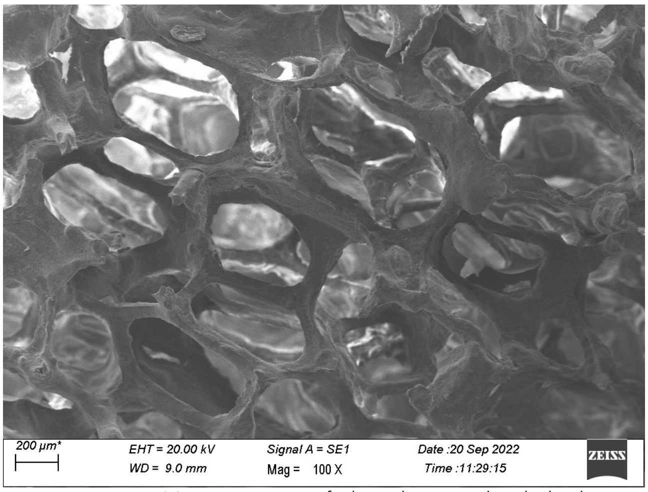
Transfer of Technologies

Materials Group

The Bhabha Atomic Research Centre (BARC) is a premier multi-disciplinary nuclear research centre of India with expertise spanning the entire spectrum of nuclear science and engineering and related areas. Within BARC, the Materials Group undertakes fundamental and applied R&D to develop advanced materials, processes and technologies that underpin national programmes and industrial growth. Over the past few years, this group has translated laboratory innovations into transfer-ready technologies that help domestic industries produce strategic materials, advanced composites, ceramic products, catalysts and nano-enabled devices. The following sections present brief summaries of a few recent technology transfers from the Materials Group, offering a snapshot of the diverse solutions developed for societal needs and industrial benefits. Due to space limitations in this newsletter, only a select set of technologies is highlighted here. Readers may refer to the official BARC website for the complete list of technologies transferred or currently available for transfer.



Microstructure of the platinum loaded alumina ceramic foam.

1 Platinum-Loaded Alumina Ceramic Foam

Platinum-loaded alumina ceramic foam is an advanced catalyst support that combines the open-cell structure of α-alumina foam with high-surface-area γ-alumina and finely dispersed platinum nanoparticles. The foam is fabricated by a replica method in which a polyurethane sponge is coated with α-alumina slurry, squeezed to remove excess material, dried and sintered to produce a ceramic replica. Because α-alumina alone has insufficient surface area for catalysis, the macroporous support is subsequently coated with γ-alumina before being impregnated with a platinum salt and heat-treated to generate catalytic Pt particles. The resulting ceramic foam exhibits porosity of 80–90 %, density around 0.7–0.9 g cm^{-3} and compressive strength ≥ 2 MPa, with an effective surface area ≥ 35 $m^2\,g^{-1}$.

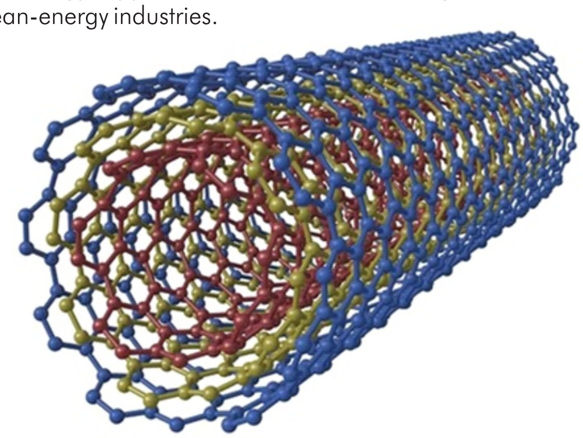
Microstructure of the platinum loaded alumina ceramic foam

These macroporous foams are lightweight, chemically stable and highly refractory, offering excellent heat and mass transfer properties. These are inexpensive compared with other ceramics and can withstand working temperatures up to about 500 °C. The high porosity and tortuosity make them suitable as catalyst supports for steam reforming, hydrogen-iodine decomposition and other heat- and mass-transfer-limited processes. Beyond catalysis, platinum-loaded alumina foams are used in molten metal and hot-gas filters, diesel exhaust treatment, biomaterials, thermal insulation and lightweight structural components in aerospace and high-temperature industries.

2 Large Scale Synthesis of Carbon Nanotubes

The large-scale synthesis technology for multi-walled carbon nanotubes (CNTs) produces high-purity (≈95 %) nanotubes with diameters of 20–50 nm and lengths of 5–10 µm. These CNTs exhibit exceptional tensile strength, high modulus, low density, and excellent thermal and electrical conductivity, making them a versatile nano-building block.

The material's high aspect ratio and porosity enable applications across diverse sectors: high-strength structural composites, electrodes for energy storage and conversion (supercapacitors, batteries), electromagnetic interference shielding, transparent conductive films, field emission displays and thermal interface materials. CNTs are also used as catalyst supports, membranes for water purification, adsorbents for gas storage, drug delivery vehicles and biosensors. By offering a reliable domestic process for bulk CNT production, this technology supports advanced manufacturing, electronics and clean-energy industries.

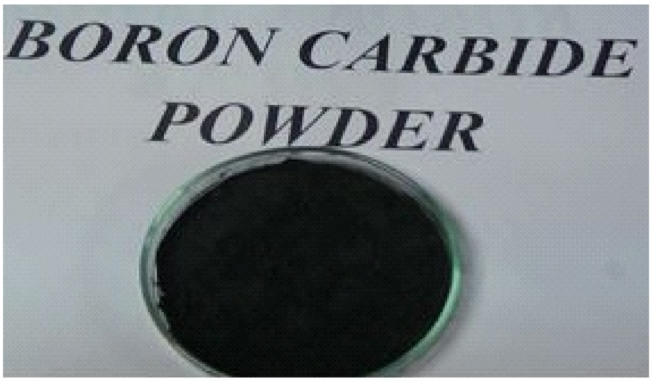


Schematic of molecular structure of CNT made at BARC.

3 Abrasive Grade Boron Carbide Powder

Boron carbide is the third hardest material after diamond and cubic boron nitride, and BARC's abrasive grade powder exploits this extreme hardness along with low density and high melting point. The powder, produced in multi-tonne quantities, is used as a high-performance abrasive for lapping and polishing gemstones, ceramics and metals, and for manufacturing sand-blasting nozzles and ceramic bearings.

Fully dense boron carbide shapes derived from the powder serve as lightweight armour plate and neutron-absorbing components in nuclear shielding. Because of its chemical stability and high elastic modulus, boron carbide is also incorporated into mortars, pestles, refractory linings and rocket propellants. The technology thus enables domestic supply of a strategic ceramic material used in defence, aerospace, nuclear power and precision finishing industries.



The boron coarbide synthesized at BARC

4 Titanium Diboride Powder and Dense Shapes

Titanium diboride (TiB_2) is a hard, refractory ceramic with a high melting point and excellent electrical and thermal conductivity. BARC synthesises high-purity TiB_2 powder by solid-state carbothermic reduction and converts it into near-theoretical-density shapes using hot pressing. The process uses inexpensive raw materials and yields >99 % pure powder and dense discs or pellets close to theoretical density.

Illistration of the TiB_2 powder and dense component made from it at BARC

Owing to its high hardness and chemical stability, TiB_2 is used in impact-resistant armour, cutting tool inserts, nozzles for molten metal handling, wear-resistant coatings and neutron-absorbing components. The availability of indigenous TiB_2 powder and densification technology supports defence, aerospace and metallurgical industries by reducing reliance on imported ultra-high-temperature ceramics and enabling new high-performance applications.

5 Zirconium Diboride Powder and High Density Shapes

Zirconium diboride (ZrB_2) is an ultra-high-temperature ceramic known for its high melting point, strong thermal and electrical conductivity, and chemical stability. BARC's process synthesises ZrB_2 powder (>99 % purity) through carbothermic reduction of zirconia with boron carbide and carbon, followed by milling and hot pressing to produce shapes approaching 99 % of theoretical density.

The material's properties—high temperature strength, low thermal expansion and resistance to extreme environments—make it attractive for thermal protection systems in hypersonic and re-entry vehicles, turbine shrouds, rocket motor components and electrodes. ZrB_2 also serves in wear-resistant coatings, molten metal crucibles and as a neutron absorber. Developing this technology domestically is strategically important for aerospace and defence sectors and supports industries requiring materials that can withstand very high temperatures.

6 Nano-Nickel Coating on Difficult-to-Plate Metals/Alloys

Metals containing aluminium, titanium, zirconium and niobium form passive oxide layers that hinder electroplating. BARC's nano-nickel coating technology removes the oxide layer in-situ using chemical/electrochemical conditioning and deposits a nano-structured nickel interlayer before conventional plating. The resulting nano-Ni layer exhibits microhardness in the range 700–900 HV and significantly improves corrosion, erosion and wear resistance.

This scalable process achieves uniform coverage on complex shapes and enhances adhesion of subsequent coatings. It finds applications in the automobile, aerospace and nuclear sectors and in metal finishing industries where protection of lightweight or reactive alloys is critical. By enabling reliable plating on otherwise difficult substrates, the technology contributes to longer component lifetimes and improved performance.

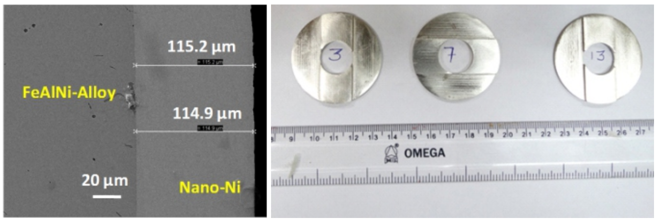
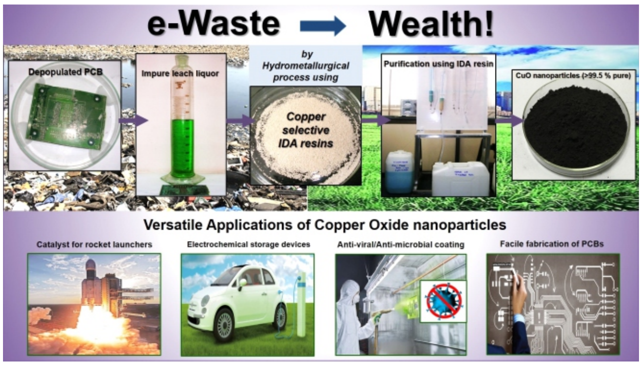


Illustration of the interface microstructure of Nano-Ni coating on a FeAlNi alloy and actual components coated with Nano-Ni using BARC technology.

7 Extracting High-Purity Copper Oxide Nanoparticles from E-Waste

BARC developed a hydrometallurgical process to extract copper from discarded printed circuit boards (PCBs) and convert it into high-purity copper oxide nanoparticles. The process leaches PCBs to produce copper-rich solutions, then uses novel copper-selective polymeric resins that remove tin and other impurities; after scrubbing and elution, the copper is precipitated and calcined to yield CuO nanoparticles. By-products such as tin oxide (SnO) and lead sulfide (PbS) are also recovered.

The technology produces >99.9 % pure CuO nanoparticles in a scalable, environmentally friendly manner and demonstrates a value-added pathway for recycling electronic waste. High-purity CuO nanoparticles find use in electronics, sensors, solar cells, catalysis, antimicrobial coatings and other nano-enabled applications, highlighting both industrial relevance and societal benefits of sustainable e-waste management.

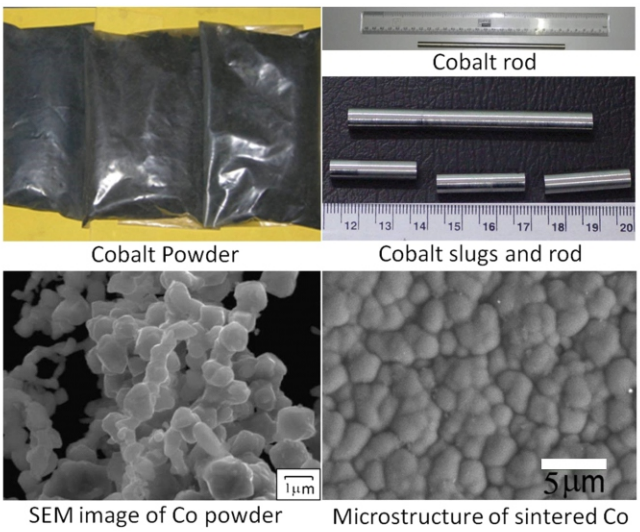


Infographic demonstrating the conversion of e-Waste into wealth through production of high purity CuO nano particles.

8 Making Cobalt Metal Powder and Shapes

Cobalt is a strategic metal used in permanent magnets, superalloys, radiation sources and batteries. BARC's technology prepares cobalt metal powder by thermal decomposition of cobalt oxalate and shapes the powder through compaction and sintering. The process uses simple equipment and minimal manpower, making it suitable for small-scale manufacturing.

Fine cobalt powders and rod-shaped products produced via this route serve as feedstock for Sm–Co and AlNiCo magnets, carbide tool materials, high-temperature cobalt-based superalloys and cobalt-60 radiation sources. Domestic production of cobalt metal shapes supports strategic sectors such as energy, aerospace and medical technology.



Production of Co powder and shapes from it.

9 Making Tungsten Metal Powder and Heavy Alloys

Tungsten possesses the highest melting point among metals, high density and exceptional mechanical strength. BARC produces tungsten powder via hydrogen reduction of tungsten oxide and fabricates tungsten metal and heavy alloys (W–Ni–Fe, W–Ni–Cu) using hot pressing and liquid-phase sintering. Tungsten heavy alloys have superior radiation-shielding capability and mechanical robustness, while W–Cu composites offer good thermal and electrical conductivity.

Applications include cemented carbide tools and high-speed steels, plasma-facing components for fusion reactors (e.g., ITER divertor plates), W–Cu electrical contacts, heavy-alloy penetrators, collimators and medical radiation shields. Access to domestic tungsten powder and heavy alloy fabrication supports aerospace, defence, energy and medical engineering industries and provides materials for emerging programmes like BHABHATRON cancer therapy units.

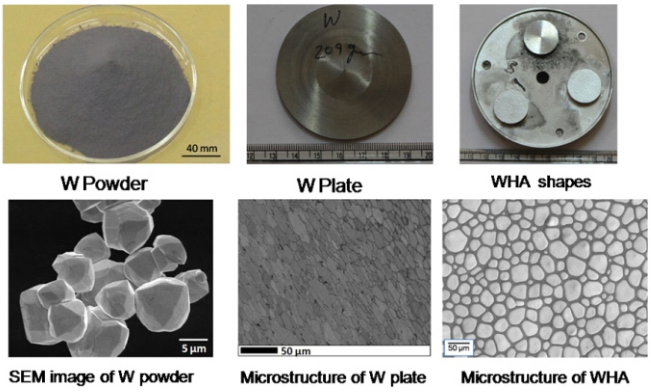
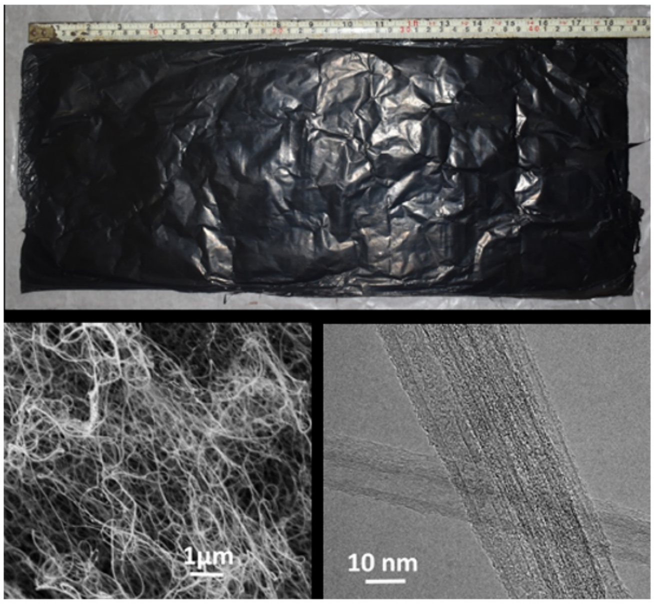


Illustration of tungsten powder and various shapes and their microstructures produced using BARC technology.

10 Making Freestanding Carbon Nanotube Sheet

Freestanding CNT sheets are produced via a floating catalyst chemical vapour deposition (FC-CVD) process where an aligned CNT aerogel is collected on a rotating drum and converted into a uniform sheet. The material consists of multi-walled CNTs with diameters of about 10–25 nm and purity >95 %. The sheets exhibit exceptional mechanical strength, low density and high electrical and thermal conductivity.

Because the sheets translate nanoscale properties into a macroscopic form, they find applications in high-strength composites, electromagnetic shielding, supercapacitors and battery electrodes, catalysts and drug delivery, energy storage and conversion devices, transparent conducting films, field emission displays and porous membranes. The scalable FC-CVD process therefore delivers a versatile nanomaterial platform for advanced energy, aerospace and biomedical technologies.



The freestanding CNT sheet produced using BARC technology and its microstructure.