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INDUSTRIAL MANUFACTURING REAL ESTATE

Chip Manufacturing: The Critical Nexus

Semiconductors and the Imperative of Manufacturing Facilities

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Semiconductors and the Imperative of Manufacturing Facilities


NexPoint Semiconductor Manufacturing DST Property, Skorpios Semiconductor Manufacturing Facility in Temecula, CA

Semiconductor manufacturing has been a driving force behind the digital revolution, enabling the creation of increasingly powerful and compact electronic devices. The relentless progress in semiconductor technology has given rise to transformative innovations, impacting industries such as healthcare, communication, transportation, and more. This revolution is underpinned by advanced fabrication processes, intricate cleanroom environments, and cutting-edge equipment.

As the demand for advanced electronic devices continues to surge, understanding the symbiotic relationship between semiconductor manufacturing and real estate infrastructure becomes crucial for fostering innovation, economic growth, and global technological leadership. Chip manufacturing plants play a pivotal role in the modern technological landscape, underscoring the vital importance of real estate facilities supporting chip production and any future technological advancements.

In 2022, The Chips and Sciences Act, a legislative initiative aimed at bolstering the semiconductor industry by making a $53 billion investment[1], recognizes the pivotal role of semiconductor manufacturing in sustaining technological innovation and economic growth. Introduced in response to the global semiconductor supply chain challenges, this act seeks to address the critical nexus between chip manufacturing and real estate infrastructure. The act allocates substantial funding for the establishment and enhancement of semiconductor manufacturing facilities, aiming to strengthen domestic capabilities and reduce reliance on foreign sources.

$53
BILLION

In government funding for the manufacturing of semiconductor chips from the CHIPS and Science Act of 2022

1 (2023) Fact Sheet: One Year after the CHIPS and Science Act, Biden-Harris Administration Marks Historic Progress in Bringing Semiconductor Supply Chains Homes, Supporting Innovation, and Protecting National Security, via whitehouse.gov

The Evolution of Semiconductor Manufacturing

EARLY FOUNDATIONS (1940S-1950S): THE BIRTH OF SEMICONDUCTORS

The history of semiconductor manufacturing traces its roots to the mid-20th century when pioneers like William Shockley, John Bardeen, and Walter Brattain at Bell Labs ushered in the era of semiconductors with the invention of the transistor in 1947. This groundbreaking discovery marked a shift from bulky vacuum tubes to compact and efficient transistors, laying the groundwork for the semiconductor industry.

INTEGRATED CIRCUITS (1960S): A REVOLUTION UNFOLDS

The 1960s witnessed a monumental leap in developing integrated circuits (ICs). Jack Kilby at Texas Instruments and Robert Noyce at Fairchild Semiconductor independently introduced the concept of integrating multiple transistors and components onto a single chip. This revolutionized electronics, enabling the production of smaller, faster, and more reliable devices. The first commercially available ICs appeared in the early 1960s, setting the stage for the semiconductor industry's rapid growth.

MOORE'S LAW AND SCALING (1970S-1980S): THE ERA OF MINIATURIZATION

Gordon Moore, co-founder of Intel, predicted in 1965 that the number of transistors on a chip would double approximately every two years, a prophecy known as Moore's Law. This prediction became a guiding principle for semiconductor manufacturing, driving a relentless pursuit of miniaturization. The 1970s and 1980s saw the development of increasingly sophisticated fabrication processes, including photolithography and cleanroom technologies, to shrink transistor sizes and produce more powerful chips.

1940S-50S
The Birth of Semiconductors

1960s
Introducing Integrated Circuits

1970s-80s
Fabricating Smaller and Smaller Chips

1980s-90s
Global Expansion to Asian Countries

2000s
Silicon Valley Innovation Boom

2010s-20s
Technological Advancements Outpace Progress

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THE SILICON VALLEY BOOM (2000S): INNOVATION HUB

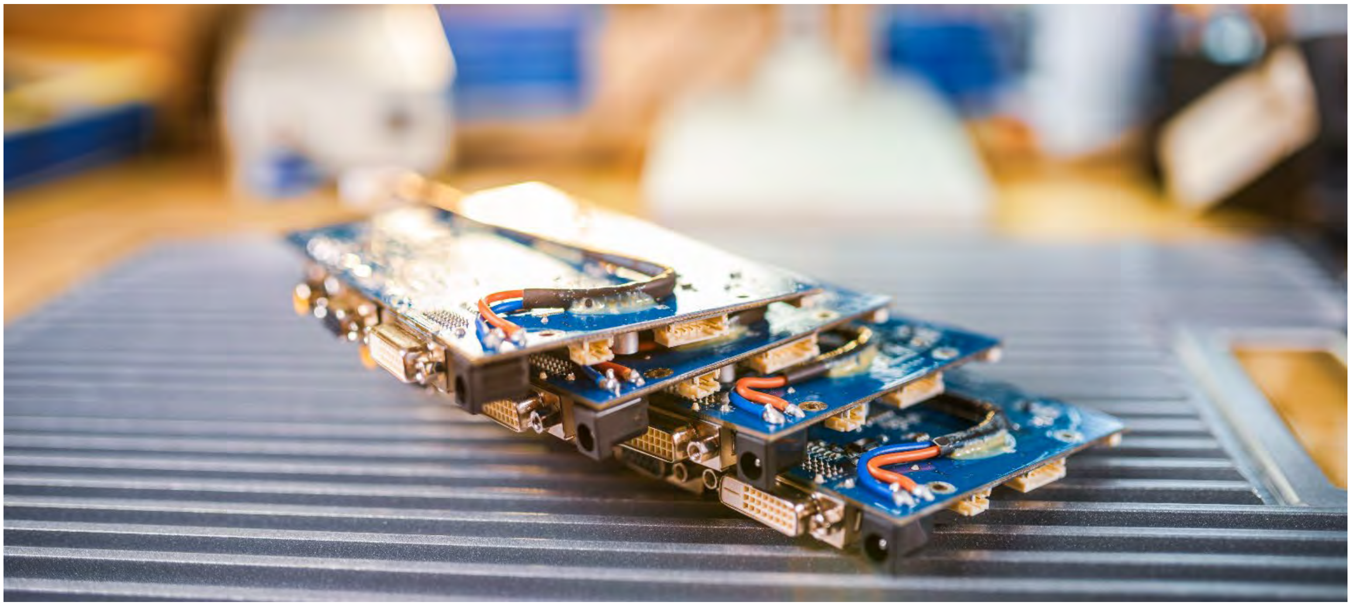
The 2000s marked a period of intense innovation, with Silicon Valley at the forefront. Companies like Intel, AMD, and TSMC pushed the boundaries of semiconductor manufacturing, introducing advanced technologies such as strained silicon, high-k metal gate transistors, and 3D stacking. These innovations propelled the industry into the realm of nanotechnology, enabling the production of more powerful and energy-efficient chips.

CURRENT LANDSCAPE (2010S-2020S): COMPLEX CHALLENGES AND BREAKTHROUGHS

The past decade has brought both challenges and breakthroughs in semiconductor manufacturing. The industry faced increasing complexities related to power consumption, heat dissipation, and the limits of traditional CMOS (Complementary Metal-Oxide-Semiconductor) technology. However, novel approaches like fin field-effect transistors, extreme ultraviolet lithography, and advanced materials have allowed manufacturers to continue the march of miniaturization, paving the way for cutting-edge technologies such as 5G, artificial intelligence, and the Internet of Things.

LOOKING AHEAD: QUANTUM COMPUTING AND BEYOND

As the semiconductor industry looks to the future, the spotlight is on emerging technologies like quantum computing. These groundbreaking paradigms pose new challenges for semiconductor manufacturing, requiring new materials and fabrication techniques and reimagining the very nature of computation. The history of semiconductor manufacturing serves as a testament to the industry's strength, adaptability, and continuous quest for innovation in the face of ever-evolving technological landscapes.



The Semiconductor Ecosystem

The intricate tapestry of the semiconductor manufacturing ecosystem is a testament to the complexities underlying the production of the ubiquitous chips that power our modern world. Spanning a spectrum of processes from initial design to final packaging, the creation of the semiconductor occurs at the crossroads of technology, expertise, and infrastructure.

1 DESIGNING THE BLUEPRINT

At the inception of the semiconductor manufacturing process lies the crucial stage of design where engineers and designers conceptualize the architecture of the semiconductor, specifying the arrangement and functionality of transistors, interconnects, and other components. The union of creativity and engineering precision utilizes cutting-edge software tools to simulate, model, and optimize the intricate circuits that define the chip's capabilities.

2 FABRICATION

Once the blueprint is crystallized, the fabrication stage takes center stage. This involves the physical realization of the design on a wafer through a series of photolithographic processes. Semiconductor fabrication facilities, commonly known as fabs, are high-tech environments equipped with advanced machinery, including photolithography equipment, chemical vapor deposition tools, and ion implantation systems. Cleanrooms within these facilities maintain stringent environmental controls, regulating temperature, humidity, and particle levels to ensure the utmost precision during semiconductor production.

3 TESTING AND QUALITY ASSURANCE

As the fabricated wafer emerges, it undergoes rigorous testing to identify any defects or irregularities. Testing involves using automated systems and specialized equipment to assess functionality, performance, and power consumption.

4 PACKAGING

Following successful testing, the individual semiconductor dies are prepared for integration into electronic devices through the packaging stage. Packaging involves encapsulating the chip in protective materials and connecting it to the external world through interconnects. Packaging facilities require specialized machinery such as wire bonding and flip-chip bonding equipment. These facilities also adhere to stringent cleanliness standards to prevent contamination and ensure the reliability of the packaged chips.

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THE ROLE OF STATE-OF-THE-ART REAL ESTATE FACILITIES

Throughout this intricate journey, the availability of cutting-edge real estate facilities becomes a linchpin for the semiconductor industry's success. Purpose-built fabs, testing centers, and packaging facilities demand specialized infrastructure beyond the conventional construction norms. Cleanroom specifications, ventilation systems, and energy infrastructure are meticulously designed to meet the unique requirements of semiconductor manufacturing, ensuring the purity of the manufacturing environment and the reliability of the final product.

Real Estate Facilities: The Foundation of Semiconductor Manufacturing

CLEANROOM ENVIRONMENTS: THE SANCTUARIES OF PRECISION

Cleanrooms serve as the sanctuaries where the delicate fabrication of the semiconductor unfolds. These controlled environments are meticulously designed to maintain exceptionally low levels of airborne particles, ensuring that the semiconductor manufacturing process remains uncontaminated. The construction of cleanrooms is a highly specialized endeavor, requiring architects and engineers to integrate advanced HVAC (Heating, Ventilation, and Air Conditioning) systems, air filtration technology, and positive pressure zones. Purpose-built facilities with cleanroom specifications are not merely structures but technological marvels, emphasizing the industry's commitment to precision and quality.

Stringent protocols govern the entry and attire of personnel, with specialized garments such as cleanroom suits and hoods being mandatory. Air showers and airlocks act as barriers to prevent external contaminants from infiltrating these pristine environments

ENERGY INFRASTRUCTURE: POWERING SEMICONDUCTORS

Semiconductor manufacturing is energy-intensive, demanding substantial power resources to fuel the intricate machinery and maintain the environmental controls within cleanrooms. Real estate facilities supporting chip production are thus tasked with housing robust energy infrastructure to meet these formidable demands. Uninterrupted operation is paramount in semiconductor fabrication, necessitating the integration of backup power systems to mitigate the impact of potential outages.

Energy infrastructure within semiconductor facilities includes high-capacity electrical grids, uninterruptible power supply (UPS) systems, and advanced power distribution networks. The reliability of these systems is non-negotiable, as any disruption could result in production delays, yield losses, or compromised chip quality. Purpose-built real estate facilities for semiconductor manufacturing are designed not only to accommodate the energy needs of today's processes but also to anticipate the increasing demands of future, more advanced technologies.

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REPLACEMENT COST REALITIES: SAFEGUARDING SEMICONDUCTOR INVESTMENTS

Major semiconductor companies are making substantial investments in fabrication facilities, allocating upwards of $2,500 per square foot for the largest facilities[1], with smaller ones costing up to three times as much when considering full development and operational ramp-up costs. The high replacement cost of these facilities highlights the critical importance of continued investment and strategic planning to maintain a cutting-edge semiconductor manufacturing landscape, ensuring sustainability and global competitiveness.

GLOBAL FAB FACILITY COMPS[1]

Company	Location	SF	Total Investment $(mm)	PSF
Samsung	Korea	31,000,000	$79,000	$2,548
Samsung	Texas	6,000,000	$17,000	$2,833
TSMC	Arizona	3,800,000	$12,000	$3,158
Intel	New Mexico	420,000	$3,500	$8,333
Intel	Oregon	270,000	$3,000	$11,111
Total		41,490,000	$114,500	$2,760

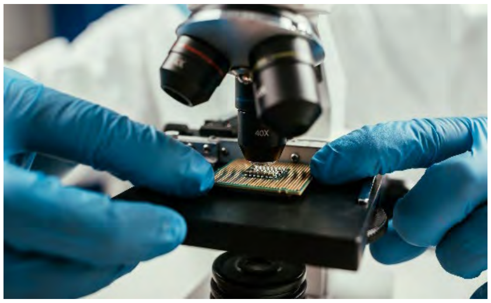
IMPORTANT CONSIDERATIONS

The dynamic nature of the industry requires a keen awareness of technological trends and global economic conditions. These considerations include:

1. High Initial Costs
   The construction and setup of semiconductor manufacturing facilities involve significant upfront costs, making entry into the market challenging for some investors.
2. Technological Obsolescence
   Rapid advancements in semiconductor technology may render existing facilities obsolete, leading to the need for continuous upgrades or redevelopment.
3. Global Supply Chain Risks
   The semiconductor industry is susceptible to global supply chain disruptions, geopolitical tensions, and trade uncertainties, affecting the stability of investments.
4. Environmental Impact
   Semiconductor manufacturing processes can have environmental implications, and increasingly stringent environmental regulations may pose challenges for existing facilities or new developments.

1 ASML Investor Day 2022 presentation, Comps reflect total investment at site and may be invested over number of years, includes all costs associated with opening facility.

Economic Impact: Driving Innovation and Growth



JOB CREATION: NURTURING A SKILLED WORKFORCE

Semiconductor manufacturing facilities stand as veritable engines of job creation, generating employment opportunities directly within their walls and catalyzing job growth in ancillary industries. The high-tech nature of semiconductor production necessitates a skilled and specialized workforce, creating jobs that range from semiconductor fabrication technicians to engineers, researchers, and administrative staff.

The demand for skilled labor extends beyond the immediate confines of semiconductor facilities. Educational institutions respond to the industry's needs by offering specialized training programs, producing a pipeline of talent ready to contribute to the ever-evolving semiconductor landscape. This symbiotic relationship between industry and education can ensure a continuous pool of skilled professionals, fostering economic development by enhancing individuals' employability and earning potential.

INNOVATION ECOSYSTEM: THE POWER OF PROXIMITY

Beyond job creation, semiconductor manufacturing facilities play a pivotal role in shaping innovative ecosystems. Proximity to semiconductor hubs sparks a virtuous cycle of collaboration, knowledge exchange, and technological advancement. These hubs become epicenters of innovation, fostering a dynamic interplay between research institutions, startups, and established companies.

The clustering effect of semiconductor manufacturing hubs cultivates an environment where ideas flourish and expertise converges. Research institutions strategically position themselves in close proximity to these hubs to tap into the wealth of knowledge generated by industry leaders. This proximity accelerates the translation of cutting-edge research into practical applications, driving the rapid evolution of semiconductor technologies.

Startups, drawn by the gravitational pull of established semiconductor companies, find fertile ground to develop and grow. Access to mentorship, funding, and shared resources within these innovation ecosystems propels startups toward success. This collaborative spirit extends beyond formal partnerships, with the organic exchange of ideas fostering an environment of continuous learning and adaptation.

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A Collaborative Future

The semiconductor manufacturing ecosystem, a convergence of innovation and precision, relies on specialized facilities to navigate intricate processes from design to packaging. Real estate tailored to chip manufacturing is not merely housing but instead supporting an integral part of the ecosystem, influencing efficiency, reliability, and competitiveness. As nanotechnology and quantum computing push boundaries, purpose-built facilities lay the foundation for the next wave of technological breakthroughs.

These facilities are more than physical spaces; they serve as dynamic hub shaping the economic impact of semiconductor manufacturing. Cleanrooms, energy infrastructure, and logistics are interconnected elements that contribute not only to job creation but also to vibrant innovation ecosystems. Semiconductor hubs become catalysts for progress, propelling economies forward through skilled workforces and a relentless pursuit of technological advancement.

The future of semiconductor manufacturing may hinge on the adaptability and sustainability of real estate facilities. Ongoing investments are essential to keep these facilities technologically advanced, aligning with the industry's pursuit of innovation. Moreover, the imperative for sustainability places real estate at the forefront of environmental stewardship, demanding a holistic approach to design, operation, and resource utilization. Collaboration among industry stakeholders, governments, and real estate developers is vital to ensuring a resilient and thriving semiconductor ecosystem, sustaining the momentum of the technological revolution and fostering global competitiveness.

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Matthew McGraner is Chief Investment Officer and serves in numerous roles across the NexPoint platform. With over ten years of real estate, private equity, and legal experience, his primary responsibilities are to lead the strategic direction and operations of the real estate platform at NexPoint. McGraner has led the acquisition and financing of approximately $18.4 billion of real estate investments.

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