

Fig. 1 Out-of-plane displacement sensitive ESPI interferometer

Interferometry : TA-ESPI

Euler-Bernoulli

2.

2.1 TA-ESPI

ESPI

TA-ESPI

가

ESPI

TA-ESPI

Fig. 1

가

(Object beam) $I_O(x, y)$

CCD

(Reference beam) $I_R(x, y)$

$K(x, y)$ CCD

(1)

$\phi(x, y)$ 가

$$K(x, y) = I_O(x, y) + I_R(x, y) + 2\sqrt{I_O(x, y)I_R(x, y)} \cos \phi(x, y) \quad (1)$$

(= $a_0 \sin \omega t$)

(2)

$$I_{aver} = I_O + I_R + 2\sqrt{I_O I_R} \cos \left[\phi + \frac{4\pi}{\lambda} a(t) \right] \quad (2)$$

$\tau (\gg 2\pi/\omega)$

$$(3) \quad \dots \quad (4)$$

가 0 Bessel (J_0)

$$I_r = I_O + I_R + \frac{1}{\tau} 2\sqrt{I_O I_R} \int_0^\tau \cos \left[\phi + \frac{4\pi}{\lambda} a(t) \right] dt \quad (3)$$

$$I_r = I_O + I_R + 2\sqrt{I_O I_R} J_0^2 \left(\frac{4\pi}{\lambda} a_0 \right) \cos \phi \quad (4)$$

$$\frac{J_0^2 \text{가}}{2\sqrt{I_O I_R} \cos \phi} \text{ 가}$$

stroboscope-ESPI

2.2

Euler-Bernoulli

Rayleigh

Ritz

Timoshenko beam

가

Euler-Bernoulli

clamped-free

(Euler-Bernoulli beam)

(Resonance frequency)

TA-ESPI

(5)

(E)

$$E = \frac{m\omega_n^2 l^4}{c^4 I} \quad (5)$$

m :

ω_n :

c :

Table 1

Copper) KS

clamped-free (90x5x0.1 mm³)

(Natural frequency)) 4

가

Table 1 Natural vibration frequency of SCPI

	1st Mode	2nd Mode	3rd Mode	4th Mode
Frequency (Hz)	43.577	122.090	239.981	399.827

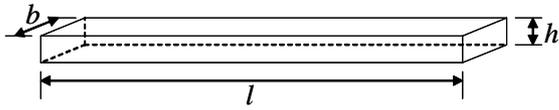


Fig. 2 Pure Copper Specimen

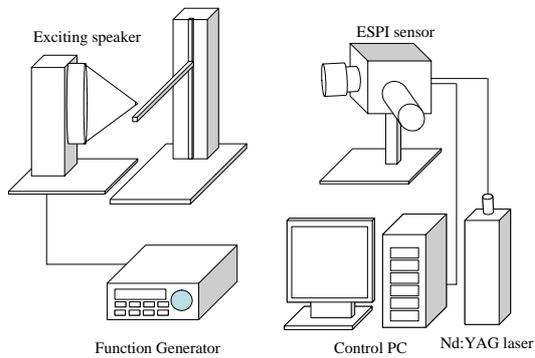


Fig. 3 Configuration of elastic modulus measurement system

3.

3.1

(Pure Copper) Foil Fig. 2
 가 1 , b, 가 h
 0.1mm, 5mm
 30mm, 40mm, 50mm, 60mm, 70mm, 80mm, 90mm

(TA-ESPI) Ettermeyer Fig. 3 Nd:YAG Laser(: 532 nm), 가
 . 가

(Function Generator) 가 Microphone

3.2

TA-ESPI

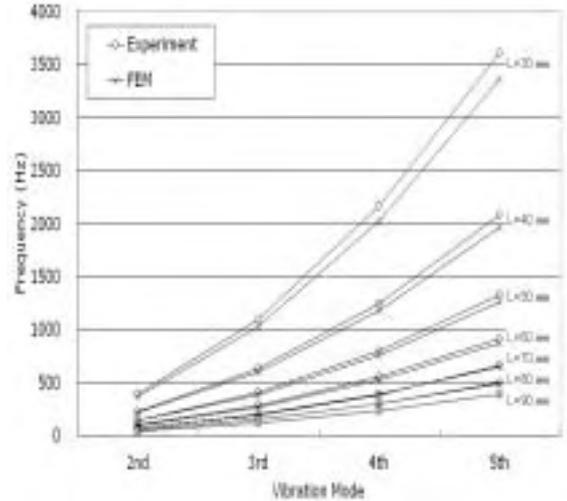


Fig. 4 Vibration Frequency of Foil Copper (t=100 μ m)

가

TA-ESPI

가

Nodal line 가
 . Nodal line

270 nm (가
 1/2) 가
 1 Hz 가
 1
 2

4.

Fig 4 가100 μ m TA-ESPI 가 104(GPa)
 (ANSYS)

110(GPa) 가

가 Euler-Bernoulli Beam ;

10

, 6

6.348%, 8
 5.356%, 12
 5%
 95% 가
 5.068%, 10
 4.629% 가
 1.09% 95%
 Euler-Bernoulli
 , 14

ASTM
 (Pure Copper)
 , Euler-Bernoulli Beam ()
 10
 14

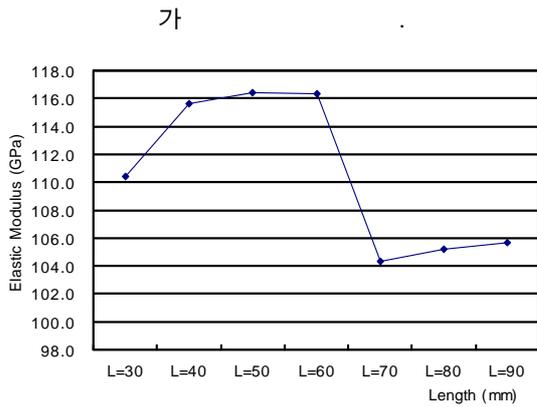


Fig. 5 Elastic Modulus of Foil Copper (t=100μm)

Fig. 5

(5)
 14
 , Fig. 4
 , 14
 104~106
 (GPa)
 ASTM
 110~120(GPa)
 TA-ESPI
 14
 104.6(GPa)

가 TA-ESPI 가 가 가 가

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5.
 가
 Euler-Bernoulli Beam
 TA-ESPI()
 Euler-Bernoulli Beam