**It’s a tech-powered world**

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In my previous articles, I have emphasized the importance for Pakistan to change tracks and focus on the manufacture and export of high-tech (high value-added) goods to improve its economy.

This proven strategy is great to rid ourselves of the burden of debt and become self-reliant. That is the path adopted by China, Korea, Singapore, Taiwan and, more recently, Vietnam. Pakistan can easily establish high-tech industrial clusters ranging from pharmaceuticals, software engineering and alternative energy to electronics, engineering goods, and new materials. Let’s have a look at the economic opportunities presented by the materials sector.

Let us first consider the field of electronics. The electronics industry stands at the forefront of material innovation, as it is continuously pushing boundaries to meet the demands of faster, smaller, and more energy-efficient devices. The advent of semiconductor materials, such as silicon carbide and gallium nitride, has revolutionized power electronics, enabled higher switching frequencies and reduced energy losses.

These advancements have facilitated the development of compact yet powerful electronic devices – from smartphones to electric vehicles. The emergence of flexible and stretchable electronics has paved the way for wearable technology and flexible displays. Materials like graphene and carbon nanotubes exhibit exceptional mechanical properties, enabling the creation of lightweight, bendable electronic components.

In the aviation sector, lightweight materials play a pivotal role in enhancing fuel efficiency and performance while ensuring safety and durability. Advanced composite materials including carbon fiber-reinforced polymers (CFRP) and ceramic matrix composites (CMC) offer significant weight savings compared to traditional metal alloys.

As a result, modern aircraft incorporate composite structures in airframes, wings, and engine components, which significantly reduce fuel consumption and emissions. The development of high-temperature materials, such as nickel-based superalloys and ceramic composites, has enabled the design of more efficient jet engines.

In the automotive industry, the incorporation of lightweight materials has led to improved fuel economy. Lightweight metals, such as aluminium, magnesium, and titanium, offer substantial weight savings without compromising structural integrity. By replacing traditional steel components with lightweight alternatives, automakers can achieve significant improvements in vehicle efficiency and performance. The rise of electric vehicles (EVs) has accelerated the demand for high-energy-density battery materials, such as lithium-ion batteries and solid-state electrolytes. These materials enable EVs to achieve longer driving ranges and faster charging times, addressing key barriers to widespread adoption.

New materials have also revolutionized the design and construction of engineering goods, industrial machinery, and consumer products. Advanced materials like shape memory alloys (SMAs) and self-healing polymers offer unique properties that enable adaptive structures and components. SMAs exhibit reversible shape changes in response to temperature variations, making them ideal for actuators, sensors, and biomedical implants.

Similarly, self-healing polymers can repair damage autonomously, prolonging the lifespan of engineered systems and reducing maintenance costs. The advent of additive manufacturing technologies, such as 3D printing, has enabled the direct fabrication of components from digital designs, eliminating the need for traditional tooling and reducing material waste.

In the textiles and leather industries too, the advent of smart and functional materials has revolutionized product design and performance. Smart textiles incorporate embedded sensors, actuators, and electronic components to provide additional functionality, such as temperature regulation, moisture management, and health monitoring. Materials like conductive fibres, shape memory polymers, and phase change materials have enabled the development of intelligent textiles with responsive and adaptive properties.

In the pharmaceutical sector, new materials hold promise for drug delivery, tissue engineering, and medical device manufacturing. Nanomaterials, such as liposomes, nanoparticles, and quantum dots, offer precise control over drug release kinetics and targeting, enhancing therapeutic efficacy and minimizing side effects. By encapsulating drugs within nanoscale carriers, researchers can overcome biological barriers and achieve localized delivery to diseased tissues.

Furthermore, biomaterials play a crucial role in regenerative medicine and tissue engineering applications. Scaffolds made from biocompatible polymers, ceramics, and hydrogels provide structural support for cell growth and tissue regeneration, facilitating the repair of damaged organs and injuries.

Turning to defence and aerospace applications, stealth materials are essential for reducing the detectability of military platforms, such as aircraft, ships, and missiles. Radar-absorbing materials (RAMs) and metamaterials have been designed to minimize radar reflections and electromagnetic signatures, making stealth vehicles less visible to enemy detection systems.

Chameleon-like materials can adjust their colour, texture, and thermal properties in real time, enabling dynamic camouflage that adapts to changing conditions and terrain. By blending seamlessly into their surroundings, stealth vehicles and soldiers gain a tactical advantage on the battlefield, enhancing survivability and mission success.

Intelligent materials encompass a broad category of materials that exhibit responsive or adaptive behaviour to external stimuli, such as temperature, light, or mechanical stress. Shape memory alloys, piezoelectric ceramics, and electroactive polymers are examples of intelligent materials that can change their properties in a controlled manner, enabling applications in actuation, sensing, and energy harvesting.

Nanomaterials (materials with dimensions on the nanometer scale) exhibit unique physical, chemical and mechanical properties that differ from their bulk counterparts. Carbon nanotubes, graphene, and quantum dots are examples of nanomaterials that offer exceptional strength, conductivity, and optical properties, respectively. These materials hold immense potential for applications in electronics, energy storage, catalysis, and biomedical imaging. By manipulating nanoscale structures and interfaces, researchers can design materials with enhanced performance, such as increased strength, conductivity, or catalytic activity.

The integration of these new materials is transforming various sectors, from industry to defence, by enabling unprecedented levels of performance, efficiency, and functionality. From lightweight composites in aviation to smart textiles in fashion, and from nanomaterials in electronics to biomaterials in healthcare, the impact of advanced materials is far-reaching.

In Pakistan the new foreign engineering university, the Pak-Austria University of Applied Science and Engineering (Fachhochschule) established under my stewardship in Haripur, Hazara as well as another under-construction foreign engineering university in Samrial, Sialkot will focus on the establishment of centres of excellence in materials engineering in order to give a huge boost to industry and defence. A Center on Nanotechnology has also been established within the International Center for Chemical and Biological Sciences at Karachi University through the magnificent donation of Chairman Husein Ebrahim Jamal Foundation Mr Aziz Latif Jamal.

The new government now needs to give the highest priority to the manufacture and export of high-tech products. That is the only way forward. The new prime minister should appoint honest, visionary and technologically competent ministers and secretaries so that we can migrate to a technology-driven knowledge economy.

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