U.S. DEPARTMENT OF ENERGY

Achieving American Leadership in the Semiconductors Supply Chain

Summary

Semiconductors are a keystone technology that are essential for the operation of every electronic device, including those that are critical to a clean energy economy. The semiconductor industry has a complex, competitive, and highly integrated international supply chain in which the United States has historically enjoyed a dominant position, but where this position has been eroding over time. In 1995, 26% of global semiconductor manufacturing capacity was located in the United States; this had decreased to 10% by 2020. Investments in key semiconductor manufacturing technologies such as high-voltage power electronics, energy-efficient conventional devices, and advanced packaging point the way to secure a strong domestic semiconductor industrial base.

Semiconductors are Critical to a Clean Energy Economy

Semiconductors are central to power and information management in technologies such as electric vehicles (EVs), energy-efficient industrial and building applications, and electricity generation. Power electronics using wide bandgap (WBG) semiconductors are helping to integrate renewable energy and battery storage systems, enabling new grid services and the development of microgrids. In addition, power electronics improve energy efficiency and enhance controllability in industrial equipment and are vital for nearly every form of electrified transport. At the same time, computation-intensive applications like Machine Learning, Internet of Things, and cryptocurrencies are driving unsustainable increases in the energy use and associated carbon emissions of conventional semiconductors.

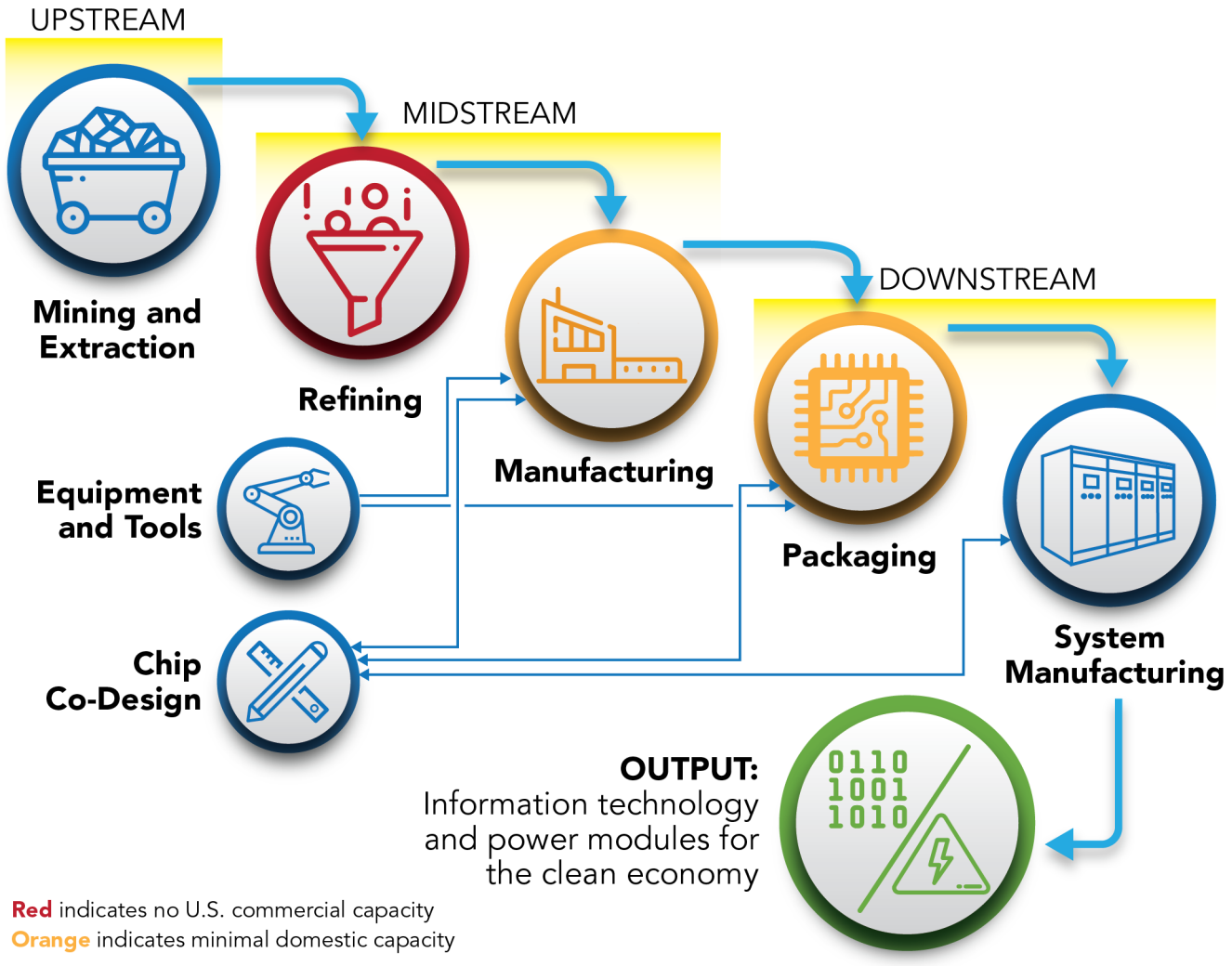
Key Findings and Opportunities

Explosive growth of semiconductor demand: Decarbonization efforts will increase the demand for renewable energy and its supporting infrastructure, including both conventional semiconductor and WBG power electronic supply chains. The demand for

products that will use both WBG semiconductors and conventional semiconductors in the future is projected to increase by more than an order of magnitude by 2050 (e.g., wind: 23-fold; EV: 68-fold increases). The U.S. strength in Silicon Carbide (SiC) power electronics offers an opportunity to expand domestic manufacturing capacity for advanced wide bandgap semiconductors and position the United States as a leader in this crucial technology.

Significant and rapidly rising energy demand of semiconductors in the use phase: The global energy use of products featuring semiconductors has doubled every three years since 2010, primarily due to the accelerating use of semiconductors in all facets of our modern economy and the deceleration of energy efficiency increases due to miniaturization. This exponential growth in energy use is projected to accelerate even more due to increased electrification from decarbonization and the exponential growth in energy-intensive computer applications (e.g., artificial intelligence). By expanding R&D into advanced architectures and technologies to improve the energy efficiency in semiconductor devices, the United States can drive innovation in new high-efficiency electronic devices that will reduce the carbon footprint of conventional semiconductors and advance computing power.

Opportunity for increased domestic manufacturing base: As the global demand for semiconductors increases in the race to a clean energy



economy, the U.S. has an important opportunity to ramp up domestic semiconductor production. Advanced packaging for semiconductors presents another important segment of the supply chain for U.S. leadership. Advanced packaging is rapidly increasing in importance for performance and efficiency and will continue to grow as we electrify economies across the globe. Advanced packaging is a rapidly growing, innovative area that depends heavily on design capabilities. The United States excels in design, but has minimal capacity in advanced packaging manufacturing. The American industrial sector has an opportunity to build these new advanced manufacturing facilities right here at home.

Download the full document and the corresponding other documents that are part of the DOE response to the supply chain executive order at: www.energy.gov/policy/supplychains

Policy Next Steps

Strengthen U.S. high-voltage wide bandgap semiconductor industry: Leverage provisions in the Bipartisan Infrastructure Law to promote domestic manufacturing of high voltage SiC wide bandgap semiconductors for power management in decarbonized electricity grids.

Catalyze innovation in wide bandgap: Engage government and private sector to expand research, development, and deployment funding on high-voltage (up to 10 kilovolt) SiC wide bandgap semiconductors for high-power and high-voltage electrification applications needed for decarbonization.

Innovate for microelectronic energy efficiency: Engage government and private sector to embed energy efficiency improvement efforts into research, development, demonstration, and commercial application investments tto improve the energy efficiency of microelectronics over the next 20 years. ■