4H-SiC substrates using the Fast Sublimation Growth Process

30 years of Silicon Carbide excellence in Kista
Electrum building, Sal B, floor 2
Kistagången 16 Kista Sweden
Wednesday, November 23, 2022

KISAB

Agenda

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KISAB

Kiselkarbid i Stockholm AB

Company

Kiselkarbid i Stockholm AB (KISAB) with operations in the KTH Electrum building in Kista, Sweden, was founded in 2017 with the purpose to develop the FSGP-M process for growth of high-quality silicon carbide substrates.

Objectives

Our ambition is to be the most innovative:

- provider of silicon carbide substrates with the lowest defect densities for use in power devices with the highest energy efficiency, highest power capability, lowest leakage current, and highest reliability on the market and

- to develop processes for low-cost production of high volumes of silicon carbide substrates.

Introduction

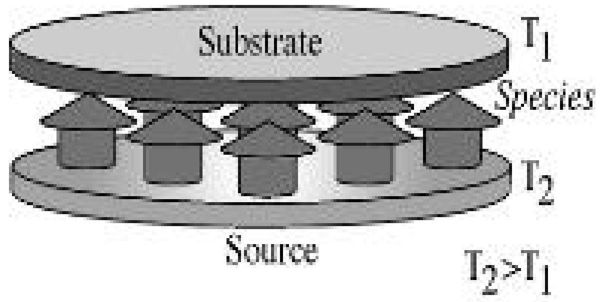
Silicon Carbide has been adopted by the power semiconductor industry in the last few years. Nowadays MOSFETs and other power devices fabricated on SiC substrates are widely used in many applications such as Electric Vehicles (EV), power plants, transportation, etc.

Remaining limitations

While SiC devices are on the forefront of performance, wafer defects are still of great concern. Even though significant progress has been made in the quality of SiC substrates, devices are still limited by defects to small footprint, low voltage, and low current densities to comply with demands for high reliability and yields. Crystal defects like basal plane dislocations must be considered when designing components as they limit the components footprint and degrade the component at high current densities or voltages.

FSGP-M - a flat growth front - the key feature

FSGP-M Principle configuration



The Fast Sublimation Growth Process – Monocrystalline (FSGP-M), is to our knowledge the only alternative to powder growth, it provides perfectly uniform seed and source substrate temperatures, and a uniform supply of growth species which ensures that a uniform growth rate is obtained over the substrate surface during the entire growth process. As a consequence, no BPDs are formed neither during nor post growth. The novel technology enables ultra high crystalline quality over large areas also in thick layers. There is practically no stress inside the crystal and in 6-inch size substrates bow is typically <5µm and warp <15µm. Doping concentration and resistivity are practically constant over the entire substrate surface.

The process is protected by several patents and further applications are pending.

BPD free 4H-SiC substrates - 6-inch size

The typical material properties are listed below:

1. ***Wafer geometry.*** *Ø= 150mm, d=350µm,* TTV<5µm, Bow<5µm, Warp<25µm.
2. ***BPD free.*** There are on the entire substrate practically no BPDs.
3. ***Killer defects.*** In the last evaluation, for voltage class 900V, 99.5% of the wafer area had no killer defects.
4. ***None killer defects.*** PL White and Black (Nuisance) maps post epitaxial growth shows that our material has two orders of magnitude less defects compared to the best material in the market.
5. ***Threading dislocation density.*** TDs<4'000 cm^{-2} on 90% of the wafer area.
6. ***Resistivity.*** Uniform resistivity in the range 19.5- 20.5 mΩcm.

Production system

We have developed and taken into operation a low volume production system. The main features of the system are:

Theoretical installed capacity. To grow up to 18’000 6- or 8-inch wafers per annum (wpa).

Scalability. Easily scalable to 56’000 wpa by adding further reactors.

***Automatic charging system*.** An automatic charging system enables unattended automatic wafer production in 24/7 operation.

High productivity. The growth rate achieved by the Fast sublimation growth process is about 4 times higher than that typically achieved in powder growth.

Footprint. The reactor system has a very small footprint (footprint / wpa).

Production system

Low energy consumption. The energy required for growth of a substrate is less than ½ of that used in PVT growth.

Lower graphite cost. The graphite costs are significantly lower than those in systems for powder growth.

Low capital costs**.** Investment in growth system / wafer produced is lower than that in powder growth.

Low-cost reactor conversion. To convert existing powder growth systems to fast sublimation growth is possible, relatively cheap and can be completed within 9 months.

Road map

Wafer size enlargement.

We are currently developing a production process for 8-inch size wafers.

Start-of-production

Start of 8-inch size wafer production is expected during Q1 2023.

Sample specification

We are focusing our efforts on wafer size enlargement and on cost reduction. We are selling small quantities of wafers to customers for use in high voltage applications and for evaluation purposes.

Polytype	: 4H polytype
Orientation	: 4º
Diameter	: 150 mm
Center thickness	: 350 µm
Bow	: <5 µm
Warp	: <15 µm
TTV	: <4 µm
Surface treatment (Si-face)	: Epi-ready
Resistivity	: 19.5- 20.5 mΩcm

<u>Defect density</u>

MP	: <10 / wafer
BPD	: None
TD – 90% of wafer area	: <4’000 cm^{-2}

Defect densities are calculated based on the entire wafer area – thus no edge exclusion. Wafers are delivered in cassettes or in single wafer containers.

KISAB

Contact information

Headquarter
Kiselkarbid i Stockholm AB
KTH Electrum
Kistagången 16, Box 228
164 40 Kista
SWEDEN

Sales office Asia
Tim Palmroos
Meikin Building 2F Room A,
Nishiki 1-13-19, Naka-ku,
Nagoya 460-0003, JAPAN
Mobile : +81 (0) 90-1280-8821
E-mail: palmroos@kisabsemi.com

URL
https://kisabsemi.com/

Electrum Building, Kista Sweden

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The End

- thank you for your time