Sinusoidal waveleangth-scanning common-path interferometer with a beam-scanning system for measurement of film thickness variations

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1.Introduction

With the advancement of electronic devices, it is necessary to accurately measure thickness of thin films. Here we describe an interferometric setup and processing methods of the interference signal for the thickness variation measurement.

2. Setup for the measurement

Figure 1 shows an setup for the measurement. A sinusoidal wavelength-scanning light source is constructed with a super luminescent diode (SLD) and an acoustic tunable filter (AOTF). A focused beam is scanned over a surface of a thin film along x- axis with a scanner mirror (SM) and a lens L2. The two beams reflected by the front and rear surfaces of the film go back along the same path and reach a photo multiplier (PMT) which detects the following interference: $S(t) = A+ B\cos(Z_b\cos\omega_b t-\alpha)$, where the term of $Z_b\cos\omega_b t$ is produced by the sinusoidal wavelength-scanning, and the phase α is proportional to thickness change of the film along the x-axis. Because of the beam scanning over the surface of the film, the phase α is a function of time. In the next section it is described how to extract the phase $\alpha(t)$ from fast Fourier transform (FFT) of the signal S(t).

3. Processing of the interference signal

The signal S(t) is sampled with the sampling frequency of $8f_b$, and the signal length is $2^N/f_b$, where $f_b=\omega_b/2\pi$ and N is an integer . FFT of S(t) is denoted by $F(\omega)=\Im\{S(t)\}$. The frequency components in the ranges of $\omega_\beta/2<\omega<3\omega_\beta/2$ and $3\omega_\beta/2<\omega<5\omega_\beta/2$ are, designated as $F_1(\omega)$ and $F_2(\omega)$, respectively. Then the following equations arederived: $F_1(\omega-\omega_\beta)=-J_1(Z_b)\Im\{\sin\alpha(t)\}$, $(\omega-2\omega_b)=-J_2(Z_b)\Im\{\cos\alpha(t)\}$ where J_n is a nth Bessel function. Inverse FFT of $F_1(\omega-\omega_\beta)/J_1(Z_b)$ and $F_2(\omega-2\omega_\beta)/J_2(Z_b)$ provide the terms of $\sin\alpha(t)$ and $\cos\alpha(t)$, respectively. Finally the values of $\alpha(\tau)$ are obtained with an arctangent function. However, the function $\alpha(\tau)$ contains frequency components which are not equal to integer multiples of $f_b/2^N$. In this case the exact frequency components of S(t) can not obtained by FFT due to the aliasing effect. Therefore a Gaussian window G(t) is used for the signal S(t) as shown in Fig.2. The components of $F_1(\omega)$ and $F_2(\omega)$ is shown in Fig.3. The phase $\alpha(t)$ finally obtained from G(t)S(t) is shown in Fig.4, where the horizontal axis is x-coordinate corresponding to the scanning beam position. As a conventional method the values of $\alpha(t)$ are calculated every one period of f_b from 8 sampled values of S(t). The result by the conventional method is shown in Fig.5.

4.Conclusion

The results shown in Figs.4 and 5 are almost the same. This means that the new signal processing is faster than the conventional one.

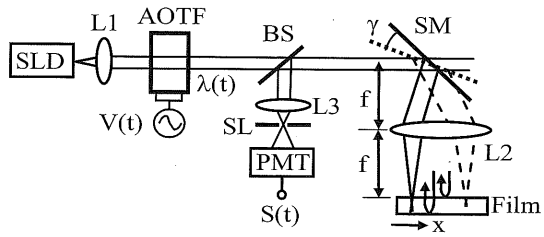

Fig.1 Setup for thickness variation measurement.

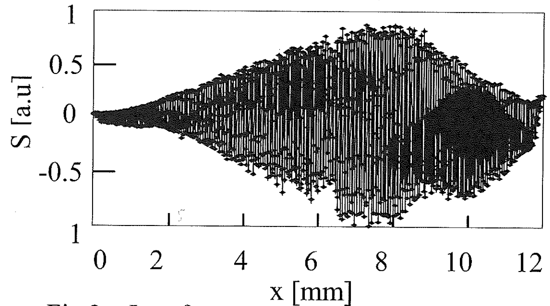

Fig.2 Interference signal multiplied by a Gaussian fuction.

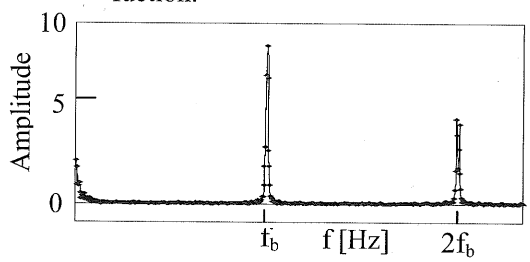

Fig.3 Amplitude of $F(\omega)$.

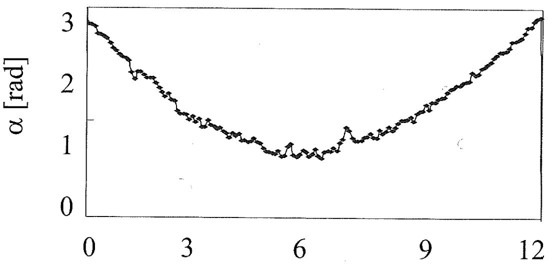

Fig.4 Phase α calculated from all of the sampled values.

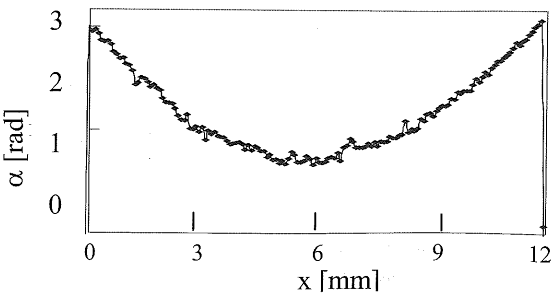

Fig.5 Phase α calculated every one period of f_b from 8 sampled values.