Need for a national mission to develop scientific instruments

There have been concerted efforts in recent years to develop indigenous technology under 'Atmanirbhar Bharat'[1]. One major initiative in this direction by the Department of Science and Technology (DST), Government of India (GoI), is an ambitious programme called Quantum-Enabled Science and Technology (QuEST) involving about 50 research groups spread across 32 institutions in the country with a total financial outlay of Rs 180 crores, being executed in mission mode in order to take a giant leap forward in developing state-of-the-art technologies[2,3]. The even more ambitious National Mission on Quantum Technology (NMQT) with a total financial outlay of Rs 8000 crores and involving four ministries is about to be launched by GoI[4,5]. While these initiatives indeed hold great potential, nearly all of the scientific equipment required to develop quantum technologies is imported. This includes commonly used tools such as high-precision voltmeters, lock-in amplifiers, lasers, lens and optical components as well as more sophisticated equipment such as lithographic tools, electron microscopes, dilution refrigerators, turbo-molecular pumps, etc. The only exception is probably thin-film deposition technology, which due to a number of favourable circumstances developed to the extent that many basic thin-film deposition systems such as sputtering, evaporation, various kinds of CVD systems are indigenously available. However, sophisticated systems like molecular beam epitaxy still need to be imported.

In today's fast-evolving, globally connected technological landscape, it is not possible for any country to completely become independent in any sphere of activity. Therefore, in the domain of science and technology (S&T) 'Atmanirbhar Bharat' should be interpreted in a broader sense, where we rely on instruments manufactured in other countries in certain areas, but also have expertise in a few areas where other countries rely upon us. Research-level scientific instrumentation is however almost a one-way traffic; we depend on imports for practically everything, but export very little. Trying to develop futuristic state-of-the-art quantum technology on the shoulders of imported classical instruments is the equivalent of learning to drive before learning to walk. Even if we disregard philosophy, there are a number of practical issues to consider. First, import restrictions either due to constraints placed by the Government of the country where the item is manufactured or by GoI regulations often cause inordinate delays in executing a project. Consequently, the most commonly heard logistic complaint from quantum technology researchers is the difficulty in importing instruments. Secondly, most of the imported instruments are from Europe or USA. Being far away from the manufacturer typically implies higher maintenance costs and longer downtimes when the machine needs to be transported for service or repair, or the engineer needs to make a visit for the same. Only few foreign manufacturers have reasonable repair or service infrastructures in India. Third, and most significantly, the cost disadvantage of importing instruments used as subunits in quantum technology renders the product unlikely to ever be commercially viable.

This situation is not healthy for the growth of S&T and needs to be addressed with the same urgency as developing quantum technologies. While our reliance on imported scientific equipment is too much to change the situation overnight, a National Mission for the Development of Scientific Instruments needs to be undertaken with the same urgency as NMQT. We can start with the low-hanging fruit, where the industry already has the basic know-how, such as optical components, precision electrical measuring equipment like that of lock-in amplifiers and nanovoltmeters. This can be followed by more complicated equipment like low-temperature cryostats, dilution refrigerators, NMR spectrometers, lithographic tools and FPGA-based specialized measurement systems.

Having closely studied the growth trajectory of one of the premier Indian thin-film deposition technology companies since its inception, I believe this is completely feasible within the same time-frame as NMQT. However, we need to provide the ecosystem where development of such technology can flourish. Uncertainty about future demand frequently discourages private enterprises from investing in the development of specialized scientific instruments. For technology that can be improvized from existing technologies, research laboratories should be encouraged to team up with private companies, while DST can facilitate this by providing grants that will cover a major fraction of the R&D costs. More complicated technologies need to be developed in research laboratories. Since development of technology that is available in the international market is often considered as academically unproductive work, such activities should be appropriately incentivized. In the long run, state-of-the-art technology development can become a self-sustaining activity only if a large proportion of scientific instruments are manufactured in the nation.

1. https://aatmanirbharbharat.mygov.in/
2. https://dst.gov.in/sites/default/files/QuST%-20-%20CFP1.pdf
3. https://www.indiatoday.in/technology/news/story/india-starts-working-on-quantum-computers-1428902-2019-01-11
4. https://www.psa.gov.in/technology-frontiers/quantum-technologies/346
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