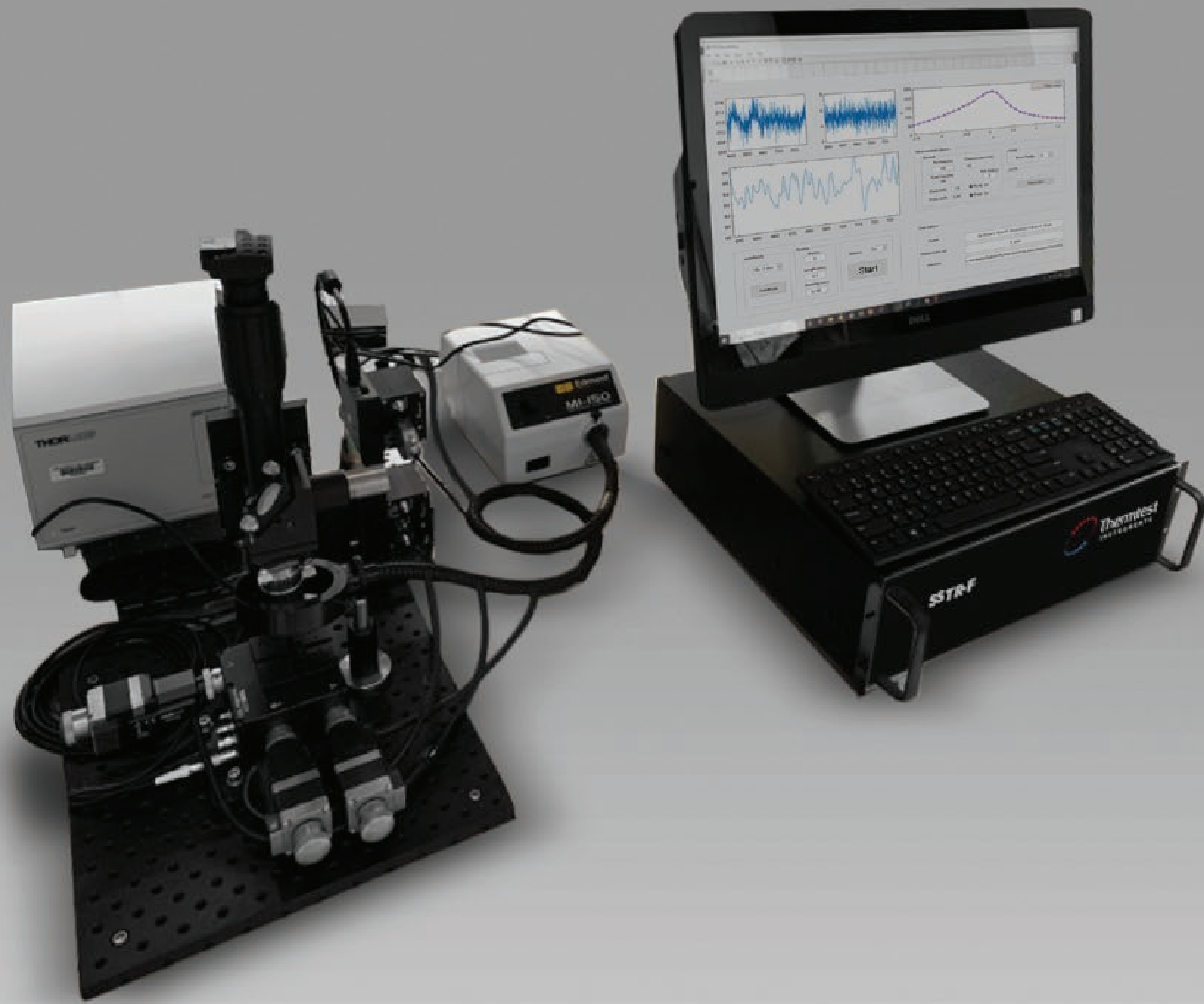
λ Brochure Paper (λ) = 0.10 W/m·K



SSTR-F

Non-contact thermal conductivity testing for coatings, thin-films and bulk materials from 0.05 to 2500 W/m•K

Thermtest
INSTRUMENTS

Thermtest INSTRUMENTS

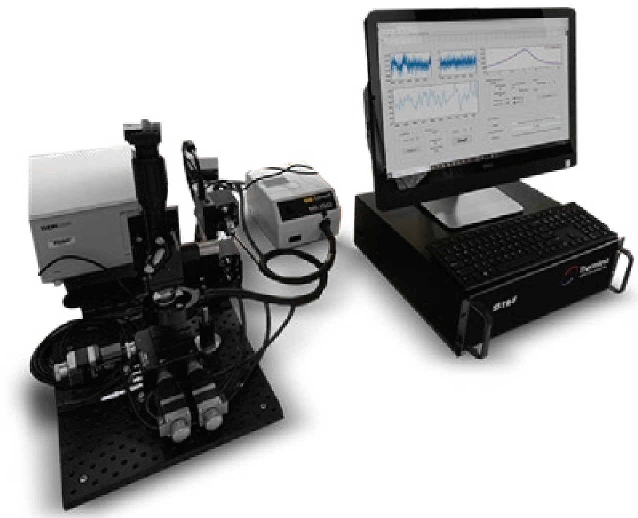
Thermophysical Testing, laboratory instrumentation line is designed for advanced measurement of thermal conductivity, thermal diffusivity, specific heat capacity, thermal resistivity and thermal resistance. Expanded capabilities include wider temperature ranges, sample size flexibility, testing automation, and data-analysis; TPS, THW, SSTR-F, MMH, HFM, and GHFM.

Thermal Analysis, laboratory instrument line for traditional thermal analysis: DSC, TGA, STA, TMA, DTA, and Dilatometer.

Thermtest PORTABLE

Thermophysical Testing, economical, easy-to-use meters for measurement of thermal conductivity, thermal resistivity, thermal effusivity and thermal resistance: TPS, TLS, THW, and GHFM.

Thermtest has been advancing the measurement of thermal conductivity, thermal diffusivity, and specific heat for more than a decade. With more than 2000 satisfied customers worldwide, our unique combination of advanced thermal conductivity instrumentation for the laboratory, portable meters for the field, and accessories, enables us to provide ideal solutions to fit any material testing application and budget.



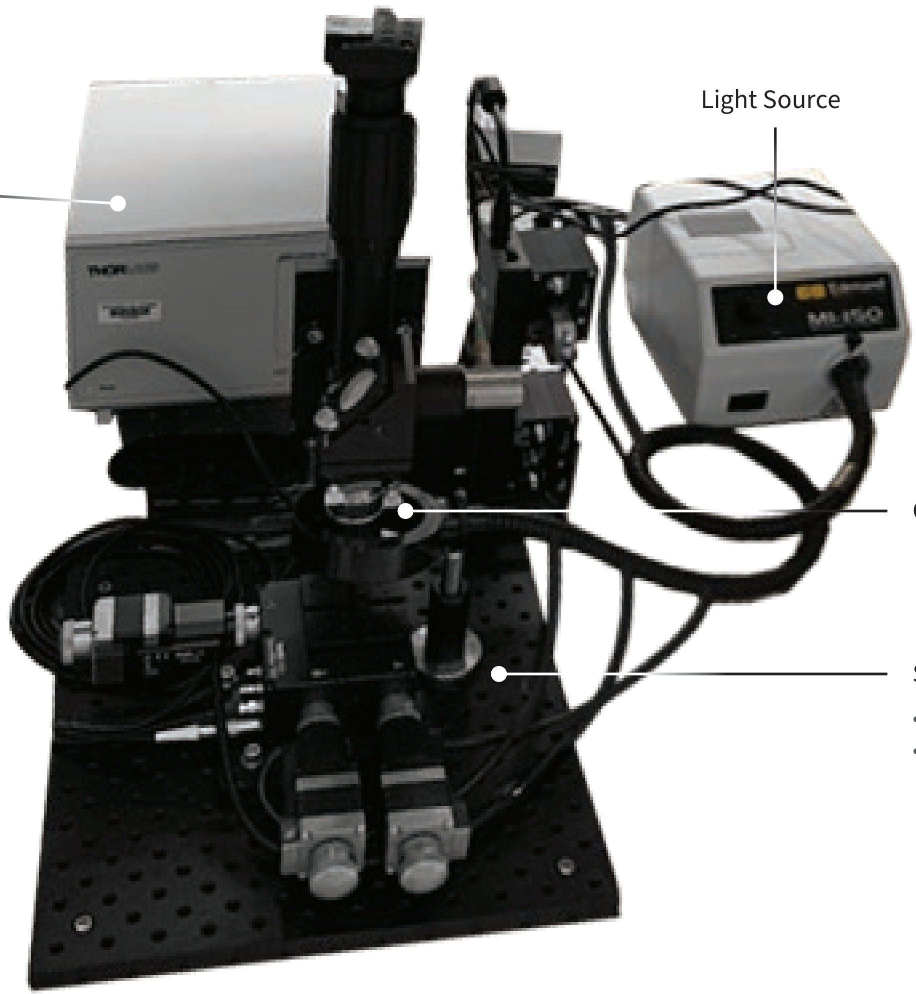
SSTR-F Steady-State ThermoReflectance Fiberoptics

Steady-State ThermoReflectance Fiberoptics (SSTR-F) combines the technological power of laser based thermoreflectance experiments with the proven measurement capabilities of steady state thermal measurements. Utilizing small measurement volumes allows for rapid steady state measurements of materials with thermal conductivities ranging from as low as 0.05 $Wm^{-1} K^{-1}$ up to 2,500 $Wm^{-1} K^{-1}$. In addition to the wide range of accessible thermal conductivities, SSTR-F can accommodate sample sizes as small as a few hundred microns. Exploiting recent advances in fiber-optic components and laser systems allows for a safe, user-friendly tool capable of high throughput thermal conductivity measurements.

Measurement capabilities are expanded with the optional FDTR Testing Module. The high frequency modulating heating event afforded in FDTR measurements extends this SSTR, to include measurements of thermal conductivity and heat capacity of materials, including thin films, thermal boundary resistance across material interfaces, and separation of the radial and cross-plane components to the thermal conductivity tensor.

The patent pending fiber-optic based thermoreflectance system (SSTR-F) and testing methodology was developed by Professor Patrick Hopkins from ExSiTE Lab at the University of Virginia.

SSTR-F **FEATURES**



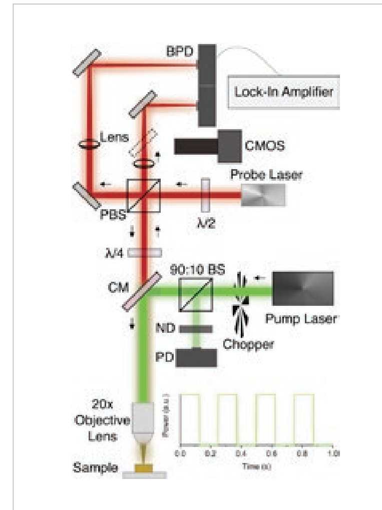


Figure 1

SSTR-F **FEATURED CAPABILITIES**

SSTR-F measures thermal conductivity using the combination of laser based thermoreflectance techniques (*Figure 1*) with traditional steady-state thermal testing concepts using the Hopkins Analysis. Harnessing decades of knowledge regarding the relationship between temperature and the thermoreflectance of metals, laser heating of a thin metal film on a material of interest allows for determination of the thermal conductivity of the underlying material without knowledge of the material's heat capacity by probing the response of the metal due to the pump. These concepts, laser based pump-probe experiments, have been utilized for decades to measure various optical, mechanical, and thermal properties of materials.

Unlike most traditional free-space (exposed laser beams) pump-probe experiments, SSTR-F incorporates all of its active and passive components in fiber-optic leading to a compact, simple system with increased safety, no need for prior optical experience, and streamlined high throughput measurements.

The technique works in principle by inducing a steady-state temperature rise in a material via long enough exposure to heating from a pump laser. A probe beam is then used to detect the resulting change in reflectance, which is proportional to the change in temperature at the sample surface. Increasing the power of the pump beam to induce larger temperature rises, Fourier's law is used to determine the thermal conductivity.

For expanded capabilities, the FDTR Testing Module may be added to the basic SSTR system. A key upgrade is the ability to measure thermal conductance and heat capacity of ultra-thin films – coatings down to a few nanometers thick. Understanding of the intrinsic and interface resistances between layers on a nano-scale, is a valued measurement for investigating the heat transfer efficiency of micro-electronics and related fields.

SSTR-F

- Absolute measurement of thermal conductivity
- Thin films and coatings (> 1 micron)
- Effective boundary resistance (thickness <1 micron)
- Auto-scanning for thermal conductivity mapping
- No inputs (i.e. heat capacity)

FDTR

- Multi-Thermophysical Properties
- Thin films and coatings (> 5 nm)
- Thermal Boundary Resistances

SSTR-F SPECIFICATIONS

Materials	Solids and Liquids
Thermal Conductivity Range	0.05 to 2500 W/m•K
Directional Measurement	Through-thickness and In-plane
Spot Size	Up to 100 microns
Temperature Range	80K - 600K
Accuracy	5%
Repeatability	2%

FDTR SPECIFICATIONS

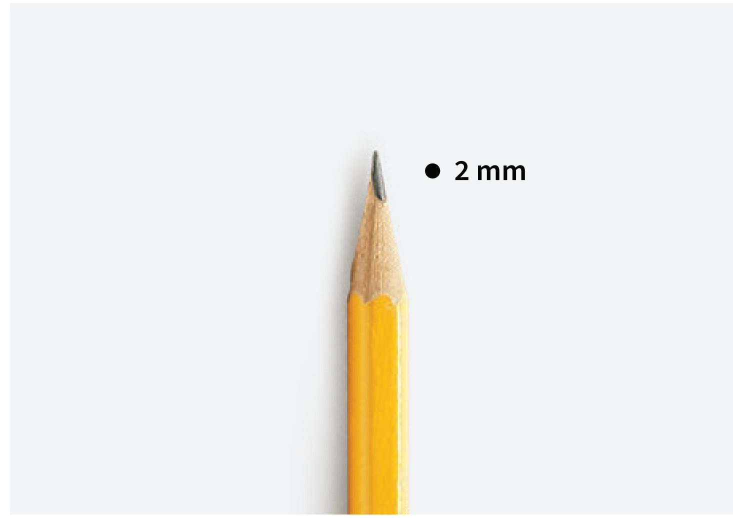
Thermal Conductivity Range	0.05 to 2500 W/m•K
Directional Measurement	Through-thickness and In-plane
Thin-film Thickness	> 5 nm

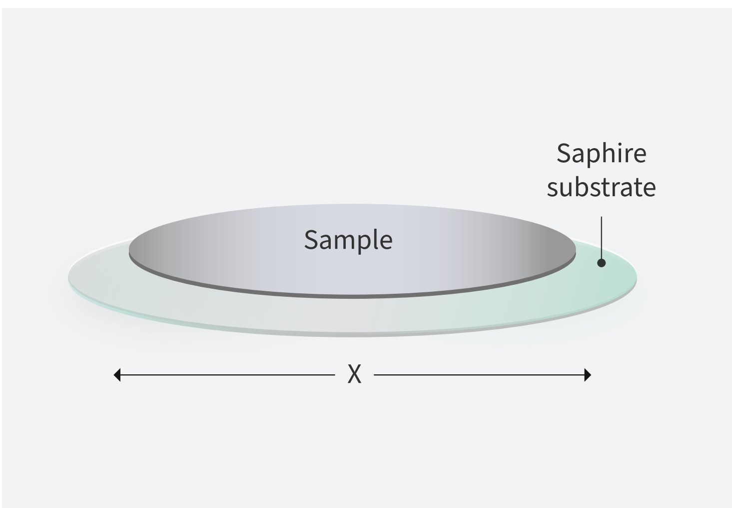
For paper reference: A steady-state thermoreflectance method to measure thermal conductivity - Review of Scientific Instruments **90**, 024905 (2019); **https://doi.org/10.1063/1.5056182**

SSTR-F **APPLICATIONS**

Bulk High Thermal Conductivity – Small Samples

Single Crystal silicon carbide (4H-SiC) wafer pieces of 2 mm diameter x 0.5 mm thickness were measured for thermal conductivity. SSTR-F testing results of 335 W/m·K +/- 28 W/m·K, correlated well with literature values (364 W/m·K) and traditional Time-domain Thermoreflectance (TDTR) measurements of 324 W/m·K.

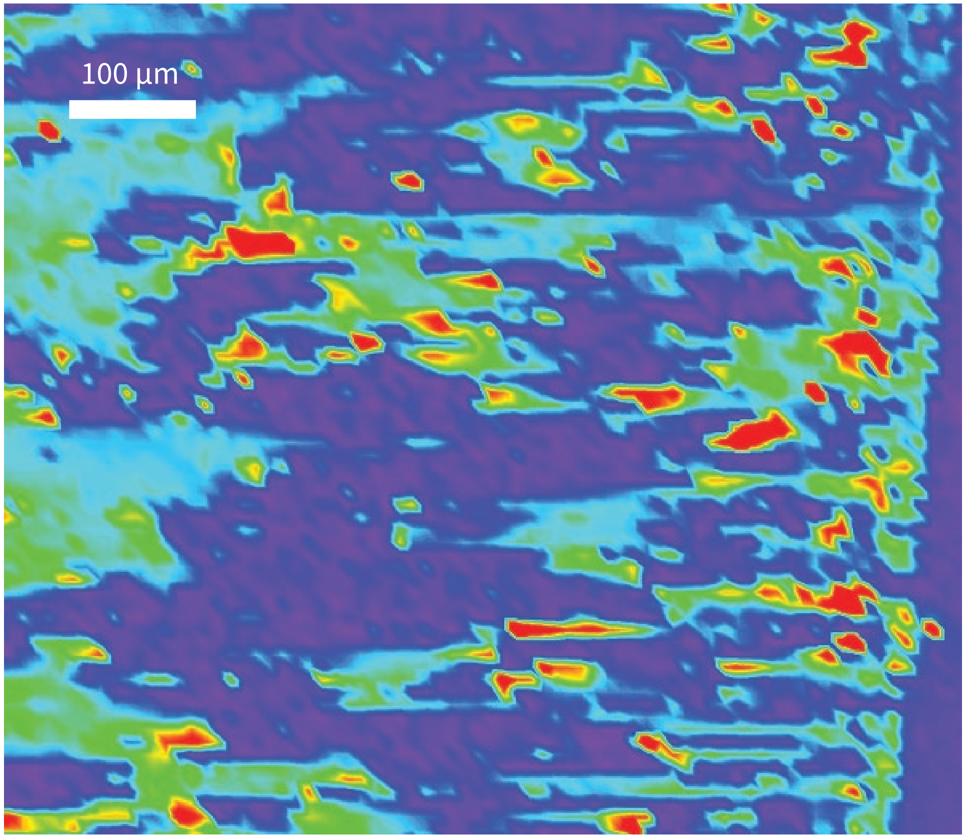


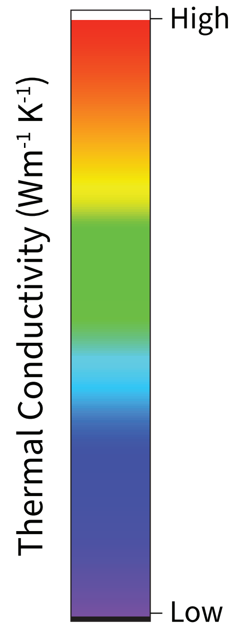


High Thermal Conductivity Coatings

High-purity aluminum nitride (AIN) coatings were grown on sapphire wafers at thickness of 6 µm. This coating was measured with test spot of 20 µm and 40 µm, and values were within +/- 5% of each other. The measured AIN in-plane thermal conductivity was measured at average of 283.7 W/m•K across multiple sample locations. Thermal conductivity values were observed to vary widely (+/- 36.3 W/m·K) due to micro-structure, grain size and defect concentrations. Additional measurement of bulk thermal conductivity on coatings as thin as 1 µm are also possible with SSTR-F.

SSTR-F **APPLICATIONS**

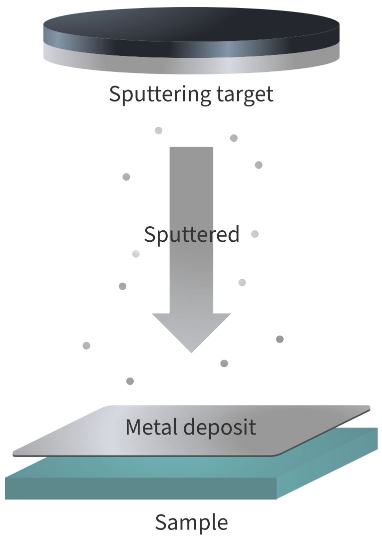




High Resolution Thermal Mapping

Using the SSTR-F and automated X-Y movement testing stage, users are able to thermally map their samples for thermal conductivity. The testing spot size can be changed via varying objectives from 1 to 100 microns for sensitivity tuning, while the step size can be optimized to match the micro-structural length scales of a sample.

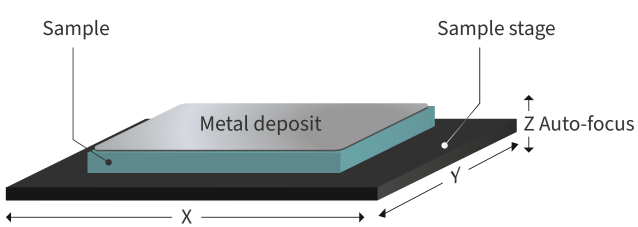
SAMPLE **MEASUREMENT**



STEP 1

Samples of interest and sapphire sample are coated with a thin metal layer and sapphire sample is tested to determine the gamma coefficient.

1 min.

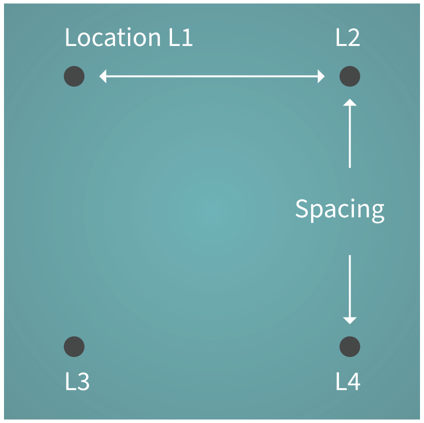


STEP 2

Place sample on stage, specify number of tests, and specify spacing. Based on Z direction, the sample stage auto-focuses the laser.

1 min.

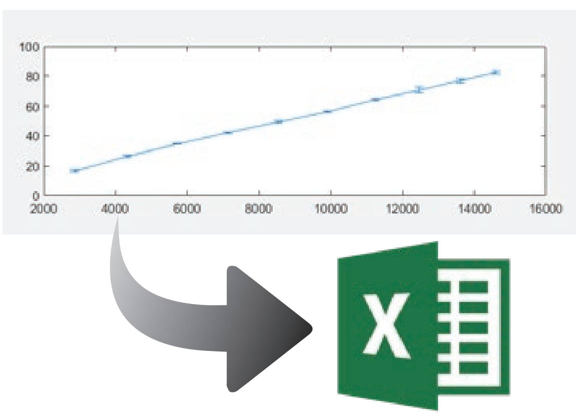
ACCURACY WITH EASE



STEP 3

The scan routine starts with autofocus at every point and runs user specified number of tests.

< 2 min.



STEP 4

Calculations of thermal conductivity with associated error are computed and reported.

1 min.

Notes:

HEADQUARTERS

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