We are supporting global environment protection of an enterprise through quality improvement of thermophysical property measurement.

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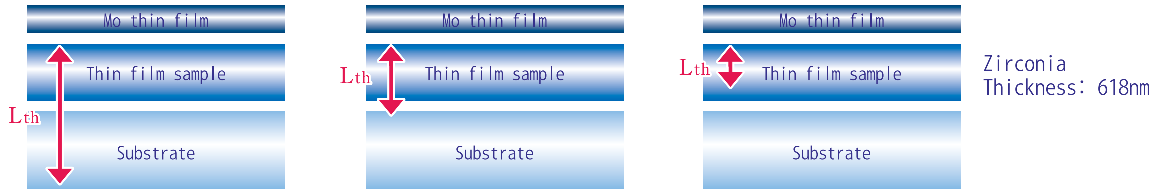
## Theory for measuring Thin Films

Thermal diffusivity length is the length that the thermal wave propagates through surface of a specimen when periodically heated the surface.

$$L_{th} = \sqrt{\lambda / \pi f C} = 1 / \sqrt{\pi f} \times b / C$$

$\lambda$=Thermal Conductivity    $b$=Thermal Effusivity
$f$=Heating Frequency    $C$=Heat Capacity (per unit volume)

If thermal diffusivity length is longer than the thickness of the film, the thermal wave propagates through the film within one cycle.
For example, the thermal diffusivity length of Zirconia is less than 618nm for 1MHz.
Theorefore, by using high frequency, measurements of thin film become possible to perform in sub-micron scale.



Heating freqency 500kHz    Heating freqency 1MHz    Heating freqency 2MHz

## ■ Specifications

| | TM3B |
|---|---|
| Mode | Thermophisical property distribution measurement ( Line, 2D, Point ) |
| Measurement | Thermal Effusivity, ( Heat Capacity ), ( Thermal Conductivity ) |
| Spot size | about 3 [μm] |
| Time of measurement | 10 seconds per point |
| Thickness | Sub micrometers to μm |
| Repetition Accuracy | ±10% for Pyrex and Silicon in thermal effusivity |
| Sample | Holder size : 30 × 30 × 5 [mm] |
| | Sample size : less than 30 × 30 × 3 [mm] |
| | Sample surface must be polished. |
| | Sample surface must be sputtered with Molybdenum. |
| Operating Temperature | 20±1 [℃] (sensor inside the system) |
| XY Stage Displacement | X axis 20 [mm] , Y axis 20 [mm] , Z axis 4 [mm] |
| Heating Laser | Laser Diode 808 [nm] |
| Probe Laser | Laser Diode 633 [nm] |
| Power Supply | AC 100 [V] - 1.5 [kVA] |
| Accessories | Sample holder, Refernce samples |
| Option | Optional table, Air-conditioning equipment, Booth for air-conditioning, Sputtering equipment |
| Main Body | Externals size : 730(W) × 620(D) × 560(H) [mm], Weight : 80 [kg] |
| Power Supply Box | Externals size : 620(W) × 480(D) × 310(H) [mm], Weight: 26.4 [kg] |

■ The numbers shown in this catalog are results from our examinations. The same results are not guaranteed in different circumstances.
■ The performance and appearance may be changed for improvement without notice.

**⚠ Caution for Safety**

Before using, please read manual and operate correctly for the safety.

CLASS 1 LASER PRODUCT
IEC/EN 60825-1 :2007

**Inquiry about products :** https://hrd-thermal.jp/en/contact/

<Manufactured and Distributed>

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https://hrd-thermal.jp/en/

<Agent>

Ver.2.03

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We wish to contribute to technological innovation and creating the future through our thermal measurement technology.

Light Heating Thermoreflectance method :
Thermophysical property measurement become easier

# Thermal Microscope

BETHEL THERMAL Search

Non contact measurement of nano order thin film with micro scale spatial resolution
Multiple samples could be automatically measured 10 seconds each

**TM3B**

BETHEL Co., Ltd.

# Thermal Microscope

## TM3B

## FEATURES

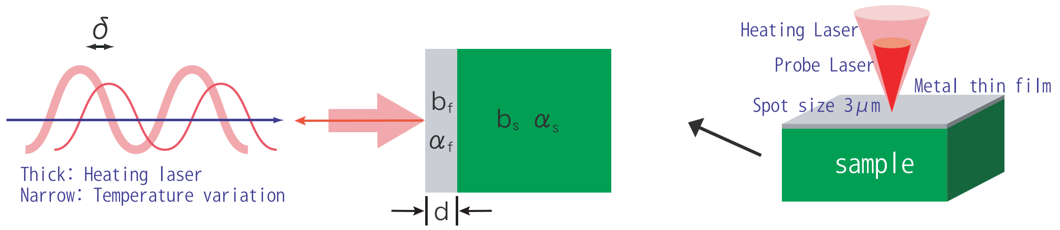
- ■ Thermophysical property measurement for thin films, 100nm order.
- ■ 2 dimensional measurement with $\phi 3\mu$m resolution.
- ■ Non contact measurement with laser.

A improvement in the material characteristics can be expected by evaluting the thermophysical property of thin film and the thermophysical property distribution inside the material.
The thermophysical property measurement for the thin film can be performed in 100nm-orders, and the thermophysical property distribution measurement can be performed in micrometer -order.

## THEORY

### Light Heating Thermoreflectance Method :
### Thermophysical property measurement become easier

Sputter Mo thin film on a sample and periodically heat the surface with heating laser.
Heat propagates though the Mo thin film and reaches to the sample. A phase lag occurs to the temperature response.
The phase lag varies with sample's thermophysical characteristics.
Since reflectance of Mo changes according to the temperature, by irradiating and datecting the amplitude variation of a probe laser beam which is coaxial to the heating laser, relative temperature variation of the surface could be measured.
By using this method, thermal effusivity measurement in high spatial resolution become possible.
Heat capacity per unit volume and thermal conductivity could be calculated be optional software.



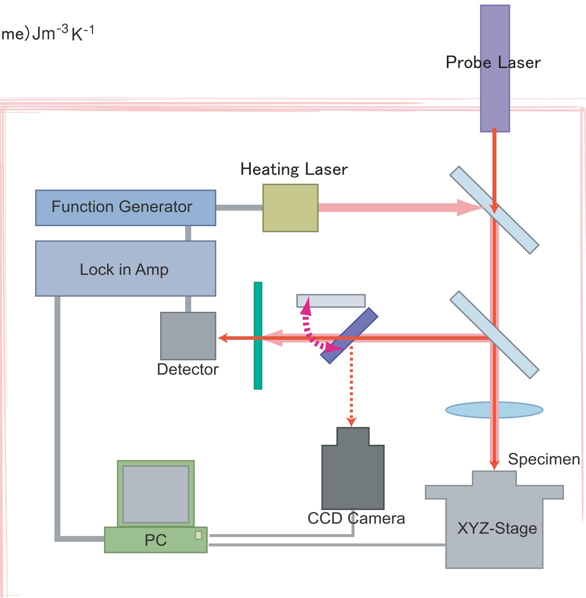
Related equation $$\delta = \arctan\left[-\frac{1+\sqrt{\frac{\omega\tau_s}{2}}}{\sqrt{\frac{\omega\tau_s}{2}}}\right]+\frac{3}{4}\pi \qquad \tau_s = \frac{b_f^2}{b_s^2}\frac{d^2}{\alpha_f} \qquad b=\sqrt{C\lambda} \qquad \lambda=\frac{b^2}{C} \qquad b=C\sqrt{\alpha}$$

$$\omega = 2\pi f$$

$b$ = Thermal Effusivity $\mathrm{Js^{-0.5}m^{-2}K^{-1}}$
$\lambda$ = Thermal Conductivity $\mathrm{Wm^{-1}\,K^{-1}}$
$C$ = Heat Capacity(per unit volume) $\mathrm{Jm^{-3}K^{-1}}$
$\alpha$ = Thermal Diffusivity $\mathrm{m^2s^{-1}}$

Ref: Thermoreflectance technique to measure thermal effusivity
distribution with high spatial resolution
K.Hatori, N.Taketoshi, T.Baba, H.Ohta,
Rev. Sci. Instrum. 76, 114901 (2005)

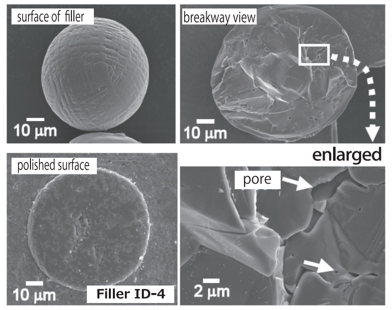
## CONFIGURATION



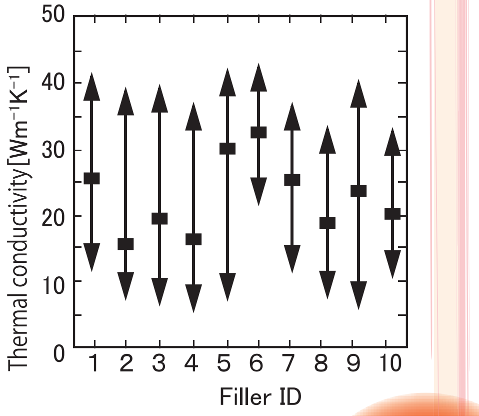
It is the best to measure the thermal effusivity of the thin film and the micro region.
A contactless and high-resolution measurement can be peformed.

[case-1]

### Alumina Filler



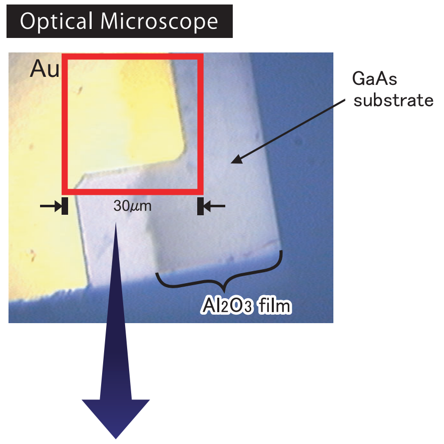
Thermal conductivity
of each filler

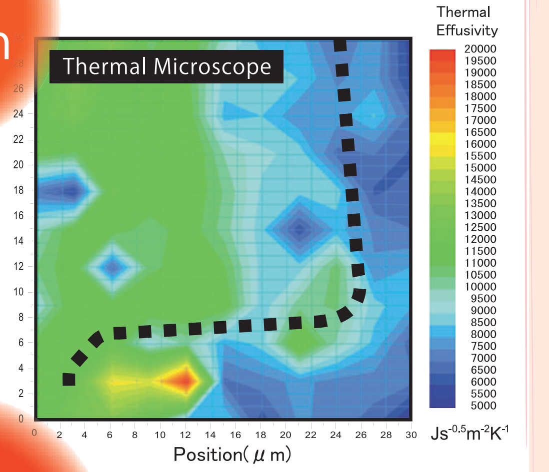


Sample offer: National Institute of Advanced Industrial Science and Technology Advanced Manufacturing Research Institute

[case-2]

### Electrode of Laser Diode





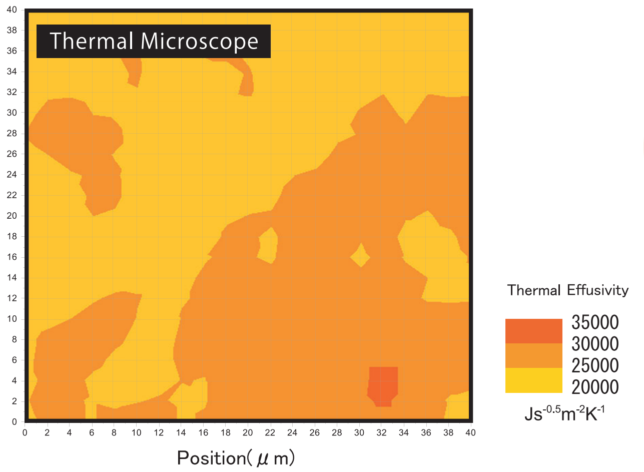
Micro Region

Mapping Measurement

The thin film Measurment

[case-3]

### SiC



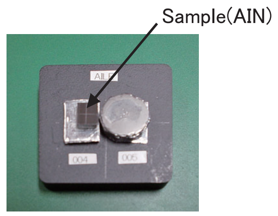
| SiC Sample | Thermal Conductivity $[\mathrm{Wm^{-1}K^{-1}}]$ ※ | Thermal Effusivity $[\mathrm{Js^{-0.5}m^{-2}K^{-1}}]$ |
|---|---|---|
| 4H−C SiC Single Crystal | 440 | 30400 |
| 6H−C SiC Single Crystal | 366 | 28100 |
| SiC Polycrystal | 274 | 24200 |

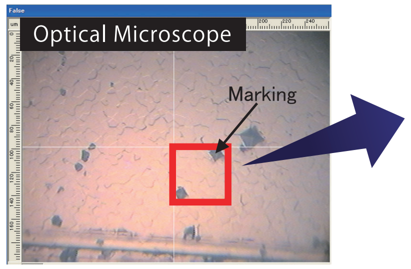
※ The value calculated as $C = 2.1\times10^6$ $[\mathrm{Jm^{-3}K^{-1}}]$

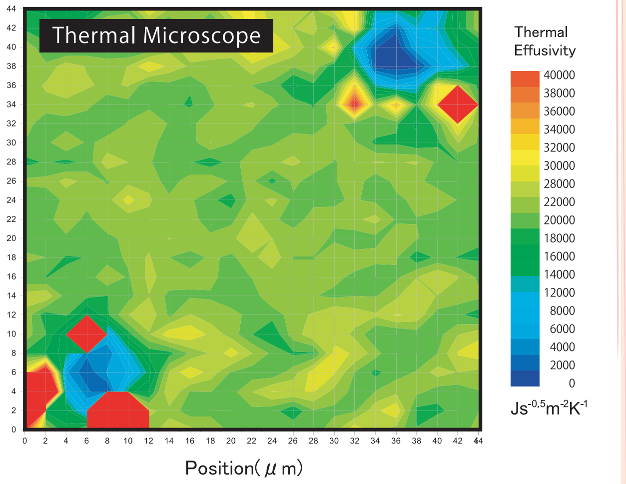
## APPLICATION

[case-4]

### Ceramics (AlN)







Sample offer: National Institute of Advanced Industrial Science and Technology
Advanced Manufacturing Research Institute