

Cornering the Graphene Market Countering Beijing's Strategy for Industry Domination

PIPS White Paper 11.6: *Executive Summary*

Lindsey Washington, Research Fellow
Caroline Duckworth, Research Intern

Graphene is a one atom thick, semimetal superconductor poised to revolutionize the renewable energy, aerospace, armor, and water desalination industries. Despite its potential, the difficulty of mass-producing graphene has limited its profitability and industrial use since the material's discovery in 2004.

The Chinese government currently invests heavily in research and development into graphene mass production. In contrast, the U.S. commercial research and development community, led by Silicon Valley, depends on investment from venture capitalists. These private investors have been reluctant to finance graphene development because barriers to mass production have limited profitability. The lack of private investment will lead to significant negative political and economic consequences for the United States should China dominate global graphene production. To counter this threat, Washington should fund and prioritize research into graphene mass production through the Department of Defense's research labs.

Graphene: A New Material for National Security

Graphene's light weight, flexibility, strength, and conductivity make it appealing to many industries. While the difficulty of mass-producing graphene has prevented the industrial use of the material, several research labs work to confront this challenge. The majority of these labs are supported by the Chinese government.

- *Properties of Graphene.* Graphene consists of a single layer of carbon atoms arranged in a honeycomb lattice. Graphene is lighter than air and flexible. Researchers also believe that it is up to 200 times stronger than steel. A single layer of the material is incredibly conductive, outperforming silver and copper. Multiple layers of graphene can be manipulated to perform as an insulator or as a superconductor, increasing its potential applications.
- *The Production of Graphene.* High quality graphene can be made by cleaving multilayer graphite into a single layer or by depositing a layer of carbon onto the surface of graphite.

However, these processes are inefficient and costly. While researchers around the globe are interested in creating scalable production methods, Chinese research and development into graphene production is outperforming that of the United States.

The Geopolitics of Graphene Applications

Graphene's properties make it attractive to many industries vital to national security, including the battery, aerospace, armor, and desalination industries. Domination of the global graphene market will allow China to undercut U.S. influence in these arenas, leaving the United States economically and strategically vulnerable.

- *Batteries.* The military and private sectors depend on batteries as a renewable energy source. Graphene has the potential to increase the lifespan and decrease the charging time of lithium-ion batteries and supercapacitors. Domination of the graphene market would allow China to undercut foreign competitors in renewable energy and give it significant economic leverage.
- *Satellites and Lasers.* Graphene can improve the propulsion and thermal management of satellites, making them cheaper and more efficient. Graphene can also improve the thermal management of lasers, which may contribute to the development of efficient weaponized lasers. Chinese domination in graphene production, therefore, could threaten U.S. superiority in space.
- *Water Desalination.* Highly efficient microporous graphene filters may replace current desalination technology. These filters will become invaluable over the next ten years as the global water scarcity crisis reaches a critical level. Should China corner the graphene market and subsequently control cost-efficient desalination equipment, it will likely gain influence over regions dependent on this technology, such as the Middle East.
- *Armor.* Including graphene in vehicle and body armor will decrease the weight and increase the strength of current protection without compromising flexibility. As a result, the U.S. armed forces will be better prepared to address threats within the increasingly close quarters of urban settings.

Driven by Profit: The Weakness of U.S. Research and Development

Because of the difficulties of mass production, graphene firms fail to attract funding from U.S. investors. As a result, U.S. firms have made little progress toward scalable graphene production. In contrast, Beijing's economic and strategic planning drives Chinese research and development and has prioritized investment in graphene mass production through subsidies, tax cuts, and direct funding.

- *Silicon Valley.* U.S. private research and development relies on venture capitalists to finance start-up firms. However, the graphene market is an unattractive investment, as it is

characterized by high levels of technology and market risk. This risk leaves graphene research in the hands of small-scale research and government labs, which focus on graphene's scientific principles and potential applications, rather than the mass production of graphene.

- *China's Top-Down Research Advantage.* The Chinese government has encouraged scientific research into graphene products and production through a top-down approach, offering state insurance and funding to Chinese firms and labs. Direct funding not only decreases the risk of entering the graphene market, but also allows Chinese firms to decrease the prices of their products below market costs, pushing foreign competitors out of the market.

Policy Recommendation

The United States traditionally addresses Chinese market manipulation through antidumping and countervailing tariffs. These policies, however, may harm the U.S. graphene industry. Instead, the United States should use the research infrastructure within the Department of Defense to develop cost-effective methods to mass produce graphene.

- *The Current U.S. Strategy, Tariffs.* Tariffs raise domestic prices, decrease domestic demand, and leave the United States vulnerable to retaliation. Tariffs also fail to improve domestic manufacturing capacity, as they inflate domestic prices, decreasing firms' incentives to innovate. As a result, the dominance of foreign firms in the industry is not averted. These consequences are demonstrated by the solar market, in which U.S. antidumping and countervailing tariffs failed to prevent Chinese dominance in solar.
- *Mass Production Research, A Long-Term Solution.* Unlike tariffs, directly incentivizing research into graphene mass production through the Department of Defense will serve as an effective, long-term solution to Chinese maneuvering in the graphene market. Incentivizing research will close the existing gap between Chinese and U.S. research efforts, addressing the root of Chinese dominance in graphene production. While government intervention in the private market is not always welcomed, the vaccine industry provides clear precedent for government intervention in industries crucial to U.S. security. This policy will allow the United States to prevent Chinese domination of the graphene market.

The United States can improve its ability to mass produce graphene using the current research infrastructure within the Department of Defense. This policy will allow Washington to prevent Beijing's domination of the graphene market. Promoting research is a preferable option compared to tariffs, which do not directly incentivize innovation and leave the United States vulnerable to tariff and legal retaliation.