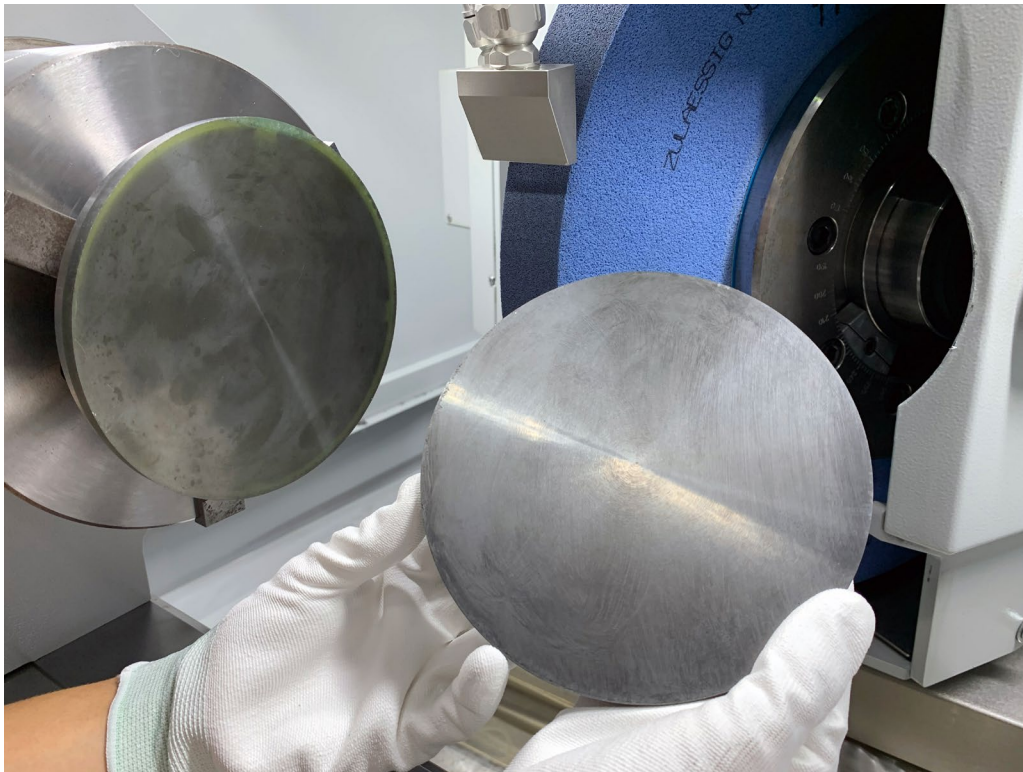


Hardinge Inc.'s Charged Up for Silicon Carbide Growth

ELMIRA, NY (September 21, 2022) – When it comes to the impact of Silicon Carbide (SiC) on today's society, the future is now. As a key semiconductor material for electric vehicles, high-speed railways, and 5G telecommunication, the demand for SiC is expected to grow exponentially. To help accelerate the process of producing wafer-ready SiC crystal (known as a "puck"), Hardinge Inc. has created an industry leading fabrication process. The Hardinge BoulePro-200AX with its patent pending Single Step Dual-plane Compensation (SSDC) capability allows for a much faster and far more cost-effective boule to puck conversion in order to meet the high demand for this important semiconductor material.



Hardinge's Technical Know-How Provides Streamlined SiC Boule Fabrication Process

In a typical manufacturing facility several pieces of equipment supporting different process steps are required to convert SiC crystal boules into wafer ready pucks, which are then sliced into wafers. Not only does this equipment take up significant real estate within the facility, but the processes are highly manual and labor intensive with operators moving the part from one tool to another to accomplish the multiple steps.

A SiC manufacturer's facility footprint can be dramatically decreased thanks to Hardinge's BoulePro-200AX. Jeff Gum, Advanced Material Specialist with Hardinge and former Director of Global Sales for GT Advanced Technologies, explains how SiC manufacturers currently require multiple pieces of equipment to produce a single puck. "What normally took up to 24 to 36 hours and utilized many different pieces of equipment to produce a puck, Hardinge's streamlined SiC boule fabrication process only needs two to three hours to turn around a part as all of the steps required are completed in a single, fully automated machine," said Gum.

With its 130 years of grinding and materials knowledge, Hardinge’s development team, along with the addition of key SiC industry experts, has addressed the inefficiencies of SiC boule processing with a comprehensive and cost-effective package. This process optimization has allowed for a significant reduction in the consumables required and in turn, reduced the cost of this process substantially compared to how the industry does it today. “For the last couple of years Hardinge has been collaborating with several different SiC raw material suppliers to optimize the production process of fabricating a wafer ready SiC puck,” said Gum. “Hardinge’s deep experience in grinding, turning, milling, and workholding have enabled a much lower cost process through the optimization of the right processing speeds, angles, workholding and machining tool types.”

Gum points out that producing SiC boules is a very unique process. “Silicon Carbide is grown via a Physical Vapor Transport (PVT) process in high temperature furnaces. It can take anywhere from two to four weeks to grow a crystal that will only be a few kilograms in size,” explained Gum. To extract value out of the boule, it needs to be converted to a wafer ready piece of material. Having a fully automated machine that performs all steps of this conversion process, including X-Ray Diffraction (XRD) to understand and appropriately compensate for crystal orientation, at a much-reduced cost basis and with improved process repeatability is key to increasing efficiency and bringing material to market more quickly and cost effectively for SiC substrate producers and users.

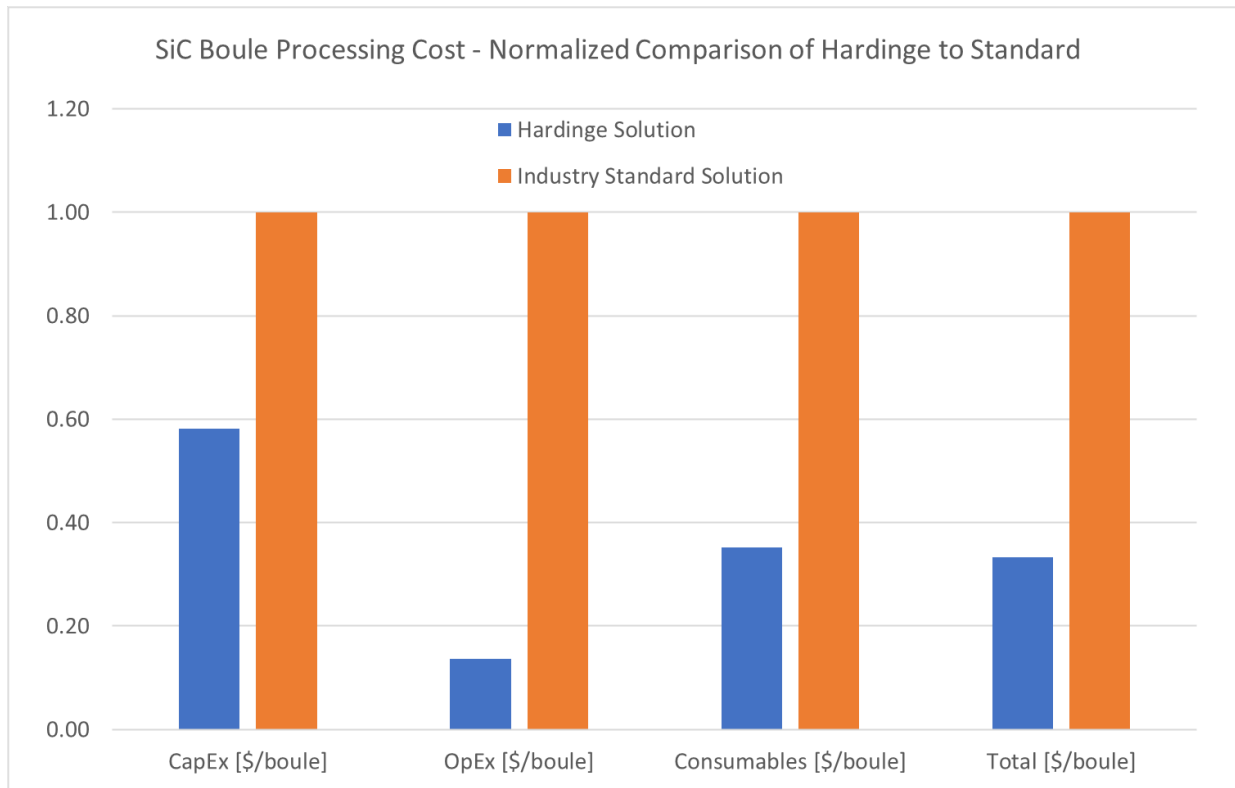


Figure1 - Cost benefit comparison between current industry production standard and BoulePro-200AX.

The “Secret Sauce” Which Produces the Wafer Ready SiC Puck

Without an industry standard Process of Record (POR) to produce the wafer ready SiC puck, manufacturers have developed individual approaches to the following five-step process:

- X-ray to determine crystal structure for correct surface orientation and application of the flat or notch
- Applying flat or notch
- OD grinding
- Removing the seed side
- Removing the dome side

As Hardinge evaluated the steps to this process and the inherent inefficiencies presented by the current solution, they have taken a clean sheet approach to an all-in-one solution leveraging core expertise from more than a century of grinding experience. As a result, the BoulePro-200AX features an integrated XRD tool and has 5-axis capability which enables it to manipulate, X-Ray, grind, and/or cutoff the part to the customer's desired specifications all in one, fully automated machine. Additionally, the machine is capable of handling all current relevant sizes of SiC boules including 100mm, 150mm, and 200mm material.

The advanced workholding of the SiC boule enables much of the machine's efficiency improvements. Having to glue and de-gluue the boule to fixtures throughout each of the process steps is one of the major issues that current SiC producers experience because it is a very time-consuming process. Additionally, the boule needs to be removed from one machine, prepared for the next step, then installed into other machines for subsequent steps. "Hardinge's advanced workholding has eliminated any glued fixtures as well as the need for manual intervention in the process and enabled the automation of all process steps in one machine," said Gum.

Including integrated XRD and Hardinge's patent pending Single Step, Dual-plane Compensation grinding capability is an imperative component to the BoulePro-200AX. The crystal orientation must be identified to machine the puck with the correct compensation in all planes such that the full puck, from end to end, will yield wafers with the correct orientation and geometry. The XRD output communicates to the machine how much of an adjustment needs to be made to the crystal surfaces when doing final machining. "Every boule needs to be x-rayed and grinded accordingly, so the crystal structure of the wafer will yield functional devices," said Gum.

The Sky is the Limit for the SiC Industry

Simply put, SiC is a more efficient material for high power electrification applications and both domestic and global investment is accelerating the market and the material adoption.

"EV's have to convert battery DC to motor AC at high voltages and switching frequencies," said Gum. "This is where SiC is a perfect material of choice for the task."

SiC is ideal for those devices which handle higher power densities and will transfer it more efficiently.

"The semi-conductor market is rapidly adopting SiC based devices for many other uses in a growing electrification space where SiC makes the most sense," said Gum. "From photovoltaics, wind, energy storage, UPS, solid state breakers, the list goes on and will continue to grow."

The present and the future looks to be very bright for SiC based devices thanks to accelerating demand from a multitude of different sectors. SiC is required for power devices such as those found in electric vehicles and high-speed rail. With a year-over year growth rate expected to be between 35-40% for SiC, there will be a need for manufacturers to be prepared to meet this expected huge demand.

Reserve Your BoulePro-200AX with Hardinge

Beginning in Q4 of this year, Hardinge will be starting customer demonstrations, however, because companies are expanding as quickly as they can with SiC production, Hardinge is offering interested customers an opportunity to accelerate their production process through Hardinge's reservation approach. "Customers can reserve their place in the production que for the Hardinge tool now with a smaller than normal and fully refundable down payment," explained Gum. "We'll then begin to order the tool's long-lead items to jump start the procurement process and by doing so, we can compress the delivery schedule significantly."



Figure2 – Hardinge BoulePro-200AX for SiC transformation from boule to puck.

The Hardinge BoulePro-200AX is the Answer

The BoulePro-200AX offers an avenue for SiC manufacturers to streamline their boule fabrication process in order to meet the ever-growing demand for high quality and lower cost SiC. Most producers are expanding as quickly as they can to meet this downstream demand and require a means to optimize all aspects of their SiC production facility. The BoulePro-200AX checks all the boxes for SiC boule to puck conversion optimization:

- One machine tool accomplishes all the required steps in a fully automated process that takes two – three hours
- Advanced degree of automation provides for improved process repeatability
- 85% reduction in labor cost
- 80% reduction in manufacturing footprint
- Total cost (CapEx, OpEx, consumables) reduction of nearly 70% compared to today's industry standard

Greg Knight, a member of Hardinge's board of directors and former CEO of GT Advanced Technologies (acquired by onsemi in October 2021), can relate to the benefits of this solution. "During my tenure at GT, the post growth boule fabrication was a particular challenge. SiC producers have deep rooted experience in crystal growth, but few have the machining background necessary to optimize the boule fabrication process. Hardinge has both recognized the need for an improved machining solution in this space and brought to market an elegant solution in an extremely short period of time."

The BoulePro-200AX saves money, time, and space. Those three words should be music to the ears of SiC manufacturers with their current and future production of SiC substrate.

About Hardinge Inc.

Hardinge, Inc. is the trusted global provider of high precision, computer-controlled machine tool solutions for critical, hard-to-machine metal parts and advanced workholding accessories. With over 125 years of experience, Hardinge offers the largest variety of metal-cutting turning machines, grinding machines, machining centers, collets, chucks, index fixtures, repair parts, standard and specialty workholding devices, and other machine tool accessories. Hardinge's solutions can be found in a broad base of industries including aerospace, agricultural, automotive, construction, consumer products, defense, energy, medical, technology, and transportation. The company designs, manufactures, and distributes machine tools in over 65 countries across North America, Europe, and Asia. For more information about Hardinge, please visit us at www.hardinge.com .