

BATTLE CARD

SILICON CARBIDE CRYSTAL GROWTH

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SOLUTION OVERVIEW

Silicon Carbide based semiconductors represent a new high performance generation of power devices that are used in various focus applications. For example electric vehicles and power systems are currently high and fast-growing markets that show a significant demand for advanced performance semiconductors.

Advanced Energy's pyrometers are used to control and monitor the process in a SiC crystal growth furnace with temperatures up to 2500°C in combination with extraordinary environmental conditions. The pyrometers measure the temperature of the graphite furnace core.

The SiC crystal growth process takes several days and requires high accuracy and a minimum of deviation => High requirements for repeatability & stability.

AE's Hero Products:

- Impac IGAR 6 Smart
- Impac ISR 6 Advanced
- Photrix (if ratio pyrometer is not needed)



Impac IGAR 6 Smart



Impac ISR 6 Advanced



Photrix

Target Markets/Customers

Crystal growers – direct business

NA:



EMEA:



APAC:



OEM furnace manufacturers

NA:



EMEA:



APAC:



Where to Avoid

There is no particular Market, Customer or Application that AE should avoid. As long as the customer is compliant with AE guidelines and existing NDAs are considered!

Audience – who to engage and when

- Customer type: Crystal growers, Furnace Builders, OEMs.
- Directors, Engineers, Facility Manager (The technical decision makers). R&D / Manufacturing division or Processing / Operations division.
- When to Engage:
 - a) Directly in the planning process of a new plant or in combination with expansion plans of crystal growers.

b) During regular business operations to e.g., validate new pyrometer technologies or as a replacement for current used solutions.

Business Benefits

- AE's optical temperature measurement tools controls and monitors the complete thermal process in a SiC crystal growth furnace. The pyrometers cover a broad temperature range and are a perfect fit to ensure high quality results.
- AE's excellent services offer a high level of customization for special and individual requirements.
- Precision is key. As the crystal growing process depends on a very precise adjustment of the temperature and other parameters in the furnace the measurement technology needs to fulfil a maximum in accuracy.

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Qualifying Questions

- Please prepare a potential visit by investigations about the customer's crystal growing process (e.g. PVT = physical vapour transport). In advance please get in touch with one of the listed internal contacts for further advice.
- What temperature ranges need to be covered by the pyrometer(s)?
- How many pyrometers are used in the process/device/reactor and where are they located (position/measurement distance)?
- Do the pyrometers need a special matching for certain combinations in a device or reactor?
- What are the ambient temperature conditions around the pyrometer?
- Are there special relevant temperature levels or crucial process steps that need extra monitoring. (this is relevant for setting the ratio level in smart mode of the pyro or we can offer special calibration points to create service business on top).
- New product design? / Current used pyrometers?
- Any chance to get a service contract?
- Budgetary concerns? Please contact Product Management or Strategic Marketing for further advise. SiC crystal growth is a very high precision process. Sometimes other budget friendly pyrometer solutions can also fit the customer's requirements or the application but that needs to be evaluated from case to case.

INTERNAL CONTACTS



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INTERNAL CONTACTS



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Customer Challenges

To maximize yield and quality of the crystal ingot, precise measurement of the absolute temperature value in combination with constant repeatability is required during many process phases. Only a few degrees deviation in process temperature can significantly influence the yield.

- Precise Temperature Measurement (Absolut & Repeatable) of a broad range up to >2500°C.
- Reliable pyrometer device with long term stability (over complete growing process itself and several process periods).
- Ensure an exact measurement of the different furnace zones (mostly top and bottom – related to crystal growing procedure and/or furnace design).



Key Features & Specs (high-level differentiators)

1. Broad temperature range: 100 to 2550°C (IGAR 6 Smart).
2. This allows full process monitoring from early stage initiation with the heating of the furnace.
3. Low measurement uncertainty. Typical requirements are:
 - Focus temperature range: 1800 to 2200 °C. Accuray: ± 20 °C.
 - High requirements for repeatability & stability: Annual drift: ≤ 3 °C.

- Deviation between set point and actual temperature ≤ 2.5 °C.
- 4. Customization is one of AE's major differentiators. Special calibration points can be set with the systems (related to focus temperature levels that are mostly customer unique).

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COMPETITIVE ANALYSIS

INTERNAL CONTACTS

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Competitor	FLUKE	KELLER
Their Positioning & Selling Points	<ul style="list-style-type: none"> Modern product Series (streamlined and well-established portfolio (Raytek & Ircon), Endurance Series) Well established in key markets and long-term customer relationships Global presence and large distribution network 	<ul style="list-style-type: none"> High end, high quality products Well known in the market Good customer service
Our Differentiation	<ul style="list-style-type: none"> Very broad portfolio. Potential alternatives for most Fluke products. Potential synergy effects with other AE products. The IGAR 6 Smart mode is a unique feature to cover broad temperature ranges Long market and useful application knowledge in various key industries. Special products for different important niche markets and applications. Dedicated sales partners. Product and application knowledge 	<ul style="list-style-type: none"> High quality, reliable and accurate products and solutions AE's worldwide network and production capacities for high volume orders are of significant relevance Special customer service, calibration
Comparative Positioning	<ul style="list-style-type: none"> Precision, high resolution measurement technology and application knowledge is key to outperform competitors We do have the matching products and the market and application knowledge Great Service & Support as well as consultancy 	<ul style="list-style-type: none"> Process temperature measurement, long term stability Highlight the value vs. competitive solution AE has highest application knowledge level on the market



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ADDITIONAL REFERENCES

System Block Diagram

