Unstoppable Trend towards Domestic Substitution of CMP Polishing Materials

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HONG KONG, CHINA, June 30, 2023 /EINPresswire.com/ -- 1.CMP is one of the core elements in the semiconductor chip manufacturing process.
1.1. CMP positioning: CMP is one of the C-level elements in wafer processing.
In the manufacturing process of semiconductor chips (hereinafter referred to as chips or semiconductor chips), the surface of a semiconductor wafer (hereinafter referred to as a wafer) becomes uneven and produces excess surface material during process steps such as etching and ion implantation. To reduce the surface roughness and unevenness of the wafer and remove excess material, a polishing pad and polishing solution are used to perform repeated polishing processes on the wafer using specialized equipment (CMP equipment) to effectively perform the next processing step. This process is called Chemical Mechanical Polishing (CMP). CMP is a critical process technology to achieve wafer surface planarization and is currently the mainstream wafer polishing technology.

In the entire semiconductor industry chain, wafer processing is the most important core element, and CMP runs through the entire wafer processing process. As the chip manufacturing process becomes smaller and the internal structure becomes more complex, CMP technology has become increasingly important. The surface flatness of wafers processed by CMP can be less than 1nm, which can meet the needs of the next processing step of various process chips. It can be said that CMP is one of the C-level elements in wafer processing.

1.2. CMP development insights: CMP process technology development and chip process technology innovation promote each other

CMP is an integral part of the semiconductor chip manufacturing process enhancement process. Since the concept of CMP polishing applications was introduced by Walsh et al. in 1965, CMP process technology development and semiconductor chip process development have been highly relevant. From the 0.35 μm to 0.25 μm semiconductor process technology node, CMP technology is the only key technology that can achieve global flattening, laying the foundation for the development of CMP process technology; and at the 0.18 to 0.13 μm technology node, with the rapid upgrading of semiconductor chip process technology, the role of CMP and its irreplaceable nature has become more prominent. According to JAK Electronics, at this stage, CMP technology has become an indispensable core technology link in the semiconductor chip

manufacturing process.

The innovation and improvement of chip processes have been a key driver of CMP innovation and development. As the trend towards smaller chip processes accelerates and the internal structures of chips become increasingly complex, the requirements for wafer surface flatness are becoming higher. To ensure that each manufacturing step achieves the corresponding level of flatness, it is necessary to increase the number of CMP polishing steps and types of polishing solutions, and to continuously improve the innovation level of CMP processes to meet the nano-level flatness requirements of wafer surfaces. This has significantly increased the difficulty of the process technology, but has also promoted the prosperity and development of the CMP industry.

The amount of CMP polishing materials used is highly correlated with changes in wafer chip manufacturing processes. Taking logic chips and storage chips as examples, the reduction in the process size of wafer manufacturing processes and changes in storage capacity will increase the number of CMP process steps and drive the consumption of CMP polishing materials. According to the annual report of Applied Materials and data from Cabot Microelectronics, the number of CMP process steps required for 14nm logic chips has increased from 10 times for 180nm chips to over 20 times, while for 7nm and below, it requires more than 30 polishing process steps. Similarly, during the upgrade process from 2D NAND to 3D NAND for storage chips, the number of CMP process steps has increased from 7 for 2D NAND to 15, showing a multiple-fold increase. It can be said that as the process of semiconductor chips improves, the CMP process steps and the demand for CMP materials will also increase simultaneously.

CMP polishing solution determines wafer polishing quality and polishing efficiency, and the wafer fab and CMP polishing solution supplier contribute to each other. In the semiconductor chip manufacturing and polishing process, wafer fabs select CMP polishing solutions that meet the requirements of each step of the wafer flatness process, such as the removal rate (MRR) and surface roughness (Ra), so that the chemical and mechanical reactions in the polishing process are mutually reinforcing to improve polishing efficiency and product yields. To achieve these objectives, both the supply and demand sides of the CMP polishing solution need to work closely with each other and invest a lot of R&D costs in trial and error to debug a polishing solution that meets the physical and chemical properties and polishing performance requirements of the wafer fab, until a polishing solution that meets the wafer surface quality requirements and achieves a high product yield is produced.

The CMP pad is one of the core components of the flattening process. During the chemical mechanical polishing of wafers, the CMP pad is used to store the CMP polishing solution and transport it to the polishing area, so that the polishing continues evenly and the required mechanical load is removed, and the by-products of the polishing process (oxidation products, polishing debris, etc.) are taken out of the polishing area to form a certain thickness of CMP polishing solution layer, which provides a venue for the chemical reaction and mechanical removal during the polishing process. By influencing the flow and distribution of the polishing

solution, the CMP pad determines the polishing efficiency and surface flatness, which is essential for wafer flattening.

2.Huge Supply-Demand Gap in Domestic Semiconductor Chips, Broad Prospects for Domestic Substitution

On the one hand, China is a big consumer of semiconductor chips, but it highly relies on imports. In 2022 alone, China imported 538.4 billion pieces of integrated circuit chips, with a total import quantity of 2.5801 trillion pieces in the past five years, deducting 1.2796 trillion pieces of exports. The net import quantity still remains at an absolute high of 1.3004 trillion pieces, and China's import share ranks first in the world. On the other hand, there is a huge supply-demand gap in domestic semiconductor chip products. From the perspective of China's IC market size and IC output value, in 2021, China's IC market size was $187 billion, while China's IC output value was only $31.2 billion, with a self-sufficiency rate of less than 17%, indicating a huge supply-demand gap, and the large demand gap highly relies on the supply from overseas giants.

In the current context of the severe disruption of the global trade system, China's semiconductor industry chain security is facing a huge threat, especially since 2018, developed countries such as the United States and Japan have successively imposed strict restrictions on the export of their high-end semiconductor chips and equipment, further exacerbating the uncertainty of China's semiconductor chip supply. This has prompted China to introduce a series of government subsidies and incentive policies to vigorously promote the independent and secure development of China's semiconductor industry, and the potential market space for domestic substitution is huge, with broad development prospects.

2.1 Domestic Wafer Fabs Expand Production Against the Downward Cycle, Accelerating the Localization Process of Semiconductor Materials

Looking at the development history of the global semiconductor chip industry, the construction of wafer fabs is the core link of the semiconductor chip industry, and the expansion of wafer fabs is imminent. Since 2022, despite the downward cycle of the global semiconductor industry, domestic wafer fabs have continued to expand production against the trend, and the demand for domestic substitution of semiconductor chips has increased against the trend. In terms of newly built large-scale wafer fabs, SEMI predicts that from 2021 to 2023, the global semiconductor industry will build 84 large-scale wafer fabs, and only in mainland China, nearly 20 wafer fabs/production lines will be newly built, accounting for about 25%. From the perspective of 300mm wafer capacity, SEMI shows in the "300mm Wafer Fab Outlook Report 2026" that the wafer capacity of 300mm front-end fabs in mainland China is expected to increase its global share from 19% in 2021 to 23% in 2025, reaching 2.3 million wpm, and the wafer capacity is close to that of Korea, the global leader, and is expected to surpass China's Taiwan region, currently ranked second, around 2024. The large-scale counter-cyclical expansion of domestic wafer fabs not only improves the self-sufficiency rate of domestic chips, reduces the absolute import quantity of chips, and alleviates the contradiction of China's semiconductor chip

supply uncertainty, but also provides a great market development space for domestic semiconductor material suppliers due to the increased demand for semiconductor materials caused by the increase in domestic wafer production capacity.

2.2 Accelerated Demand for Domestic Substitution of Semiconductor Materials, Continuous Benefits for CMP Polishing Materials

China is not only a big consumer of semiconductor materials but also the fastest-growing market in the world. According to data from reports by the China Commerce Industry Research Institute, from 2006 to 2023, the global share of China's mainland semiconductor materials market size has increased year by year, from 6.38% to about 20.49%. By 2023, the market size of semiconductor materials in mainland China will reach 102.434 billion yuan (a YoY growth of 12.02%), thanks to the continuous expansion of domestic wafer fabs, and domestic semiconductor material companies have also continuously improved their R&D technology level and actively seized the incremental market share in China. This has effectively promoted the localization process of China's semiconductor materials and made China the fastest-growing semiconductor material market in the world. Among them, the cost of CMP polishing materials accounts for about 7% of the cost of semiconductor materials, and as the semiconductor materials market continues to grow, the CMP polishing market is expected to benefit from this growth in sync.

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