Sekidenko Optical
Fiber Thermometry

thermal temperature integration for semiconductor processing

As device architectures and coating requirements become more demanding in silicon processing, an accurate measurement of temperature and temperature uniformity becomes critical to achieving high yield in production tooling. AE Sekidenko non-contact optical fiber thermometers (OFTs) have proven effective in achieving the required thermal budget in many process applications. For closed-loop process control, process monitoring, component monitoring, tool development, and component testing, Sekidenko technology offers the process engineer an accurate and flexible measurement system that neither lags nor influences the temperature of the target substrate.

products
Sekidenko optical fiber thermometers (models OR1000 and OR2000)

applications
Semiconductor processing, including RTP, HDPCVD, PVD, PECVD, LPCVD, etch, strip, epitaxy, and more

who benefits
OEM and end-user process engineers

Flexible optical fiber carries the emitted radiation from the access probe to the thermometer controller, allowing for ease of access and immunity to EMI.

Installed at strategic points in the process tool, non-contact OFTs deliver accurate, dynamic temperature measurement. A single controller can support as many as four measurement points, making custom configuration easy. You can access the target substrate via either a pyrometer, viewing through a window port, or a vacuum-tight sapphire lightpipe. AE’s superior manufacturing process produces sapphire probes with finer measurement precision, compared to competing models. The result is extremely high-quality probe output.

The measurement architecture supports national laboratory accuracy (±1.5°C, 2.7°F), ease of field calibration, and emissivity compensation. The repeatability of these measurements is well within ±0.2°C (±0.36°F) for consistent targets. Piece-wise integration of the Planck distribution\(^1\) ensures this level of accuracy, and proprietary black-body calibration methods obtain strict quality control.

Non-contact OFTs enable you to make corrections for the emissivity of the target substrate either by external communication (RS-232) of an assumed or measured value, or by internal compensation in real time (model

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You can also send data-collection and parameter settings via the RS-232 interface of the controller. Custom data-acquisition software, supplied with each controller, augments this feature. For special applications, such as end-point detection and cooldown monitoring, you can set the controller to output photocurrent directly.

Primary considerations in the implementation of OFT technology include the material properties of the target substrate, the temperature range (and accuracy required), the accessibility of the target substrate, and levels of background stray light. AE application engineering is uniquely positioned to help you implement probe and controller configurations that will meet and exceed your measurement requirements. Manipulation of the sensor transmission and blocking spectrum is a primary technique used to attain these ends.

**Substrate properties**

For non-contact measurement to work smoothly, the target substrate should be opaque or have a well-defined emissivity over the range of sensing wavelengths used. For thin-film substrates, film composition and temperature excursions can strongly influence the emissivity. Semiconductor substrates have material properties that are strongly dependent on temperature, creating a constrained sensor spectrum and resultant temperature range. Deposited films that are opaque in the near infrared eliminate this constraint, allowing you to measure lower temperatures.

**Temperature range**

The temperature range of the controller is a strong function of the target emissivity and the sensor transmission spectrum. For lightpipe probes, the table below gives minimum temperature (at the required accuracy) and maximum temperature for a series of sensor transmission bands.

The OFT’s wide temperature range (50°C to 2000°C, 122°F to 3632°F, or higher) addresses many different semiconductor processes. The 250°C to 2000°C (482°F to 3632°F) range applies to many pre-metal processes such as epitaxy and RTP, which often benefit from high-speed sensing capability. The 50°C to 550°C (122°F to 1022°F) range has a broad array of applications, including plasma CVD, plasma etch/strip, and PVD.

**Wafer or chuck accessibility**

The best way to measure wafer temperature is with an in-situ lightpipe, but the wafer chuck needs to be designed with a lightpipe sensor in mind. Otherwise, you can measure the wafer temperature (or other object to be measured) with a pyrometer externally through a viewport, provided a clear line-of-sight to the wafer exists.

**Background-light signals**

The most common barrier to an accurate and reliable OFT measurement is the presence of background-light signals, which are caused by scattered light from reflective surfaces, the transmission of light through various materials, or unaccounted sources of light, such as ion gauges, heating lamps, other heat surfaces, or plasmas. Usually, a slight change in the OFT configuration, sensor location, or sensor design reduces background light to acceptable levels.

<table>
<thead>
<tr>
<th>Sensor Transmission Band</th>
<th>Minimum Temperature at 1°C (1.8°F) Resolution</th>
<th>Minimum Temperature at 0.1°C (0.18°F) Resolution</th>
<th>Maximum Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>850 nm (0.85 µm)</td>
<td>370°C (698°F)</td>
<td>460°C (860°F)</td>
<td>1500°C (2732°F)</td>
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<tr>
<td>920 nm (0.92 µm)</td>
<td>300°C (572°F)</td>
<td>380°C (716°F)</td>
<td>1400°C (2552°F)</td>
</tr>
<tr>
<td>940 nm (0.94 µm)</td>
<td>330°C (626°F)</td>
<td>420°C (788°F)</td>
<td>1500°C (2732°F)</td>
</tr>
<tr>
<td>950 nm (0.95 µm)</td>
<td>290°C (554°F)</td>
<td>370°C (698°F)</td>
<td>1400°C (2552°F)</td>
</tr>
<tr>
<td>1020 nm (1.02 µm)</td>
<td>270°C (518°F)</td>
<td>350°C (662°F)</td>
<td>1300°C (2372°F)</td>
</tr>
<tr>
<td>1050 nm (1.05 µm)</td>
<td>220°C (428°F)</td>
<td>270°C (518°F)</td>
<td>1000°C (1832°F)</td>
</tr>
<tr>
<td>1500 nm (1.50 µm)</td>
<td>130°C (266°F)</td>
<td>180°C (356°F)</td>
<td>1200°C (2192°F)</td>
</tr>
<tr>
<td>1600 nm (1.60 µm)</td>
<td>50°C (122°F)</td>
<td>90°C (194°F)</td>
<td>700°C (1292°F)</td>
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