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IS INDIA MISSING THE GRAPHENE BUS?

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A sample of graphene-infused rubber. | Photo Credit: AP

What Artificial Intelligence (AI) is to software and quantum computing is to computers, graphene is to materials. These three emerging technologies will disrupt the existing human-machine interface in the next couple of decades. While India is among the leaders in AI and a potential challenger in quantum computing, it needs to catch up in the area of graphene.

Graphene is the world's thinnest, strongest, and most conductive material of both electricity and heat. It conducts electricity better than copper. It is 200 times stronger than steel but six times lighter. It is almost perfectly transparent as it absorbs only 2% of light. It is impermeable to gases, even those as light as hydrogen and helium. It has the potential to revolutionise electricity, conductivity, energy generation, batteries, sensors and more. Also, when added to other materials, graphene even in small quantities produces composite materials with dramatically transformed qualities. Graphene composites are used in aerospace, automotive, sports equipment and construction. It is used for high-performance batteries and super-capacitors, touchscreens, and conductive inks. Graphene-based sensors are used for environmental monitoring, healthcare and wearable devices. Graphene oxide membranes are used for water purification and desalination. Graphene-based masks were made during COVID.

Graphene is important for defence and aerospace as well. Its exceptional strength makes it promising material for armour and ballistic protection. Graphene has the potential to absorb and dissipate electromagnetic waves, making it valuable for developing stealth coatings and materials that reduce radar signatures and electromagnetic interference. Graphene is highly sensitive to environmental changes, which makes it an excellent candidate for sensing chemical and biological agents, explosives, radiation, and other hazardous substances. Besides, graphene-based materials can also protect us against chemical and biological attacks. Better energy storage and electronics properties make graphene attractive in defence and aerospace as well as in civil and commercial applications.

Never has one material had such an impact on so many sectors. Materials define an age — the stone age, iron age, plastic age and silicon age. There are reasons to believe that we are entering the graphene age. According to the Grand View Research, the global graphene market size was valued at $175.9 million in 2022 and is expected to grow at a CAGR of 46.6% between 2023 and 2030.

Although graphene was discovered in 2004, it was difficult to produce high-grade large-scale

graphene. However, things are changing fast. As per a report, at least one graphene-enhanced product was launched every week in 2022. Over 300 companies are now producing graphene or its derivatives.

Among the leading countries in graphene research are China, the U.S., the U.K., Japan, South Korea, Russia, and Singapore. Till 2012, graphene-related patent filing was dominated by the U.S. From 2013 to 2016, South Korea and China matched the U.S. After 2017, China surged ahead. In 2018, China filed 218 patents while the other leading countries together filed 79. India had eight filings.

China and Brazil are global leaders in the commercial production of graphene. At the Beijing Graphene Institute, set up in 2018, several companies produce industry-grade graphene products. India produces about one-twentieth compared to China and one-third compared to Brazil.

But India's progress has been better than many nations. The Centre for Nano Science and Engineering at IISc Bangalore along with KAS Tech produced a graphene-based system several years ago. Some start-ups and foreign subsidiaries have started graphene or graphene derivatives in India. Notably, Tata Steel has succeeded in growing graphene (about 50 micrometers large domains) using annealing and extracting atomic carbon from steel surface. It has also mixed graphene with used plastic products to recycle them as new. India's niche is going to be innovation using graphene. It figured out how graphene oxide-based wrappers loaded with preservatives can increase the shelf life of fruits and vegetables. The IIT Roorkee-incubated Log 9 has patented a technology for graphene-based ultracapacitors, and the IIT Kanpur-incubated RF Nanocomposites has developed EMI shielding and stealth technology using graphene-based nanotubes. But this trickle needs to be converted into a torrent. A laudable step in this direction was the setting up of the India Innovation Centre for Graphene in Kerala. It is being implemented by the Digital University Kerala in partnership with Tata Steel and C-MET, Thrissur. The Centre needs to become the nodal point to spur large-scale innovation activity around graphene.

Governments have a crucial role to play. China declared graphene a priority in its 13th Plan. Europe set up the Graphene Flagship, with a budget of €1 billion in 2013. Can India not have a national graphene mission? A nodal Ministry needs to be entrusted with this responsibility; else the subject will fall through the cracks. India needs to be among the leaders in graphene because we may experience the 'winner takes the most' situation here. Given the high cost-to-volume ratio for high-grade graphene, its production may get concentrated in a few locations in the world, as in the case of semiconductors. India missed the semiconductor bus in the mid-1990s. The time to step on the graphene pedal is now.

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