Attn: Members of the press

March 1, 2021
Kwansei Gakuin University
Toyota Tsusho Corporation

Kwansei Gakuin University and Toyota Tsusho Develop Innovative Process that Achieves "Zero Defects" in 6-Inch SiC Substrates

- Supply of Samples to Device Manufacturers to Begin to Facilitate Early Mass Production –

Kwansei Gakuin University and Toyota Tsusho Corporation ("Toyota Tsusho") have succeeded in developing "Dynamic AGE-ing®", a process technology for controlling the arrangements of atoms on the surface of substrates at the nanometer level to neutralize defects* in SiC (silicon carbide) substrates, a next-generation power semiconductor material.

With performance tests on 6-inch SiC substrates completed, this highly innovative technology will simultaneously achieve both high quality and better productivity for SiC substrates. SiC substrates will play a major role in our decarbonized society of the future, as we expect these substrates to see a great increase in demand in a wide variety of areas, such as the global automotive industry currently undergoing a rapid change to produce electric vehicles.

We will start providing samples to semiconductor device manufacturers, as well as verify our technology to enable its use into mass production lines. In addition, we will advance our development to apply our technology to large diameter, 8-inch SiC substrates, which are expected to be in widespread use in the future.

1. Background

Compared to the widely used power semiconductor material Si (silicon), SiC can significantly minimize power loss, thereby allowing more effective use of power and making cooling solutions more compact. SiC devices are starting to be applied to areas where green innovation is spreading, such as the automotive, rail, industrial equipment, and power industry, where devices having mid-to-high withstanding voltages are needed. In particular, there is a great demand to apply these devices to EVs, HVs, and FCVs; a huge increase in demand is forecasted within the auto industry in Japan as well as overseas.

To manufacture highly reliable power semiconductors at low cost, it is imperative that high quality, large diameter, SiC substrates are provided stably. However, conventional SiC substrates had issues in that crystals deformed during machine processing (processing deformation layer) or intrinsic defects, i.e., Basal Plane Dislocations (BPD), can cause the performance of power semiconductors formed above these defects to degrade significantly.

2. The Effects of "Dynamic AGE-ing®"

Kwansei Gakuin University (Professor Tadaaki Kaneko, School of Engineering) and Toyota Tsusho have jointly developed a unique technology called “Dynamic AGE-ing®”. Unlike the conventional machine processing, this is a contactless process technology integrating thermal etching and crystal growth, allowing control at the nanometer level. By placing the SiC substrate under a gas phase environment with extremely high temperatures, the atoms on the surface of the substrate are autonomously arranged, thereby wholly eliminating the process deformation layer as well as neutralizing the harmful effects of BPD by blocking its extension (see Figure 1). Applying "Dynamic AGE-ing®" will improve the quality of SiC substrates regardless of its manufacturer or size. In addition, this technology will simplify the substrate manufacturing process and improve its yield, which in turn will improve the productivity of SiC substrates (see Figure 2).

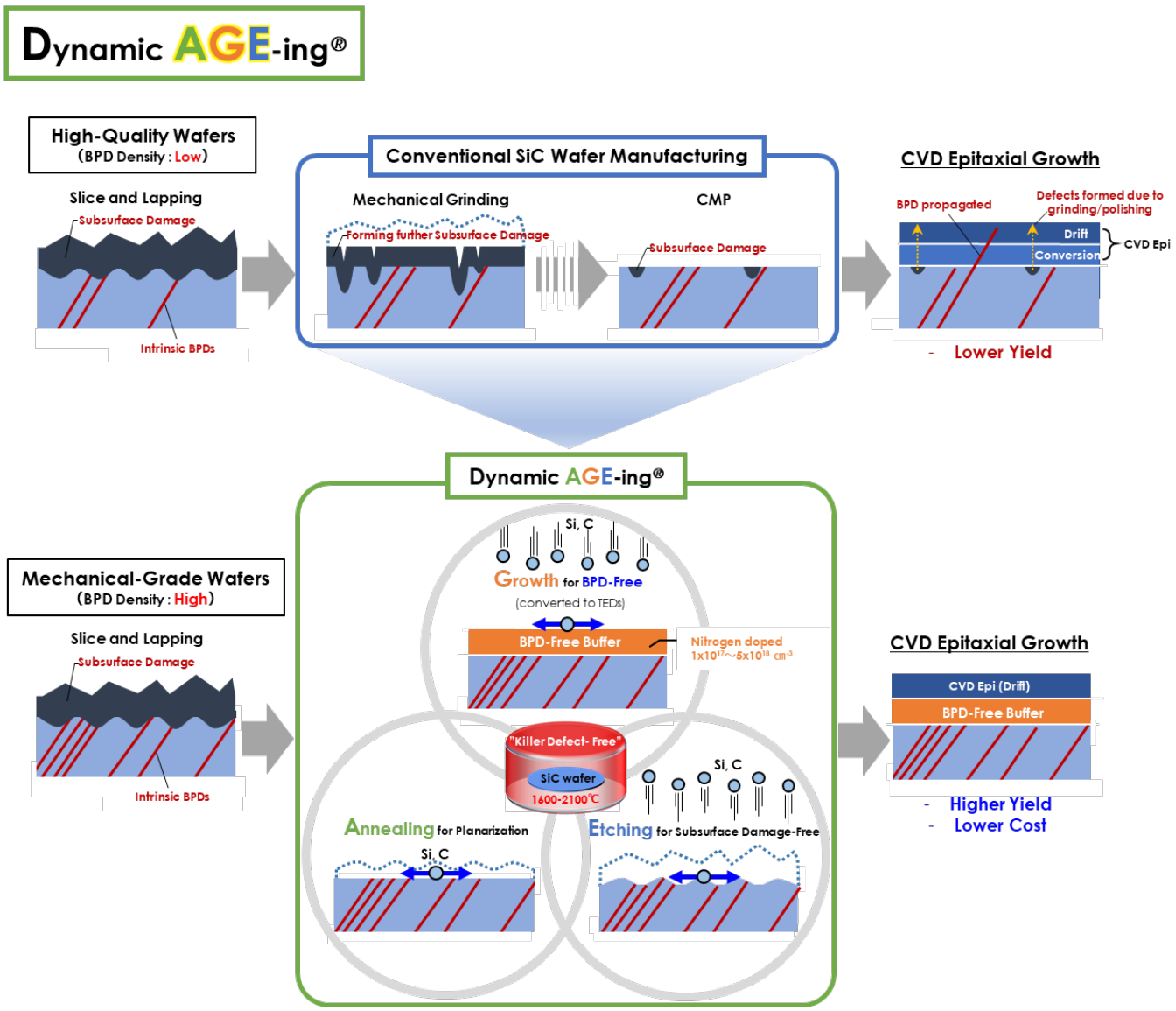
3. Development through Open Innovation

Kwansei Gakuin University and Toyota Tsusho utilize both SiC-related technology Kwansei Gakuin University nurtured for the past 20 years and the extensive business connections Toyota Tsusho cultivated to advance technological development and its practice through open innovation, allowing a wide range of user companies and manufacturers to participate in these activities.

4. Future Development of Dynamic AGE-ing® for Practical Use

Kwansei Gakuin University and Toyota Tsusho will start supplying SiC substrate samples applied with Dynamic AGE-ing® from the first half of fiscal year 2021, as well as collaborate with semiconductor device manufacturers to verify the technology into use in the field. To provide high quality, competitive 6-inch SiC substrates to various user companies, mainly those in the automotive industry, we will ask a wide range of business partners to participate with us, to ensure our technology is swiftly adopted to mass production. Further, we will accelerate our development to apply the “Dynamic AGE-ing®” to large-diameter, 8-inch SiC substrates.

* Defects: Basal plane dislocation, a type of crystal dislocation



(Figure 2) Example of Verifying the Neutralization of BPD Harmful Effects with Dynamic AGE-ing® ("DA")

We confirmed applying DA to commercially available 4° off Si-face 4H-SiC substrates led to having no more than 1 BPD in the entire substrate surface for the following manufacturers and size.

Manufacturer	Size (Inches)	BPD Density : Occurrences per cm²	
		Before DA	After DA
Company A	6	5,347	0.006
Company B	6	4,959	0.00
Company C	4	>7,000	0.015
Company D	4	1,102	0.00

Before DA : Measured by X-ray Topography.
After DA : Measured by Photoluminescence (Lasertec SICA-88)

For inquiries concerning this press release, please contact

Toyota Tsusho Corporation Press Group, Public Relations Department Tel : 03-4306-8200