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2023 TECHCET's CMR™

SILICON CARBIDE

A UNIQUE SEMICONDUCTOR MATERIAL
FOR CHALLENGING APPLICATIONS

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RESEARCH METHODOLOGY

TEHCET employs subject matter experts having first-hand experience within the industries which they analyze. Most of TEHCET's analysts have over 25 years of direct and relevant experience in their field. Our analysts survey the commercial and technical staff of IC manufacturers and their suppliers and conduct extensive research of literature and commerce statistics to ascertain the current and future market environment and global supply risks. Combining this data with TEHCET's proprietary, quantitative wafer forecast results in a viable long-term market forecast for a variety of process materials.

This report represents the interpretation and analysis of information generally available to the public or released by responsible agencies or individuals. Data was obtained from sources considered reliable. However, accuracy or completeness is not guaranteed.

ANALYST BIOGRAPHY



Robert Rhoades is the President and CTO of X-trinsic Inc. and a frequent contributor to TECHCET's CMP Critical Consumables Reports. He earned a Ph.D. in Electrical Engineering from the University of Illinois in 1992. His background includes 2 years at Oak Ridge National Laboratory researching high density plasma technology followed by 3 years at Motorola as a senior process engineer leading their efforts to bring CMP into silicon device manufacturing for the first time. In 1997, he joined a small slurry company, Solution Technology, Inc, which was later acquired by Rodel, Inc (now part of Dupont). During five years at Rodel, he led the global process engineering team and managed multiple applications labs in the USA and Asia. In

2002, Dr. Rhoades joined Entrepix as CTO and helped launch a new business model providing process and equipment services for customers using CMP for everything from R&D prototypes through volume production on virtually any material. In 2017, he joined Revasum, a polisher and grinder OEM based in San Luis Obispo, CA, where he served as CTO and led development efforts for advanced polishing and grinding equipment, particularly focused on ultrahard materials such as silicon carbide. Dr. Rhoades is a named inventor on more than 12 patents or patent applications and has authored more than 140 technical publications and conference presentations.



Ian Currier is the Director of Process Technology for X-trinsic Inc. He has spent his career conducting research and developing processes for the fabrication of exceptionally hard materials including sapphire, silicon carbide, and diamond. While at II-VI, Inc., he initially worked on the transition from 3inch to 100 mm SiC wafers. Later, he spearheaded the efforts to develop the first fabrication methods to effectively produce large diamond optics for extreme ultra-violet lithography systems. In 2105, he joined Cree, Inc. (later Wolfspeed) and drove the development of the first single-wafer processes in preparation for 200 mm wafer production. This involved working in tandem with the original equipment manufacturers to modify their machines for

the unique requirements of silicon carbide. It also required heavy coordination with consumable suppliers to optimize their products to enable cost-effective, high yielding wafer production.



Dan P. Tracy, Ph.D. – is TECHCET's Sr. Director of Market Research, with a focus on sputtering targets, deposition and packaging materials. He has over 30 years of electronics market analysis experience covering semiconductor packaging, thin films, semiconductor process equipment, and semiconductor materials. He has particular expertise in analyzing dependencies between equipment and materials, and between the front- and back-end of the semiconductor industry, including insights pertaining to LEDs, MEMS, and sensors. Prior to TECHCET he led the Industry Research & Statistics group at SEMI as Sr. Director and worked for Rose Associates covering electronic materials as a Sr. Analyst. Additionally, Dan has a background in packaging engineering from National Semiconductor. He holds a Ph.D. in Materials Engineering from Rensselaer Polytechnic Institute, a M.S. in Materials Science & Engineering from Rochester Institute of Technology, and a B.S. in Chemistry from SUNY College of Environmental Science and Forestry.

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2 SCOPE, PURPOSE AND METHODOLOGY

2.1 SCOPE

This report is focused on silicon carbide (SiC) wafers used to make semiconductor devices, and includes market drivers, wafer forecast, wafer making landscape and supplier activities. Additionally, it provides a comprehensive look at wafer making including manufacturing costs as well as what is required to estimate consumable and capital expenditures needed to build out a wafer making facility.

This report contains data and analysis from TECHCET's database and from the author's experience, as well as that developed from primary and secondary market research. For more information on TECHCET Critical Materials Reports™ please go to <https://TEHCET.com>

2.2 PURPOSE

This Critical Materials Report™ (CMR) provides focused information for supply-chain managers, process integration and R&D directors, as well as business development managers, and financial analysts. The report covers information about key suppliers, issues/trends in the material supply chain, estimates on supplier market share, and forecast for the material segments.

This report aims to provide information within the above scope for SiC wafer makers and end users interested in managing their supply chains and wafer manufacturing plans and costs. Information about this critical material is essential to plan for and deliver the necessary materials and devices to meet growing demand across the world. The goal is to take a snapshot of the current state of the industry, assess the strengths and weakness of the associated supply chain, and provide relevant guidance for business management decisions.

2.3 METHODOLOGY

TEHCET employs subject matter experts having first-hand experience within the industries which they analyze. Most of TECHCET's analysts have over 25 years of direct and relevant experience in their field. Our analysts survey the commercial and technical staff of IC manufacturers and their suppliers and conduct extensive research of literature and commerce statistics to ascertain the current and future market environment and global supply risks. Combining this data with TECHCET's proprietary, quantitative wafer forecast results in a viable long-term market forecast for a variety of process materials.

We track micro-economic and macro-economic trends pertaining to the semiconductor industry and track overall industry trend and needs, equipment supply and demand situation, deduction towards the quartz material requirement, and supplier/fabricators situation one by one. From this vantage point, we check the suppliers/fabricators and the base material company information, and then the raw materials market information. Included in our work is an analysis of public information, website information, supplier interviews, supplier surveys, supplier peer-data cross-checking, and reference comparison. In addition, we conduct a

material base usage calculation with respect to a demand and supply micro-economic analysis. We then conduct a forward and backward sweep of the forecast until data is in sync. In the meantime, for the data points that are missing, we use past historic, forward-looking data, and peer data so to extrapolate from three different levels of cross-checking. This provides us an estimation based on judgment from industry experience. In this year's report, we especially added special industry situation reporting and analysis for exogenous factors affecting the industry, which can be big percentage influence factors than normal trend parameter contributors.

2.4 OVERVIEW OF OTHER TECHCET CMR™ REPORTS

TEHCET produces electronic material supply chain reports each year as one of its functions for the Critical Materials Council. Reports to be published in 2023 can be found at www.techcet.com and are listed in the table below:

Table 2: Available TECHCET Critical Material Reports

TEHCET's Critical Materials	
1	CMP Consumables (Pads/Slurry)
2	CMP Equipment Consumables
3	CVD /ALD Hi K Precursors
4	CVD DIELECTRIC Precursors
5	Equipment Components – Quartz*
6	Equipment Components – Silicon*
7	Equipment Components – SiC/Ceramics*
8	Gases - Electronic Specialty, Bulk & Rare Gases
9	Metal Plating Chemicals+
10	Photoresist, Ancillaries & Extension Materials
11	Sputter Targets
12	Silicon Wafers
13	Wet Chemicals / Specialty Cleaning Chemicals
14	Impact of Chip Expansions
15	Packaging Materials