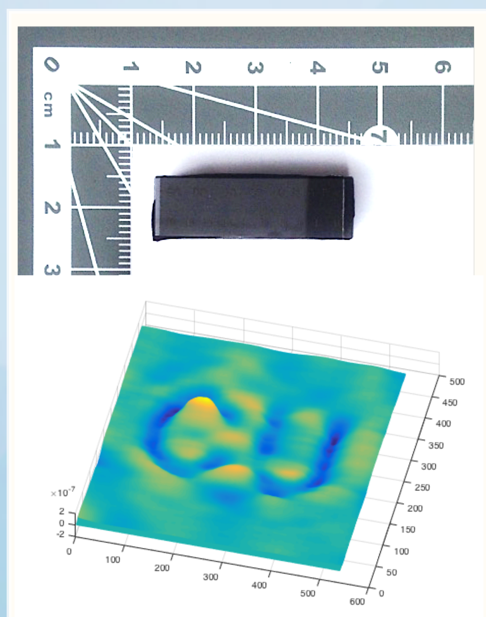
Result of S00-sample



S00-sample is SN-sample that coated by a transparent resin layer.
Transmittance is 1.00.
Refractive index is 1.829.

3D profile of 'CU'-mark for S00-samples.

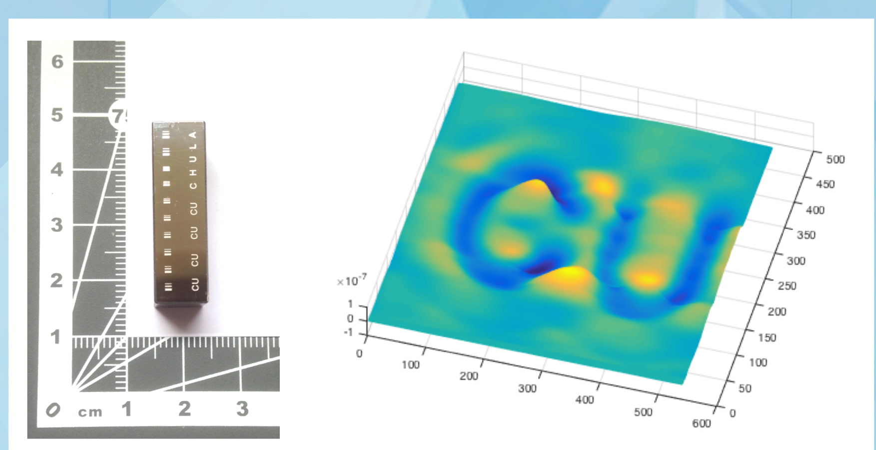
Result of S10-sample



S00-sample is SN-sample that coated by a 1.0% semi-transparent resin .
Transmittance is 0.31.
Refractive index is 1.532.

3D profile of 'CU'-mark for S10-samples.

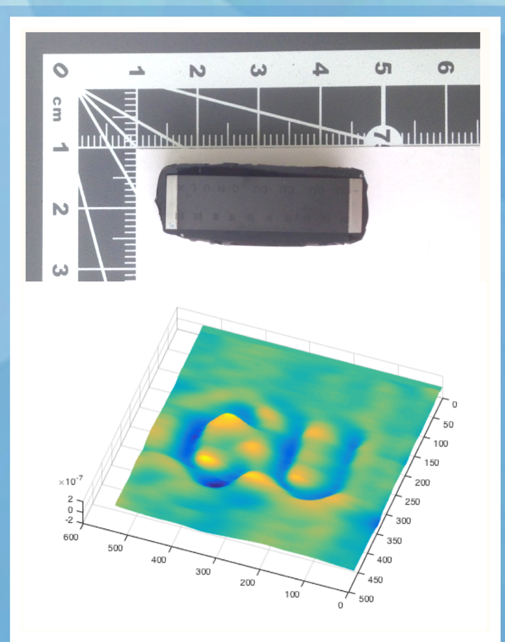
Result of SN-sample



SN sample is prepared by engraved the 'CU'-mark on a steel gauge box.

3D profile of 'CU'-mark for SN sample.

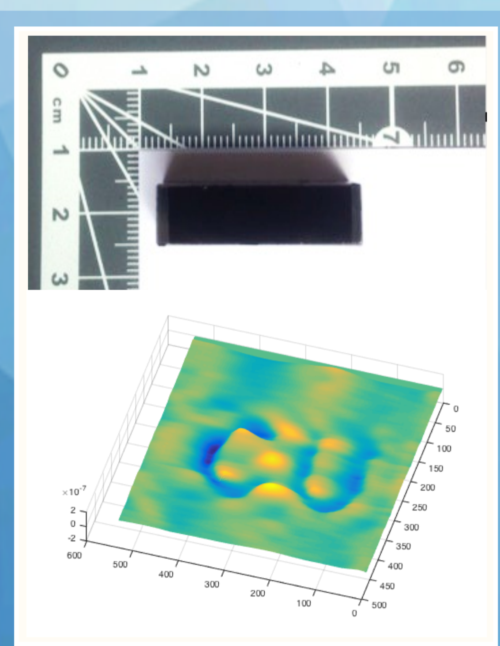
Result of S05-sample



S00-sample is SN-sample that coated by a 0.5% semi-transparent resin .
Transmittance is 0.49.
refractive index is 1.536.

3D profile of 'CU'-mark for S05-sample.

Result of S15-sample



S00-sample is SN-sample that coated by a 1.5% semi-transparent resin.
Transmittance is 0.25.
Refractive index is 1.813.

3D profile of 'CU'-mark for S15-samples.

Note: Semi-transparent resin is made by adding volume in percent unit of the opaque black resin to the transparent one

Discussion and conclusion

SLD phase difference interferometry with FFT is a suitable, less-time consuming and nondestructive optical method for retrieving the concealing 3D mark of all samples on the surface beneath the semi-transparent layer. S15 sample is just only a sample that can hided mark under the semi-transparent layer from photography, but its 3D mark can be revealed. So the transmittance of opaque layer for this method should not be less than 0.25.

Acknowledgements

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References

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[2] Laopornpichayanuwat W, Visessamit J and Tianprateep M 2012 *Measurement* **45** 2400-06
[3] Tay C J, Quan C and Li M 2007 Japan. *Opt. Laser. Eng.* 45 907-13