ADVANCE RIKO

2-Omega Method Nano Thin Film Thermal Conductivity Meter

TCN-2ω

Simple evaluation of thermal conductivity in thin film

◆ General Description

This system is the only commercially available system which can measure thermal conductivity in normal direction of the nano thin film by 2-Omega method.
The sample can be easily prepared and measured compared with another method.

◆ Features

1. Evaluation of thermal conductivity in thin film at nano scale

The method of detecting temperature change of the surface of the metal thin film by thermoreflectance method during periodic heating was developed. The temperature increase on the sample surface can be analyzed on the basis of one-dimensional heat conduction model along thickness direction. Thermal conductivity can be simply evaluated along the thickness direction. (Japan patent: 5426115)

2. Simple preparation of sample

Metal thin film(1.7mm×15mm×100nm) can be coated on the thin film without the lithography technique.

◆ Applications

1. Best suited for evaluation of thermal conductivity of thin film required for thermal design.

Low-k film, Organic thin film, Thin film of thermoelectric material

2. Capable of evaluation of thermoelectric conversion thin film.

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◆ Measurement principle

Metal thin film is heated by the periodic heating method with the basic frequency (f / Hz). As a result, the response frequency with the thermal energy, 2f / Hz, is equal to two times as large as the basic one. In the case of the film composed of metal thin film (0) – thin film (1) – substrate (s) as shown in Figure, the temperature increase T(0) on the upper surface for the metal thin film can be calculated on the basis of one-dimensional heat conduction model. Assuming that the energy completely arrived at the bottom substrate, T(0) is following the equation,

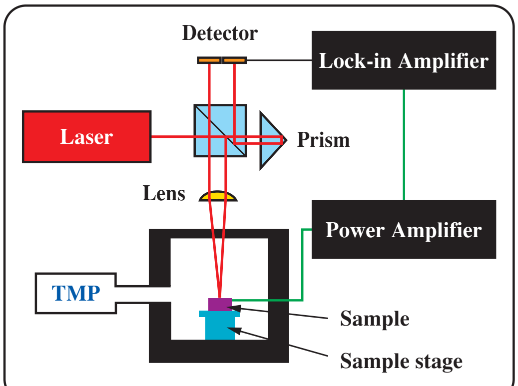
$$\frac{T(0)}{q\,d_0} = \frac{1}{\sqrt{2C_s\lambda_s(2\omega)}} + \left(1 - \frac{C_1\lambda_1}{C_s\lambda_s}\right)\frac{d_1}{\lambda_1} + \left(\frac{1}{2} - \frac{C_0\lambda_0}{C_s\lambda_s}\right)\frac{d_0}{\lambda_0} + \frac{i}{\sqrt{2C_s\lambda_s(2\omega)}}$$

$(\lambda\,/\,\mathrm{W\,m^{-1}\,K^{-1}},\ C\,/\,\mathrm{J\,K^{-1}\,m^{-3}},\ q\,/\,\mathrm{W\,m^{-3}},\ d\,/\,\mathrm{m},\ \omega(=2\pi f)\,/\,\mathrm{s^{-1}})$

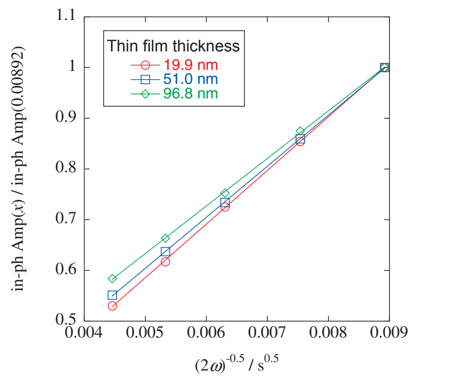
We note that the real part (in-phase amplitude) contains the information for the thin film. Assuming that the thermal energy completely arrives at the bottom substrate, the in-phase amplitude is proportional to $(2\omega)^{-0.5}$. Thermal conductivity for the thin film (λ_1) is estimated from

$$\frac{1}{\lambda_1} = \frac{1}{d_1}\left(\frac{C_1 d_1 + C_0 d_0}{C_s\lambda_s} - \frac{d_0}{2\lambda_0} + \frac{n}{m\sqrt{2C_s\lambda_s}}\right)$$

(m:slope, n:intercept)



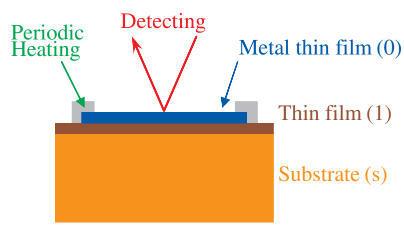
Schematic figure of TCN-2ω



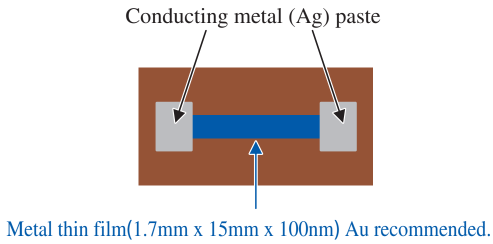
Experimental result for various SiO_2 thin films measured by TCN-2ω

◆ SiO_2 film (20-100nm) – Si substrate

d_1 / nm	λ_1/ W m^{-1} K^{-1}
19.9	0.82
51.0	1.03
96.8	1.20



Evaluation in thin film



Sample preparation

◆ Specifications

1. **Measurement temperature:** room-temperature
2. **Sample size:** wide 10 mm Length 10~20mm ×
   thickness 0.3~1mm (Substrate)
3. **Substrate:** Si (recommendation),
   Ge, Al_2O_3 (High thermal conductivity)
4. **Preparation:** Metal thin film (100 nm) coating on thin film is needed. (Gold thin film is recommended.)
5. **Measurement range:** 0.1～ 10 W m^{-1}K^{-1} in thin film
   (When thermal conductivity of thin film is about 1 W m^{-1}K^{-1}, thickness of thin film is above 20 nm.)
6. **Measurement atmosphere:** in vacuum

※Specification and appearance are subject to change without notice for performance improvement.

Agent

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