REPORT SNAPSHOT

Indian Ceramics Market

Industry Snapshot, including Global and Indian Ceramics Industry Overview and Dynamics

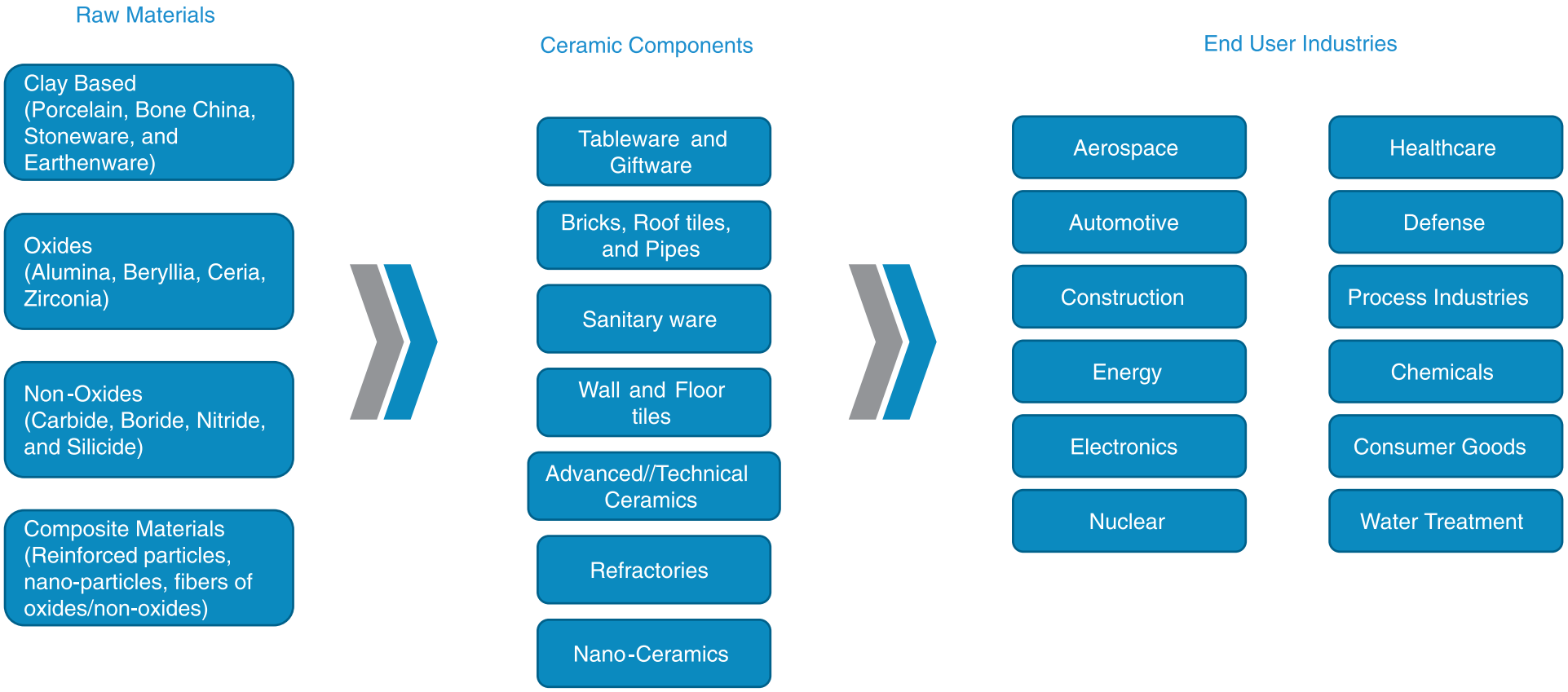
Mordor Intelligence

Indian Ceramics Asia 2019

27 February – 1 March, 2019

The Exhibition Centre, Gandhinagar, India

CERAMIC INDUSTRY SNAPSHOT


Raw Materials
Clay Based (Porcelain, Bone China, Stoneware, and Earthenware)
Oxides (Alumina, Beryllia, Ceria, Zirconia)
Non-Oxides (Carbide, Boride, Nitride, and Silicide)
Composite Materials (Reinforced particles, nano-particles, fibers of oxides/non-oxides)
Ceramic Components
Tableware and Giftware
Bricks, Roof tiles, and Pipes
Sanitary ware
Wall and Floor tiles
Advanced//Technical Ceramics
Refractories
Nano-Ceramics
End User Industries
Aerospace
Automotive
Construction
Energy
Electronics
Nuclear
Healthcare
Defense
Process Industries
Chemicals
Consumer Goods
Water Treatment

Aerospace

Uses: Sensors, Antennas, Capacitors, Resistors, Turbine, Batteries and Ceramic Matrix Composites

Process Industries

Uses: Offshore Drilling, Pressure Transducers, Vacuum Pumps, Level Controls, Flow Meters, Flow Sensors, Leakage Detection, Mass Spectrometer and Moisture Control

Construction

Uses: Interior and Exterior tiles, Fire Proof tiles, Acid Proof tiles, Sanitary ware, Non-Refractory bricks, Drainage, Sewer, Chimney pipes and Linings

Energy

Uses: Energy Storage, Power Transmission Lines, Radiation Detector Components, Turbine Blades, Fuel Cell Components, Compressed Air Storage, Thermal Hydro-Powered Systems, Cable Insulators, Vacuum Interrupters and Insulating Ceramics for Poly-Crystalline Silicon Growth

Electronics

Uses: High-Voltage Systems Power Distribution Systems, Power Transmission Lines, Sensors, Antennas, Capacitors, Resistors, Inductors, Circuit Protection Devices, Batteries and Switches

Health Care

Uses: Dental Implants And Restorations, Bone Fillers, Hip Replacement, Heart Valves, Blood Sampling, Distribution Valves and Cancer Treatments

Defense

Uses: Ceramic Armor, Vehicle Armor Tiles, Ultrasonic Welding, Shot Blasting, Ballistic Testing, Fingerprint Scanning, Resistors and Capacitors

Automotive

Uses: Valve Systems, Spark and Glow Plugs, Sealing, Brake Discs, Knock Sensor, Oxygen Sensor and Pressure Sensor

Nuclear

Uses: Handling Nuclear Wastes, Oxide Ceramics fuels, Electrical Insulators, Thermal Insulators, Refractories and Ceramic Coatings

Chemicals

Uses: Coatings, Mass Spectrometer, Particle Accelerators, Gas Detection, Electron Microscopes, Oxygen Probes and Moisture Control

Consumer Goods

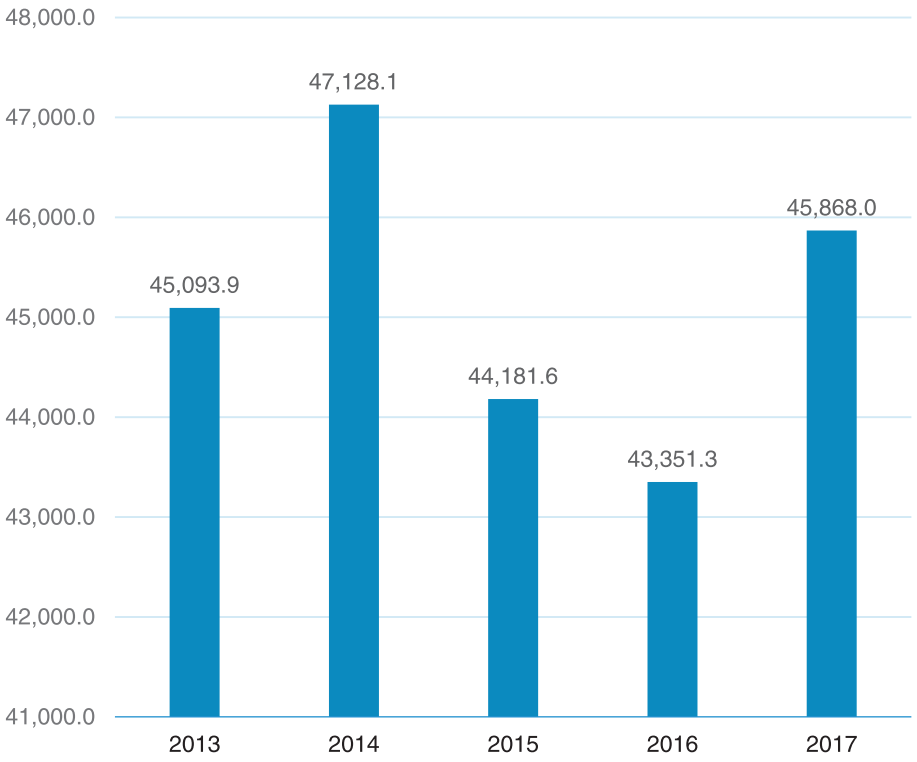
Uses: Ceramic Pots, Ceramic Knives, Plates, Glassware, Packaging, Toys, Gifts and Art Pieces

GLOBAL CERAMICS INDUSTRY OUTLOOK

- Ceramics is a diverse industry with several categories of products, including sanitary ware, refractories, cement, advanced ceramics, and ceramic tiles.
  - Ceramic products, like crockery, sanitary ware, tiles etc. find very wide use in bathrooms and kitchens in modern households to medical centers, laboratories, milk booths, schools, public conveniences, etc.
  - The ceramic industry has been modernizing continuously by newer innovations in product design, quality, etc.
- During the period from 2010 to 2017, ceramics industry trade grew at a CAGR of 2.96%, from USD 79 billion to USD 99.8 billion. During the period, exports increased from USD 39.4 billion to USD 53 billion (CAGR of 3.78%), while imports increased from USD 39.6 billion to USD 46.8 billion (CAGR of 2.11%).
  - The United States was the largest trader for global ceramics industry, with a total trade of USD 26.7 billion during 2017, followed by Germany, France, and United Kingdom with a total trade of USD 8.6 billion, USD 5.8 billion, and USD 5.4 billion, respectively.
  - The United States was the largest ceramic exporter during 2017, with exports of USD 20 billion. Germany, France and United Kingdom followed United States with annual exports of USD 5.4 billion, USD 3.7 billion and USD 3.6 billion, respectively. The top ten countries together accounted for close to 61.7% of total ceramics exports in 2017.
  - In addition, United States was also the world's largest ceramic importer, with imports worth USD 6.7 billion in 2017. The United States rely heavily on ceramic imports to meet its domestic ceramics consumption. The United States is followed by Germany, France and United Kingdom with annual imports of USD 3.2 billion, USD 2.1 billion and USD 1.7 billion, respectively.
- The global ceramic industry has undergone a period of significant change over the last few years. While the emerged markets of Europe and the United States continue to grow, primarily led by public sector investment.
  - However, the most significant developments are to be found in the emerging economies. These emerging economies have, in recent years become the most significant players in the ceramic market, in terms of consumption, growth and investment.

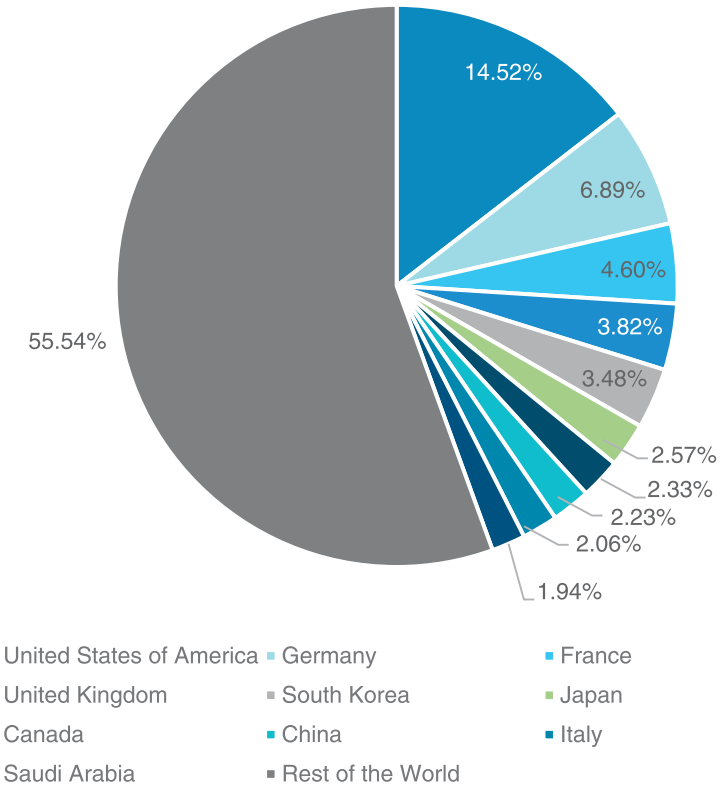
**re-import and re-export is not considered during the analysis

Ceramics Market : Imports Value in USD million,
Ceramics Products (HS CODE: 69), Global, 2013-2017



Source: UNCOMTRADE & Mordor Intelligence Analysis

Ceramics Market, Imports Share (%), by Country,
Ceramics Products (HS CODE: 69), Global, 2017



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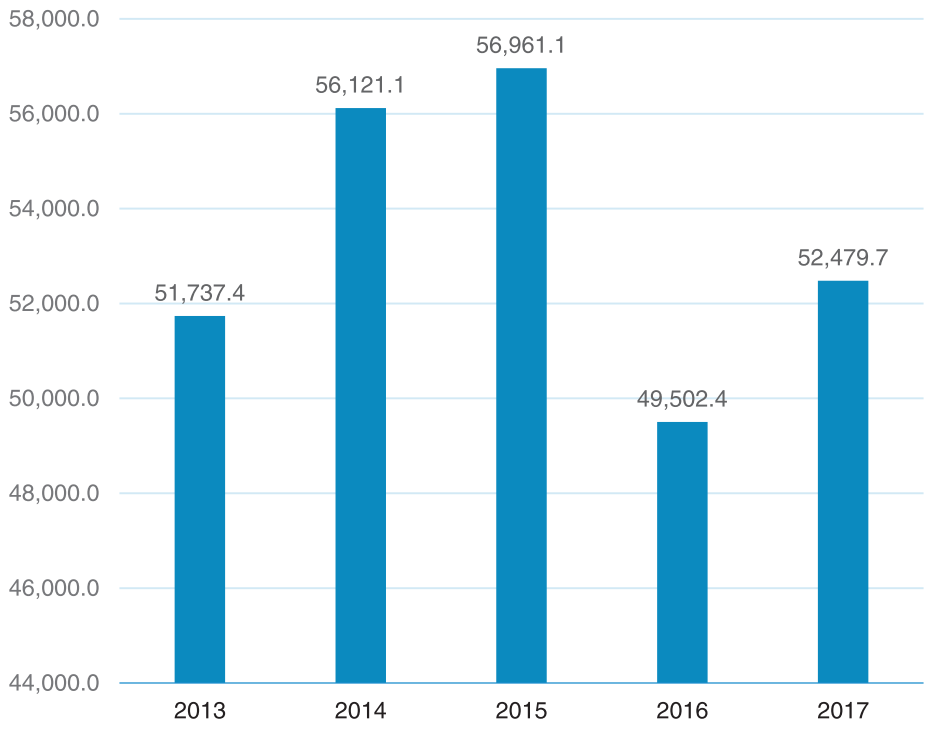
Ceramics Market: Exports Value in USD million,
Ceramics Products (HS CODE: 69), Global, 2013 -2017



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Ceramics Market: Exports Share (%), by Country,
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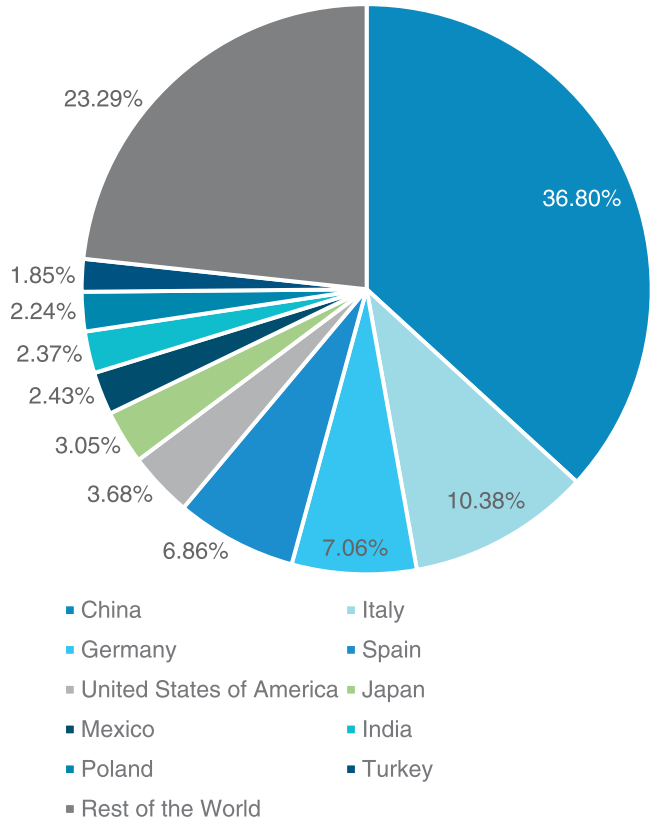
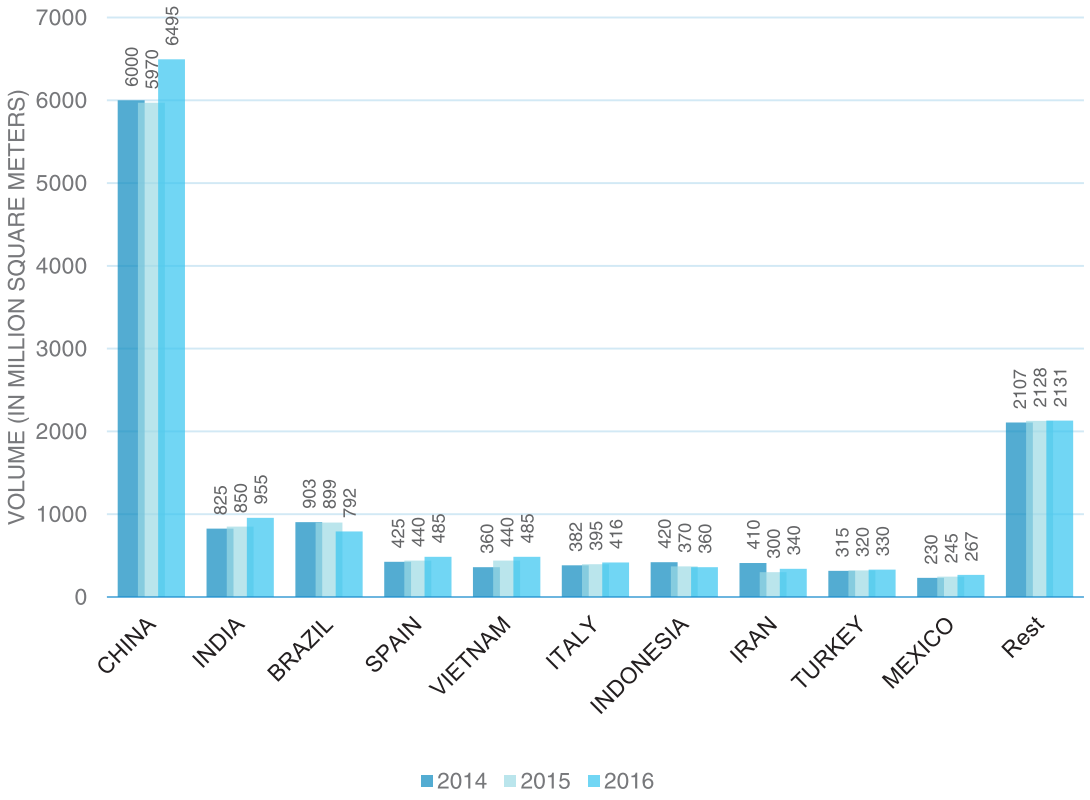
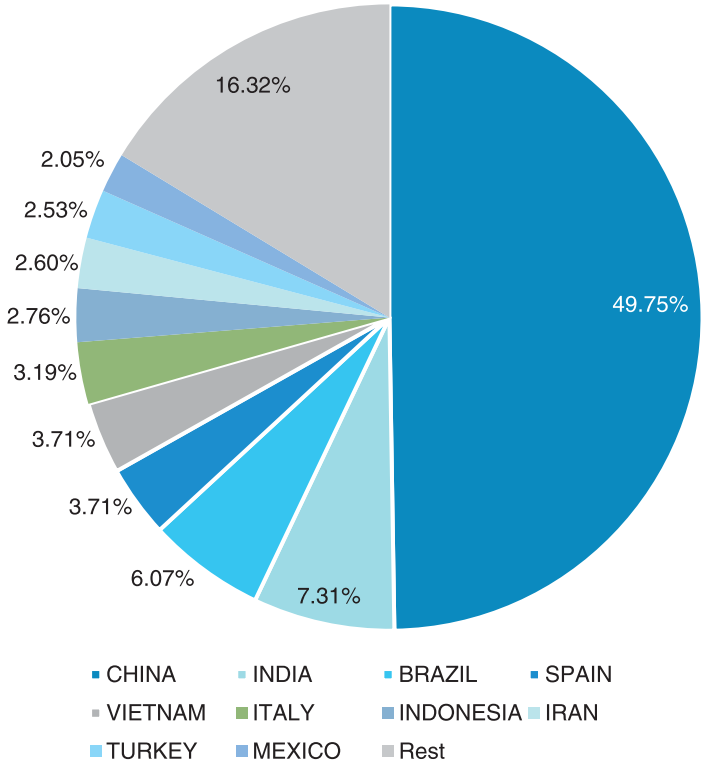


Ceramic Tiles Production by Country, Global



Source: Indian Council of Ceramic Tiles and Sanitary ware (ICCTAS)

Ceramic Production (%), by Country, Global, 2017

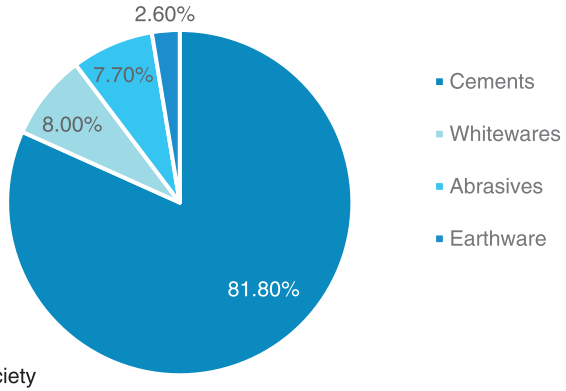


Source: Mordor Intelligence Analysis

GLOBAL CERAMICS MARKET INSIGHTS – BY PRODUCT

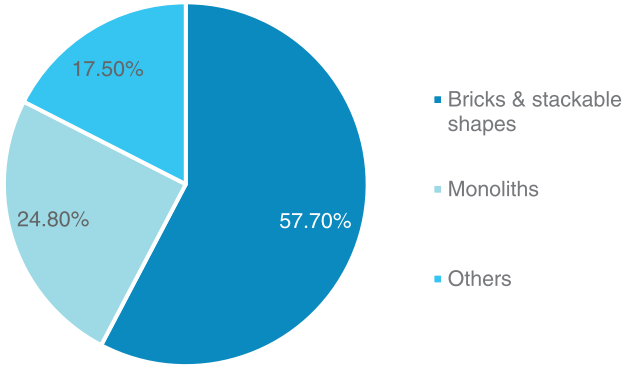
Product type	Main products	End-use
Refractories	Refractory bricks, tiles, blocks, linings, crucibles, spouts, ladles, and fibers	Industrial applications
Structural clay products	Tiles, bricks, drainage/sewer pipes, and chimney pipes/linings	Construction and furnishing/decoration
Whitewares	Fine tableware/cookware, china, sanitary ware, decorative articles, and porcelain coatings	Food/beverage, construction, and furnishing/decoration
Earthenware	Tableware, cookware, vases, pots, figurines, and decorative objects	Food/beverage and furnishing/decoration
Abrasives	Abrasive powders, grains, beads, and wheels	Industrial applications
Cements	Portland cement, mortars, and concrete bricks/blocks	Construction

Other Traditional Ceramics Market Share (%), by Type, 2017



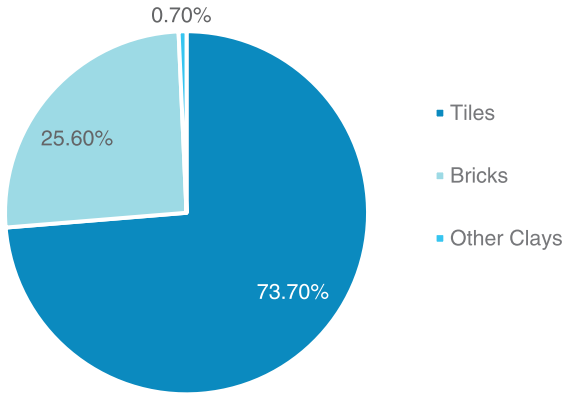
Source: American Ceramics Society

Refractory Market Share (%), by Type, Global, 2017



Source: American Ceramics Society

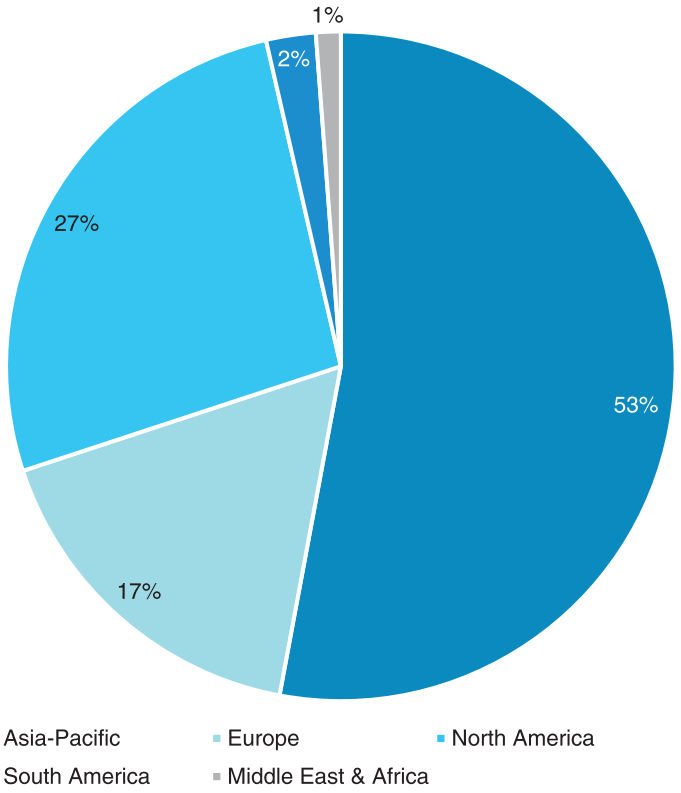
Structural Clay Products Market Share (%), by Type, 2017



Source: American Ceramics Society

- A major factor driving the global advanced ceramic market is its increasing consumption as an alternative to metals and plastics. Ceramics provide a better alternative to metals and plastics owing to their physical stability, heat resistance, chemical inertness, good electrical properties, and suitability to be used in mass products. These are even known for high chemical purity and careful processing.
- One of the major driver in the market is increased investment on the development of infrastructure.
- The global construction industry is growing rapidly with a major contribution from emerging countries. The revenue generation of the construction market is expected to reach approximately USD 15 trillion by 2025.
    - ➢ The emerging countries accounts for 52% of the total construction industry and are estimated to contribute approximately 62.5%, by 2025. The governments of these regions are investing significantly in residential homes, owing to the rapid urbanization.
- The increasing use of the product in the medical applications is one trend found prominent in the ceramic industry. High-tech ceramics have been a significant part of modern medical devices. Currently, they are used as acetabular cups and femoral heads for total hip replacement, restorations and dental implants, bone scaffolds and fillers for tissue engineering.

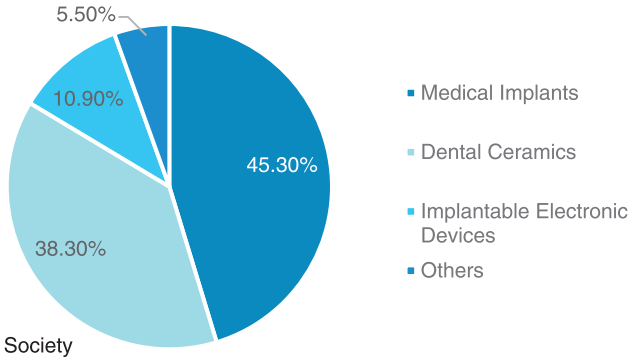
Advanced/Technical Ceramic Market : Revenue Share (%) by Demand, by Region, Global, 2017



Source: Mordor Intelligence Analysis

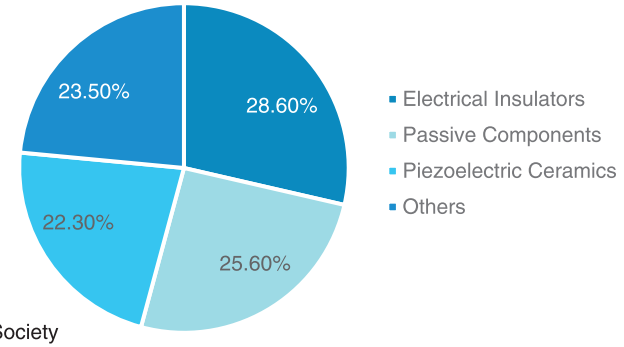
Product type	Main products	End-use
Medical ceramics	Medical implants, dental implants and prostheses, orthodontic products, biomedical coatings, part for implantable electronic devices, surgical instruments, drug delivery devices, tissue engineering scaffolds, pumps	Life sciences
Electro-ceramics	Capacitors, inductors, fixed and variable resistors, circuit protection devices, piezoelectric devices, antennas, substrates and films for circuit devices, ceramic packages, low- and high-temperature co-fired ceramics, sensing elements, permanent magnets, spark plugs, electrical insulators, ceramic arc tubes, hermetic insulating packaging	Electronics and electrical applications, defense and security, sensors and instrumentation, energy
Optoceramics	Transparent conductive coatings, substrates and films for photonic integrated circuits, optical filters, parts for solid-state lasers, components for solid-state lighting devices, optical coatings, optical switches, scintillators, non-linear optical components, components for military systems	Optical applications, optoelectronics, defense and security, sensors and instrumentation
Structural ceramics and ceramics for extreme environments	Cutting tools, bearings, pump seals, valves, nozzles, friction products, wear-resistant coatings, catalysts, catalyst carriers, filtration media, high- and ultra-high temperature components armors, parts for nuclear reactors	Mechanical applications, chemical, applications, environmental applications, defense and security, aerospace and space exploration, sensors and instrumentation
Ceramics for energy transfer, storage and conversion	Components for solar energy storage, thermoelectric generators, superconducting devices, batteries, and fuel cells	Energy
Other ceramics	Cosmetic products, antibacterial agents, food packaging, additives for lubricants, paint and ink additives	Consumer products, chemical applications

Medical Ceramics Market Share (%), by Type, Global, 2017



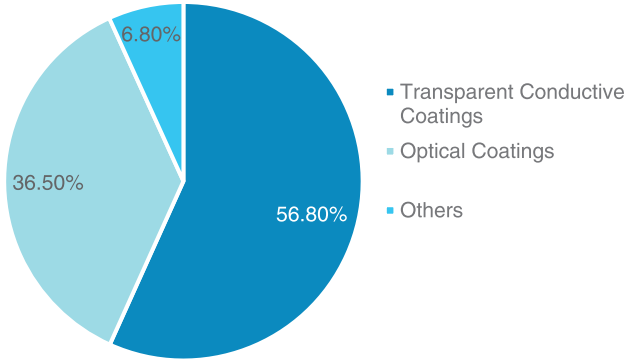
Source: American Ceramics Society

Electroceramics Market Share (%), by Type, Global, 2017



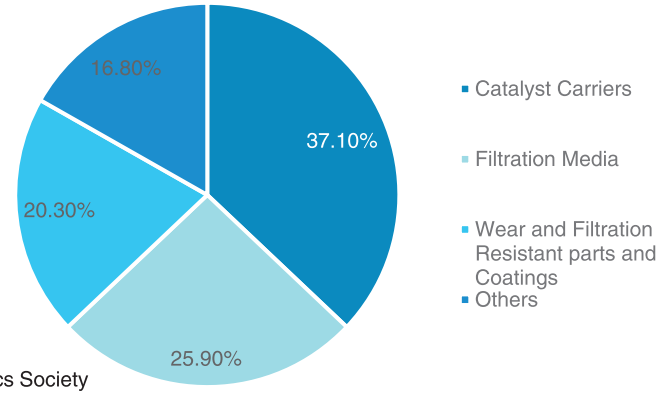
Source: American Ceramics Society

Optoceramics Market Share (%), by Type, Global, 2017



Source: American Ceramics Society

Structural Ceramics and Ceramics for Extreme Environments Ceramics Market Share (%), by Type, Global, 2017



Source: American Ceramics Society

GLOBAL HOTSPOTS – CERAMICS MARKET

1. CHINA

- China represents one of the biggest aerospace industries, across the world. The Chinese government is making huge investments in the aerospace sector, in order to increase its domestic manufacturing, and is planning to build new airports, which is expected to drive the MRO market over the forecast period. Currently, the country is running 2,185 general aviation aircraft, and is planning to have more than 5,000 aircraft and 500 airports, by 2020.
- China's semiconductor consumption growth continued to far exceed the worldwide semiconductor market growth for the seventh consecutive year, in 2017. China's semiconductor consumption market currently occupies about 62% of the global market.
- The Chinese government has planned for massive construction plans, including making provision for the movement of 250 million people to its new megacities in the coming ten years, despite the efforts to rebalance its economy to a more service-oriented base.
- One-third of the world's new wind power and solar PV facilities are installed in China. China also accounts to more than 40 % of the global investments in electric vehicles, in the current scenario.
- China's healthcare market is the world's second-largest market, with a medical device and pharmaceuticals market value of RMP 5,670 billion. The combined market has exhibited a 12 % y-o-y growth, in 2017.
- China has registered sales of 29.12 millions of automotive vehicles, in 2017, which amounts to over 30% of global sales. The Chinese automotive sales grew at a CAGR of 5.79%, over 2013-2017 and is expected to reach 38.57 million, by 2022.

Industry Indicators – China	
GDP Growth	6.20%
Foreign direct investment (USD million)	168,223
Population Growth	0.56%
Automotive Production (2017)	29,015,454
Renewable electricity output (% of total electricity produced)	29.93%
Military Expenditure (% of GDP)	1.91%

2. GERMANY

- The aviation industry of Germany is witnessing a phase of steady increase, in terms of aircraft manufacture, as well as air passenger travel. The air travel in Germany has been growing at a CAGR of 3.25% (2013-2017) and is expected to grow to a rate of 0.25 million passengers annually, in 2022, from 0.21 million passengers, in 2017.
- Germany is the fourth-largest manufacturer of electronics products in the world. German industrial electronics production accounts to 50% of total European output. Germany's electronics production has grown from USD 34.9 billion in 2014 to USD 36.9 billion in 2016, at an annual average growth rate of 3%.
- In 2017, the German building and construction sector experienced an increase at a y-o-y rate of 2.5 %. Germany's building firms expect to see their nominal sales growth at nearly 4% in near future, owing to some promising signs, such as the increased public investment in building and construction sector.
- Germany has rapidly expanded in the clean energy sector, which contributes over 29% of the country's electricity production, in 2017. The country is in plans to increase the share of clean energy to 35 %, by 2020. In addition, Germany is the largest solar PV installer, globally.
- Germany is the world's second fastest-growing market for electric vehicles, witnessing a y-o-y growth 20% in 2017, and the growth is expected to remain over 15% till 2023.
- Germany has registered sales of 3.8 millions of automotive vehicles in 2017, which accounts to over 3.95 % of global sales. The automotive sales in the country witnessed a CAGR of 3.19 %, over 2013-2017 and is expected to reach 4.45 million, by 2022.

Industry Indicators – Germany	
GDP Growth	1.90%
Foreign direct investment (USD million)	77,983
Population Growth	0.42%
Automotive Production (2017)	5,645,581
Renewable electricity output (% of total electricity produced)	29%
Military Expenditure (% of GDP)	1.22%

3. JAPAN

- Japan is a world leader in the production of video cameras, compact discs, computers, photocopiers, fax machines, cell phones, and other key computer components. Consumer electronics accounts for one third of Japan's economic output.
- The government approved growth strategy, better known as the “Rebirth Strategy for Japan”, is focused on strengthening the manufacturing sector (which has targeted the development of new industries by 2020) and would cost around USD 1.3 trillion. The primary focus has been on the medical sector and energy sector, among others. These growth trends are anticipated to boost the advanced ceramic market in Japan, over the forecast period.
- Regional manufacturing of Mitsubishi Regional Jet (MRJ) aircraft, which is a new 90-seat plane, is expected to be delivered by 2020. Mitsubishi Aircraft company has orders for about 233 MRJs, and aims to sell more than 1,000 of the planes over the coming two decades.
- The demand for city gas has increased in Japan, owing to the rise in demand of industrial users, specifically due to rising production of steel, chemicals, machinery, and on fuel switching for industrial furnaces and boilers.
- The collective sales of fuel oil has been decreasing at a CAGR of -1.35%, over 2014-2018, accounting to a volume of 171 billion liters, in 2018. The prominent reason for the decrease in sales is the diffusion of fuel-efficient cars and the evolution of electric vehicles.
- Japan is among the few countries in the Asia-Pacific, experiencing a decline in the sales of automotive vehicles at a CAGR of -0.51%, over 2013-2017.

Industry Indicators – Japan	
GDP Growth	2.50%
Foreign direct investment (USD million)	18,838
Population Growth	-0.16%
Automotive Production (2017)	9,693,746
Renewable electricity output (% of total electricity produced)	15.98%
Military Expenditure (% of GDP)	0.93%

4. UNITED STATES

- Owing to the rapid pace of innovation and wide range of R&D activities in the electronics industry, there is a huge demand for newer and faster electronic products in the United States. There is a spur in the number of manufacturing plants and development centers in the United States, focusing on high-end products to cater to the increasing consumer demand.
- The gradual growth of the commercial sector, primarily office space construction, is likely to have a positive impact on the construction sector in the country. The office space market in the country is estimated to grow by almost 10% in the next few years. Additionally, rise in home sales, coupled with the renovation of the existing houses, is boosting the demand for residential construction in the United States.
- According to the Federal Aviation Administration (FAA), the total commercial aircraft fleet is expected to reach 8,270 in 2037 from 7,039 in 2016, primarily owing to the growth in air cargo. Also, the US mainliner carrier fleet is expected to grow at a rate of 54 aircrafts per year, due to the growing need for replacing older fleet.
- Natural gas use in the country has increased more than any other fuel sources, in terms of quantity of energy consumed. This can be attributed to the rising demand from the industrial and electric power sectors, while the consumption of coal has been on a decline lately, and is expected to decrease throughout the forecast period..

Industry Indicators – United States	
GDP Growth	0.90%
Foreign direct investment (USD million)	354,282
Population Growth	0.71%
Automotive Production (2017)	11,189,985
Renewable electricity output (% of total electricity produced)	13.23%
Military Expenditure (% of GDP)	3.15%

4. UNITED STATES

- An significant increase in the demand for clean energy, like wind power, is expected to be witnessed in near future, owing to the stringent emissions regulations and growing environmental concerns.
- United States has registered sales of 25.78 millions of automotive vehicles in 2017, which accounts to over 26.64% of global sales. Despite the slight decline in sales lately, the automotive manufacturing and component manufacturing sector is expected to grow at slow rate in the coming years.

Industry Indicators	– United States
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Foreign direct investment (USD million)	354,282
Population Growth	0.71%
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FOCUS: INDIA CERAMICS INDUSTRY OUTLOOK

- India is one of the emerging economies of the world, which is currently witnessing strong economic growth. In 2017, the country's GDP reached INR 2.6 lakh crores. During 2018, the country is expected to record about 7.3% growth in its GDP, as against 6.6%, in 2017.
- The country's growth is fuelled by robust growth of construction sector, favorable government policies and initiatives, which has been promoting investments and economic activities in the country, and increasing output in the domestic manufacturing industry. Such market trends are also facilitating the growth of numerous other industries. Ceramic industry is one of those industries, which have been reaping the benefits from such trends in the country.
- Ceramic products in the country are produced, both in organized, as well as in unorganized sector. The share of organized sector in total production is around 55%, and is characterized by the existence of a few large players. Small and medium enterprises (SMEs) account for more than 50% of the total market in India.
- The industry produces around 2.5% of the total global output, presently. Gujarat accounts for around 70 % of the total ceramic production.
- During 2017, India was the 24th-largest ceramic trading nation in the world, and accounted for a share of around 0.9% in total ceramics trade. During the period, from 2010-2017, India's ceramics trade increased from USD 836.8 million to USD 1.8 billion, at a CAGR of 10.07%.
- The increase in trade was led by a huge rise in exports, which increased from USD 301.5 million in 2010 to USD 1.2 billion in 2017, at a CAGR of 18.9%. India's ceramic imports on the other hand increased at a CAGR of 0.7%, from USD 535.3 million to USD 565.6 million.
- Saudi Arabia, Mexico, and United States were the major destinations for India's Ceramics exports during 2017. India's top-five ceramics export destinations, together accounted for 39.3% of India's total ceramics exports.
- The Indian ceramic industry holds potential to become the largest producer in the world, as the industry is looking to almost double its turnover by 2021, driven by rising domestic consumption from the end-user industries, and exports to the Middle East, Europe, and other newer destinations.
- Indian ceramic industry growth is majorly driven by the increasing demand for ceramic tiles, sanitary wares, pipes, etc., for construction application. The construction sector is growing at a tremendous rate (approximately 7-8%), with urbanization projects and new construction activities in the country.

- The country holds investment requirement of about INR 50 trillion (i.e. USD 777.73 billion) for infrastructure development by 2022. The investment gap and market opportunities in the country has been creating significant attraction for the international investors in the infrastructure and commercial sector.
- According to the Department of Industrial Policy and Promotion (DIPP), total FDI received in construction development sector (i.e. townships, housing, built up infrastructure, and construction development projects) from April 2000 to June 2018 amounted to USD 24.87 billion.
- The 100% FDI in the construction sector has also supported the growth of construction industry, and the government initiative 'Housing for All by 2022' is also supporting the new residential construction in the country.
- Besides, the government has announced a target of USD 376.5 billion investment in infrastructure by 2020, including USD 120.5 billion for developing 27 industrial clusters, and USD 75.3 billion for road, railway and port connectivity projects.
- In June 2018, the Asian Infrastructure Investment Bank (AIIB) announced an investment of USD 200 million into the National Investment & Infrastructure Fund (NIIF).
- Hence, with all such investments into construction sector, the requirement for ceramic tiles, and sanitary wares, like sinks, washbasins, sewer pipes, toilet bowls, etc. is projected to increase. This is further likely to positively influence the demand for ceramic market.

- In addition, ceramic find varied applications in industries, such as automotive, aerospace, defense, energy, healthcare, process industries, etc. Such industries have also been witnessing strong growth on account of government policies, such as "Make In India", which is not only influencing domestic investors, but also the foreign investors to set up manufacturing units in the country.
- With "Make in India" initiative, the government plans to make India a manufacturing hub. The efforts have been attracting some major hi-tech manufacturing companies as such - General Electric (GE), Siemens, HTC, Toshiba, and Boeing, which have either set up or are in process of setting up manufacturing plants the country.

- In addition, attractive foreign policies, such as, the Asian Development Bank (ADB), is also helping India to grab the attention of foreign investors. ADB has approved USD 631 million loan to develop the Vishakhapatnam-Chennai industrial corridor to develop manufacturing and export industries along the East coast. With this, the demand for ceramic is likely to increase for industrial applications.
- In automotive industry, ceramic is used in the production of various automotive components, such as valve systems, sealings, brake discs, sensors, spark and glow plugs, etc. Indian automotive industry became the fourth largest in the world, with sales increasing 9.5% year-on-year to 4.02 million units (excluding two wheelers) in 2017. In addition, it stands to be the 7th largest manufacturer of commercial vehicles.
    - Since 2014, the automotive production has been increasing in the country, which has now increased to over 4.7 million units in 2017, which has simultaneously increased the consumption of ceramic in the past years.
    - This trend is further likely to continue in the automotive industry, owing to increasing domestic demand for luxury vehicles; growing adoption of online cab booking platforms, like Ola and Uber; and continuous innovation in the automotive industry, like introduction of electric and hybrid vehicles. With such trends, the automotive production is further likely to increase in the coming years.
    - Such market potential is further leading to new investments into the domestic automotive industry. For instance:
        - In 2018, Hyundai planned investment of USD 1 billion in India, by 2020.
        - SAIC Motor has also announced to invest USD 500 million in India, by 2020. The company has appealed the government of India to provide incentive driven policies for electric vehicles, as it plans to invest on developing electric vehicles in the country.
        - FAME scheme was launched by the government to boost electric vehicle manufacturing in India. The aim is to achieve production of around 7 million EV's by 2020. In this regards, Mahindra & Mahindra has planned to invest USD 600 million to benefit from the surging demand for electric vehicles in India.

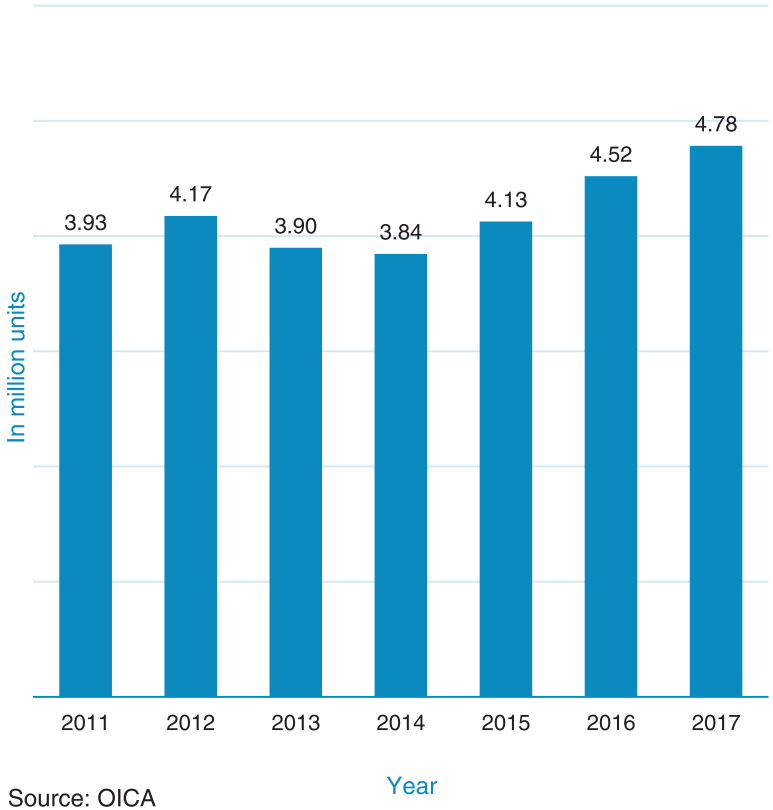
- Moreover, government favorable policies, such as 100% FDI in auto component sector is further increasing the investments into the auto components industry. With such efforts, the government plans to make the Indian auto-components industry, the third largest in the world, by 2025.

- With such market opportunities and increasing investments in the industry, the automotive and auto components production is projected to increase in the coming years, which is likely to simultaneously increase the demand for ceramic market in the country.

- Similarly, the country also plans to develop its energy sector. For instance, the government has planned an investment of INR 4,200 crore to increase the capacity of Green Energy Corridor Project, along with other wind and solar power projects. For such projects, the country is likely to witness increase in the production of products, such as turbine blades, fuel cell components, radiation detector components, compressed air storage, cable insulators, vacuum interrupters, etc. This, in turn, is projected to increase the demand for ceramics in the country.

- The electronics market in the country has been witnessing robust growth, and is expected to reach about USD 400 billion, by 2022. The growth of the market is likely to be driven by the growing market for disruptive technologies, like robotics, IoT, industrial and office automation, and analytics, which are being adopted across the industries. The IoT has been connecting billions of electronic items, like sensors, cameras, monitors, computers, phones, etc.

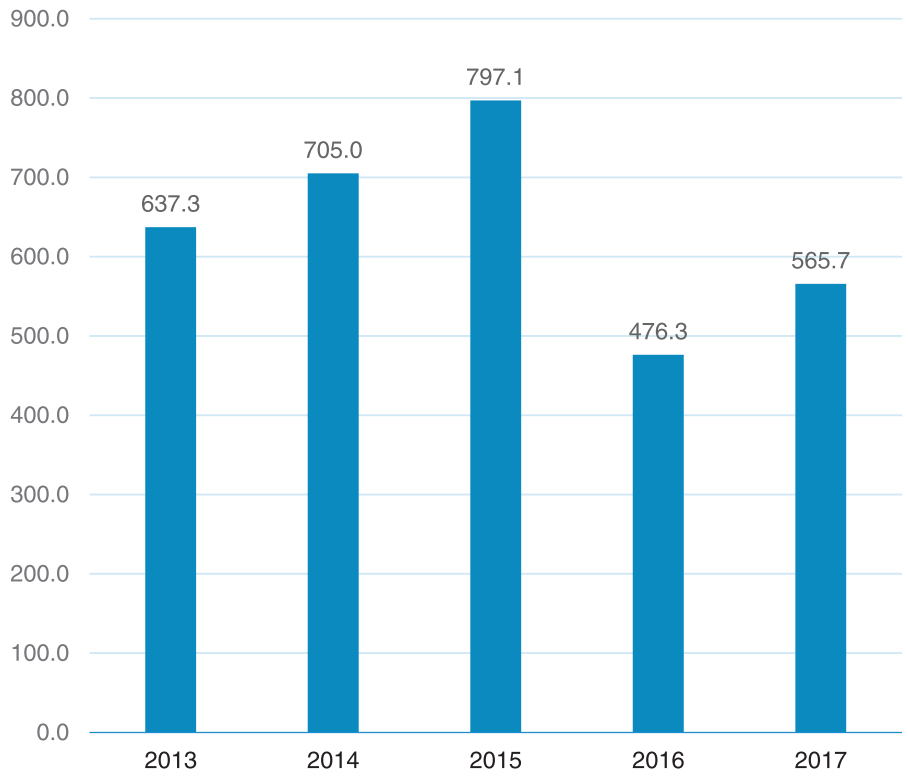
Automobile Production in million units, India, 2011-2017



Source: OICA

- Besides, the government has also been pushing the growth of electronic industry through various initiatives. For instance, the government launched a phased manufacturing program (PMP) to add more smartphone components under the Make in India initiative, in order to push the domestic manufacturing of mobile handsets. With such initiative, the country has been witnessing new investments to increase the production.
    - In July 2018, Samsung inaugurated the world's largest mobile phone factory, in Uttar Pradesh. The factory already planned to double the company's mobile phone production capacity to 120 million units, by 2020.
    - In September 2018, the government exempted 35 machine parts from basic custom duty, in order to boost mobile handset production in the country.
    - With such measures and investments in the electronic industry, along with growing production, the demand for ceramic for application in electronic products, such as capacitors, resistors, inductors, circuit protection devices, batteries and switches, is expected to increase in the coming years.
- However, one challenge in the market is high production cost as the industry is highly energy intensive. Petroleum and raw material products together form the most critical component in the production of the sector. The fluctuation in the cost of raw materials is affecting the supply of ceramic products in the market, which is posing a challenge to the ceramics market.
- Thus, the fluctuation in the price of vital energy resources, such as atomic and crude oil, is affecting the manufacture of these materials, which hinders the growth of the market.
- China was India's main source of ceramics imports during 2017 with imports worth USD 351.1 million followed by Germany and the United States, with imports worth USD 44.1 million and USD 24.3 million, respectively. India's top five import sources together accounted for close to 82% of India's total ceramics imports. China alone accounted for 62.1% of India's ceramic imports.
- Moreover, as per the government regulations, the industry also has to pay an excise duty if it exceeds the stipulated turnover. This rule discourages the industry rather than promote growth and development.
- Therefore, the aforementioned market trends in the end-user industries in the domestic market, is likely to provide attractive growth in the demand for ceramic during the forecast period.

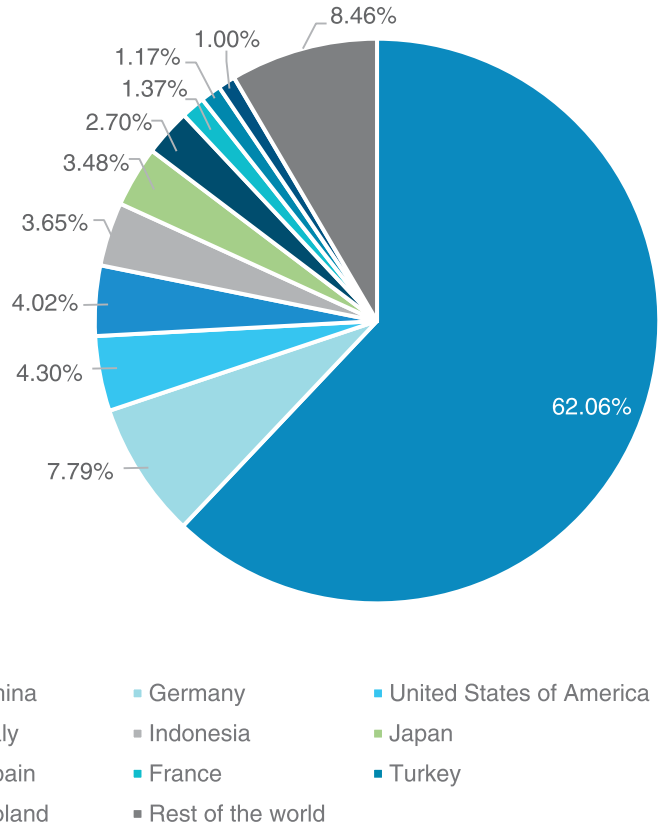
Ceramics Market: Imports Value in USD million,
Ceramics Products (HS CODE: 69), India, 2013-2017



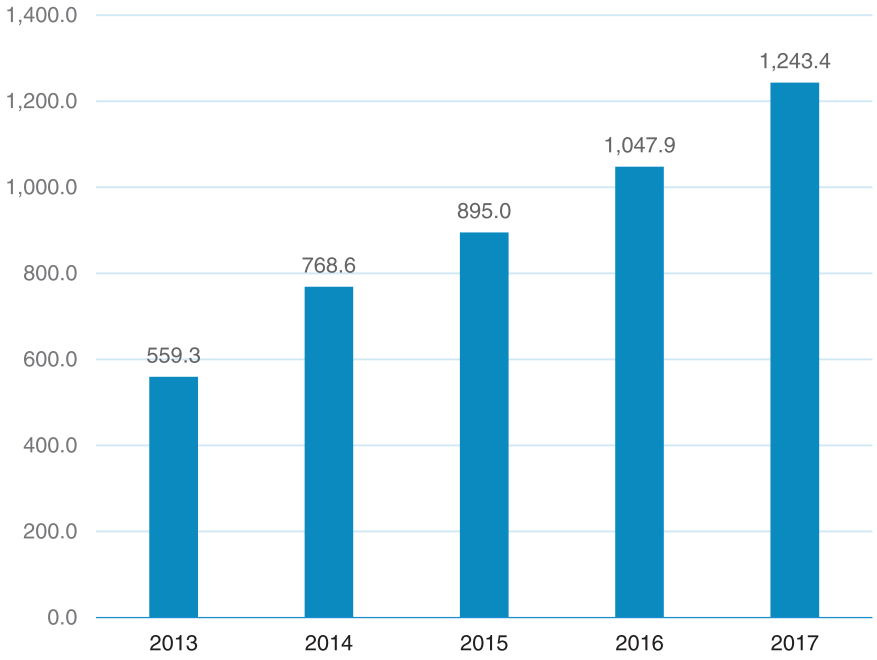
Source: UNCOMTRADE & Mordor Intelligence Analysis

**re-import and re -export is not considered during the analysis

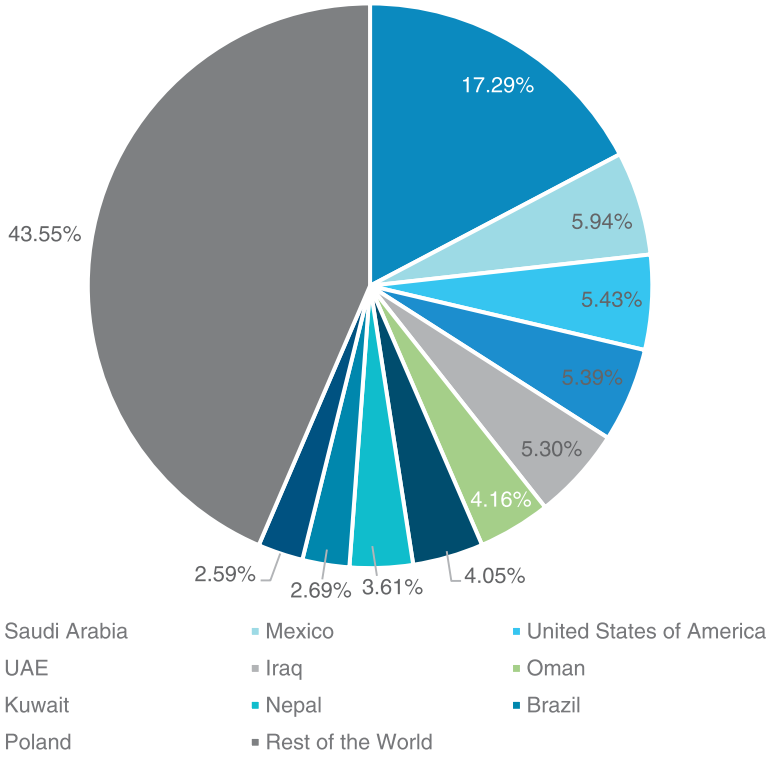
Ceramics Market: Imports Share (%), by Country,
Ceramics Products (HS CODE: 69), India, 2017



Ceramics Market: Exports Value in USD million, Ceramics Products (HS CODE: 69), India, 2013 -2017



Ceramics Market: Exports Share (%), by Country, Ceramics Products (HS CODE: 69), India, 2017



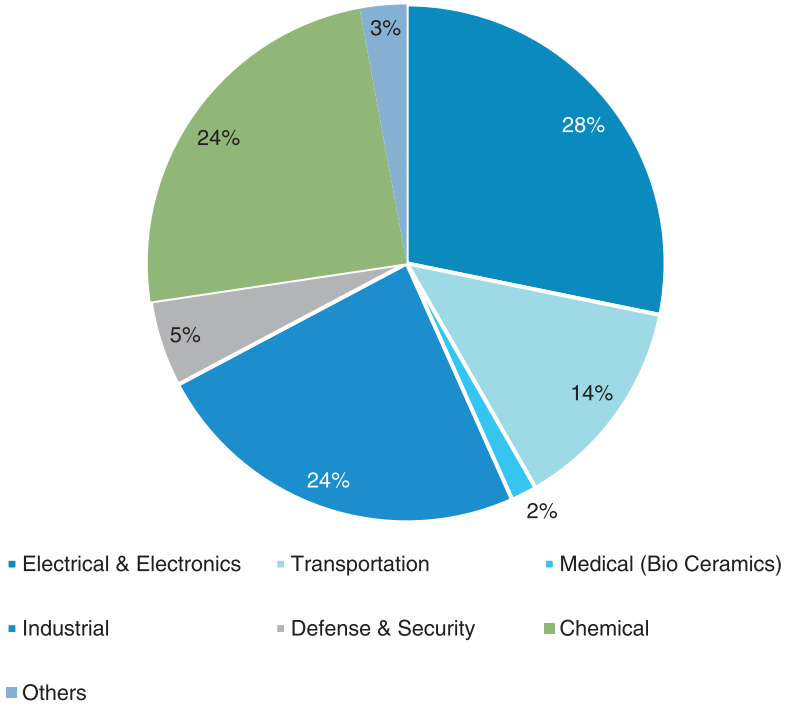
Source: UNCOMTRADE & Mordor Intelligence Analysis

**re-import and re -export is not considered during the analysis

INDIA MARKET INSIGHTS – ADVANCED/TECHNICAL CERAMICS AND REFRACTORIES

- The Indian advanced ceramics market is projected to witness a CAGR of 11.31%, during the forecast period. One of the major factors driving the growth of the market is the increasing demand for advanced ceramic materials in electrical and electronics applications.
- There is an increasing expenditure on R&D activities in the advanced ceramics segment in the country.
- India is witnessing a significant growth in novel drug delivery system, due to its efficiency and bio-availability. The pharmaceutical industry is continuously developing new innovative drug delivery systems and is known for quick adaptability of new technologies. This will lead to increase in demand for bio-ceramics for the drug delivery systems in the country, during the forecast period.
- India lacks the technology for large-scale commercial production of advanced ceramics although laboratory-scale technology is available in the country. The ARCI's(Advance Research Center for Powder Metallurgy and New Materials) new developments in the processes of making the nano ceramics, will help in bringing the technology from the laboratories to the industries in the country.
- The major end-user sector (electrical and electronics) is on the rise, as the country is now open to 100% foreign direct investment. This will increase the investment in this sector, and create a huge demand for the advance ceramics in the country.

Advanced/Technical Ceramic Market : Revenue Share (%) by Demand, by End Use, India, 2017



Source: Mordor Intelligence Analysis

- Ceramics has multiple applications in the electronic and electrical industry, both as circuit components (such as capacitors, inductors, and resistors) and as circuit devices (e.g., low temperature cofired ceramics or LTCCs). These circuit components and devices are further used in a number of the electrical and electronics applications, such as sensors and other electronic gadgets. Ceramic devices are also used as electrical insulators, like hermetic packaging, spark plugs, ceramic arc tubes, and protective parts (e.g., beads and tubing) for bare wires and power lines.

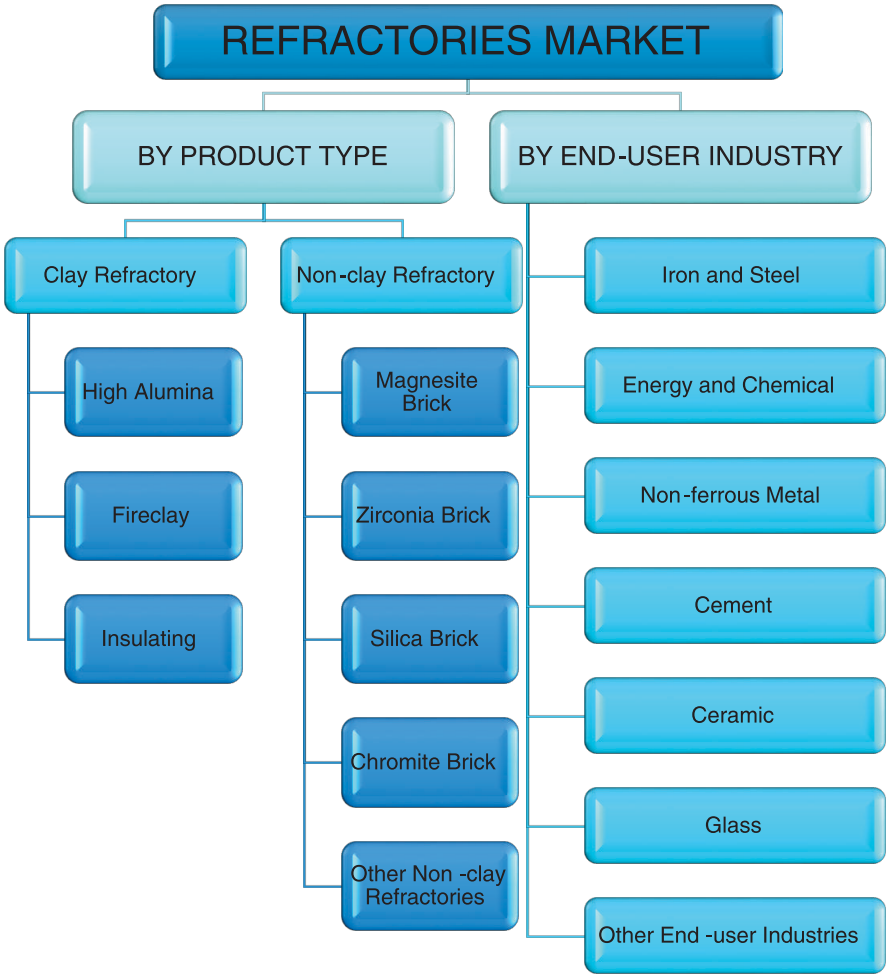
- Passive products are another broad category of application for ceramics. These products are used in manufacturing of general semiconductor for the electronics industry. Significant decline in the semiconductors market has affected the demand for ceramics, over the year. Additionally, price pressures continue to persist for passive components. In fact, the average unit selling price has dropped at an annual rate of approximately 3%, during the past years. However, the revival of the electronics market from 2016, has altered the negative dynamics of the industry, and the demand for semiconductors has also been at rise ever since.

- The increasing medical insurance penetration in the country is increasing the demand for medical implants. However, the Indian implants industry is highly dependent on the imports, with Europe and the United States, supplying high-end dental implants and China, Korea, and Israel, supplying low-cost ones.

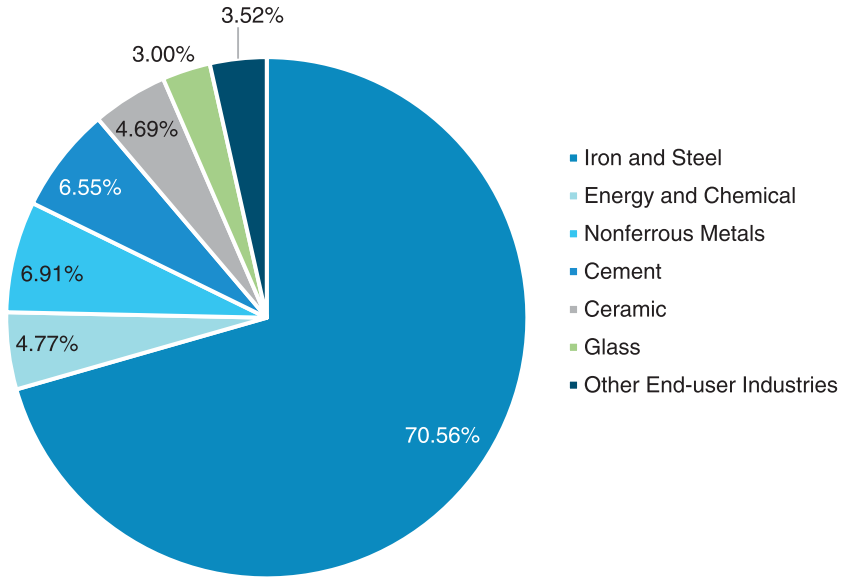
- The increasing encouragement by the government to the local manufacturers and increasing demand for low-cost implants, the manufacturing of dental implants in the country is expected to rise. This would, in turn, steer the demand for the advanced ceramics in the country.

- Even the medical devices market in India is highly dependent on the imports, with over 65% of the medical devices in India being the imported one. However, with new government encouragement, such as National Medical Devise Policy and increased import duties on the devices being imported, the demand for the local manufacturing is set to rise, which is expected to increase the demand for advanced ceramics in the country.

- Advanced ceramics, owing to their properties, such as high-strength, resistance to chemical, resistance to heat, high-stability, thermal resistance and insulation, flexural strength, etc., are used in the industrial segment. They are used in applications, such as wear parts, filters, industrial engine parts, cutting tools, few insulators, etc.
- The industrial sector is growing, owing to the “Make in India” initiative as number of manufacturing plants for different industries has increased, and is expected to increase further in coming years. This is expected to increase the demand for the cutting tools, and thus, the demand for the advanced ceramics. The industrial sector’s growth rate for the last fiscal year was 7.4% and during mid-2016, growth of 0.4% was observed in the Index of Industrial Production (IIP), owing to positive growth in electricity generation and moderated by declining mining and manufacturing sectors.
- Properties such as high-strength, stiffness, resistance to chemical, and heat, etc., make these ceramics ideal for application in the defense and security segment. In this segment, advanced ceramics are used in the electronic counter measures, vehicle armor tiles, military vehicles, body armor plates, X-ray tubes, RF capacitors, etc.
- India is one of the top ten countries in the world, in terms of military expenditure, and 60% the country’s defense-related requirements are met by imports. The government now plans to reduce its import by 35-40%. Thus, the government has been encouraging defense manufacturing in the country, by lifting FDI limits on the defense manufacturing.
- In the construction, advanced ceramics is used in floors, roof and wall tiles, pipes, brick, cement, windows, etc. The usage is on the rise, as newer applications are being found in the industry, resulting in the increased use of these ceramics over the forecast period.
- Moreover, advanced ceramics withstand high temperatures. Hence, they are used in the renewable energy sector, power plants, etc. The penetration of advanced ceramics in these segments have been increasing, and thus, is expected to drive the market for advance ceramics, during the forecast period.



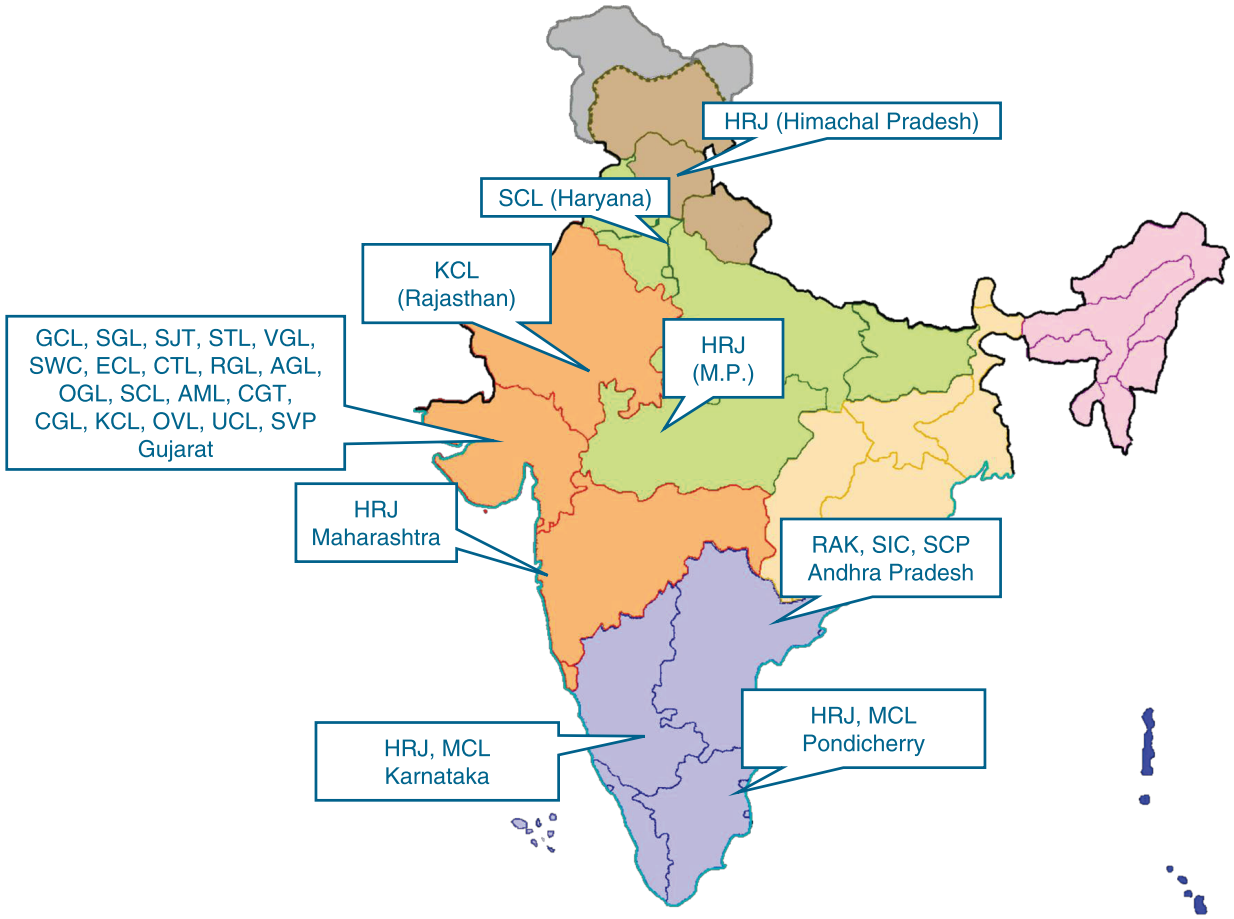
Refractories Market: Revenue Share (%) by Demand, by End -user Industry, India, 2017



Source: Mordor Intelligence Analysis

- India is the third-largest producer of iron and steel in the Asia-Pacific region. Iron and steel production in the country has been increasing at a rapid pace. The production of steel in the country is projected to be doubled by 2031, with an expected growth rate of over 10% in production for the fiscal year 2018.
- Recently, increasing government spending on smart cities and urban infrastructure is boosting the cement production in the country. The cement production capacity in India is expected to reach 550 MT by 2020 from a volume of 455 MT in 2017, according to the India Brand Equity Foundation (IBEF). This is expected to support the consumption of refractories in the coming years.
- The glass industry accounts for the least demand for refractories in the country. However, the demand for glass in the country is expected to increase in the infrastructure, real-estate, and automotive sectors, hence, giving a boost to the demand for refractories.
- India is the third-largest producer of ceramic tiles in the world, with a very high domestic market growth rate of nearly 15%. The increasing investments in the ceramics industry is expected to increase domestic production by a significant rate.
- Hence, the aforementioned factors are expected to boost the market for refractories in the country during the forecast period.
- On the flip side, the following factors may negatively impact the refractories market in India during the forecast period:
    - Higher raw material prices in the country
    - Weak bargaining power of refractory manufacturers
    - Low availability of skilled workforce
- Orient Refractories Ltd, IFGL Refractories, and Vesuvius are few major players in the Indian refractories market.

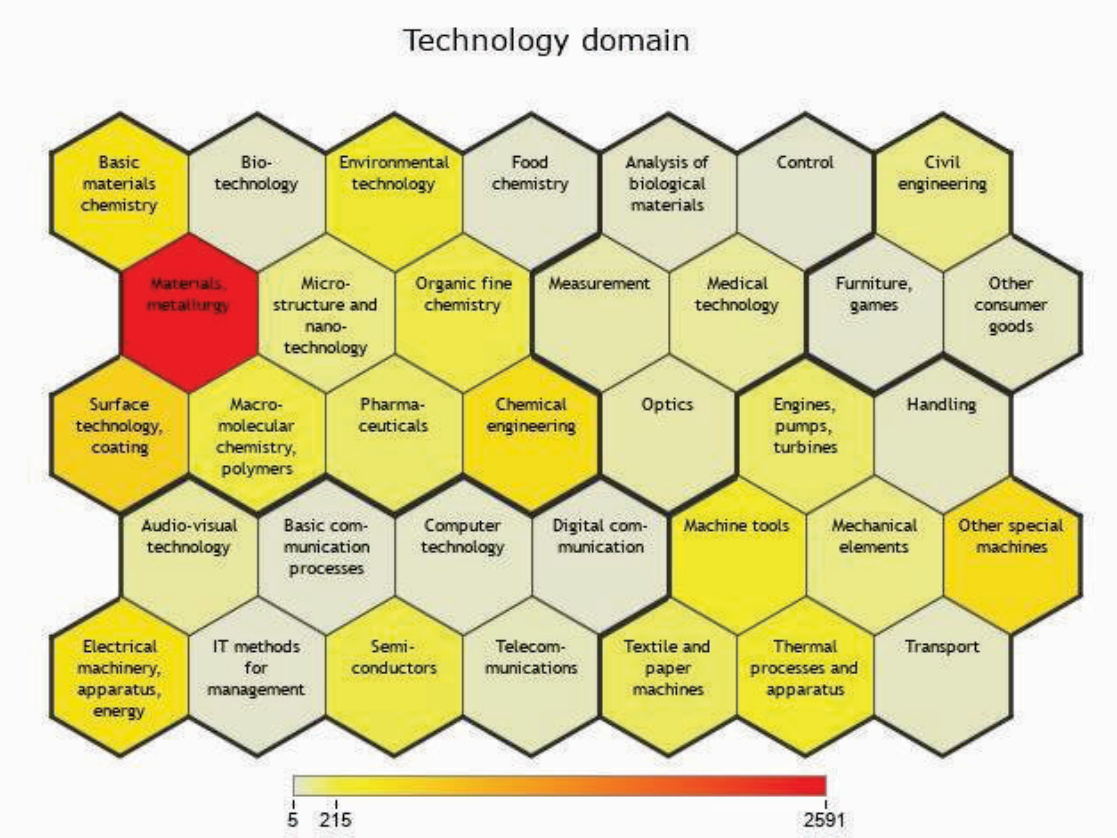
COMPETITIVE LANDSCAPE – INDIA



Source: Indian Council of Ceramic Tiles and Sanitary ware (ICCTAS)

- AML for Antique Marbonite Pvt Ltd, Morbi, Gujarat
- AGL for Asian Granito (India) Ltd, Sabarkantha, Gujarat
- CGT for Coral Gold Tiles Pvt Ltd, Morbi, Gujarat
- CGL for Coral Granito Pvt Ltd, Morbi, Gujarat
- CTL Cengres Tiles Ltd, Dist. Mehsana, Gujarat
- ECL for Euro Ceramics Ltd, Kutch, Gujarat
- GCL for Gokul Ceramics Pvt Ltd, Rajkot, Gujarat
- HRJ for H & R Johnson(India) A Division of Prism Cement Ltd, Dewas-MP, Kunigal-Karnataka, Pen-Maharashtra, Karaikal-Pondicherry, Baddi-HP
- KCL for Kajaria Ceramics Ltd, Sikandrabad-UP, Gailpur-Rajasthan, Mobi-Gujarat
- MCL for Murudeshwar Ceramics Ltd, Karaikal-Pondicherry, Hubli, Bangalore, Karnataka,
- OGL for Oracle Granito Ltd, Sabarkantha, Gujarat
- OCL for Orient Ceramics & Industries Ltd, Sikandrabad, UP
- OVL for Jaxx Vitrified Pvt Ltd (Formerly Ozzy Vitrified Pvt Ltd), Morbi, Gujarat
- RAK for R.A.K Ceramics India Pvt Ltd, Samalkot, AP
- RGL for Regent Granito (India) Ltd, Himatnagar, Gujarat
- SGL for Senso Granito Pvt Ltd, Rajkot, Gujarat
- SCP for Sentini Cermica Pvt Ltd, Krishna, AP
- SIC for Silica Ceramics (P) Ltd, West Godavari, AP
- SCL for Somany Ceramics Ltd, Bahadurgarh-Haryana, Kadi-Gujarat
- SVP for Simpolo Vitrified Pvt Ltd, Morbi, Gujarat
- SJT for Spectrum Johnson Tiles Pvt Ltd, Rajkot, Gujarat
- STL for Sunshine Tile Co. Pvt Ltd, Rajkot, Gujarat
- SWC Swastik Ceracon Ltd, Dist. Mehsana, Gujarat
- UCL for Umiya Ceramic Pvt Ltd, Morbi, Gujarat
- VGL for Varmora Granito (P) Ltd, Rajkot Gujarat

Ranking based on patent filings in the India



Source: Mordor Analysis and Questel Orbit

With emphasis on patent filing in the space of ceramics India, the proposed applications range between an array of applications as shown in the adjacent graph. Below are some recent filings:

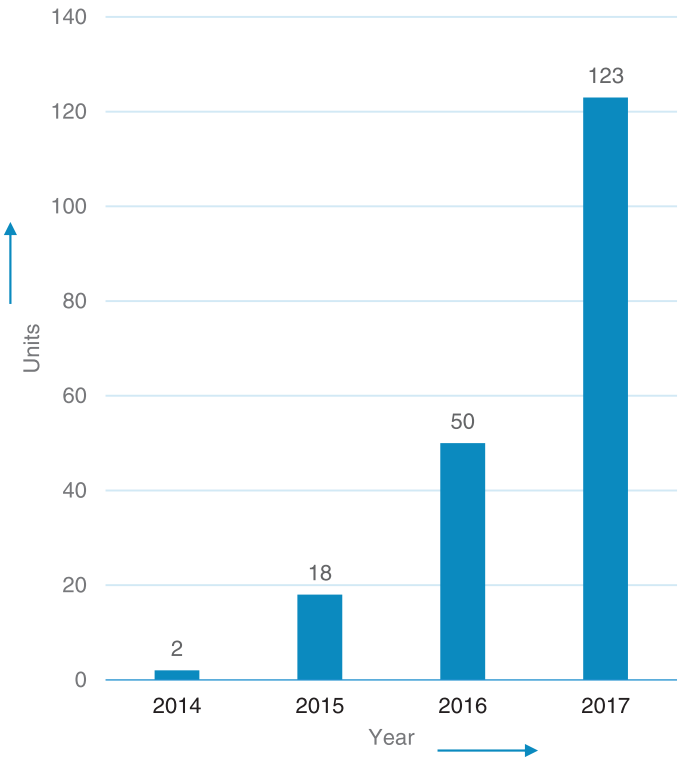
- French Institute of Petroleum - Process for preparing solids from a mixture of at least two malachite powders
- Johnson Electric - Motor, circuit board, and engine cooling module including the motor
- Indian Institute of Technology - Method of manufacturing of ceramics by utilizing waste materials
- NGK Spark Plug - Gas sensor, electrically conductive oxide sintered body, and wiring board
- Indian Space Research Organization - A process for preparation of silicon carbide coated carbon nanomaterials using polyborosiloxanes
- Shilpa Medicare - Pharmaceutical compositions of lignocaine hc1
- SASOL - High strength shaped aluminas and a method of producing such high strength shaped aluminas
- Toyota Motor – Micro Coil
- 3M - Elongate shaped abrasive particles, methods of making the same, and abrasive article including the same

MARKET ATTRACTIVENESS – INDIA

- According to the ceramic industry, the tile, sanitary ware, and bathroom fittings market in India is valued around USD 6 million, in 2017. With sustained public and private measures in recent years, the level of sanitation in India has increased considerably. These measures have created a huge market for products used in the construction of public sanitation facilities, as well as domestic bathrooms.
- Due to an increase in the popularity of concept washrooms, some manufacturers are using a one-stop shop solution for the sanitary ware and fittings requirements. In addition, as in-store experiences have acquired tremendous importance, manufacturers are establishing experience centers, where customers can see a virtual version of the bathroom, after it undergoes a complete renovation. The rising number of these experience centers is enticing consumers to invest in premium products for bathrooms, therefore, strengthening the growth of the Indian tile, sanitary ware, and the bathroom fittings market.
- The introduction of nanotechnology has revolutionized the market, as it helps in enhancing the shelf life of tile and making them resistant toward dirt and bacteria. Currently, these tile are gaining traction in areas, such as clinics, hospitals, laboratories, and food processing plants, where hygiene plays an important role.
- Bio toilets are increasingly being adopted by governments of India, to improve sanitation facilities in rural areas. Homeowners are also expected to adopt bio toilets in the future, to reduce toilet maintenance costs. The adoption of bio toilets will, therefore, represent a key trend driving market growth, during the forecast period.
- LIXIL Asia-Pacific inaugurated its first ceramic ware facility in India. The plant was established in 45-acre land, with state-of-the-art facility at Andhra Pradesh, and will serve as a central production base for the Indian market. The LIXIL India invested INR 40 billion for the plant. The plant will produce select ranges of GROHE and ceramic ware.
- The plant with state-of-the-art facility with the current production capacity of over 1 million units per annum, scalable to 2mn pieces annually. The plant will manufacture select range of ceramic ware products for LIXIL's major power brands in the Indian market, including GROHE, American Standard. While 80% of the production will cater to the Indian market, LIXIL plans to export 20% to its global markets.

- The smartphone revolution, which began just over a decade ago, could only happen because of advanced ceramics and glasses. Demand for new functionality in smartphones drives constant materials innovation for better, faster, and smaller devices. In 2017, smartphone suppliers shipped some 1.5 billion devices to end users worldwide, accounting for USD 479 billion in global sales.
- According to 2018 ACerS (The American Ceramic Society) Bulletin, there are a surprising number of ceramic components within an average mobile device, which includes capacitors, filters, antennas, and substrates for image sensors. With the sale of nearly two billion units mobile phones annually, the number of ceramic components in phones is at least an order of magnitude higher. At present, almost 15% of a mobile phone is made from ceramics and glass, in order to support electronic applications with circuit boards for thermal management to the cores of passive components, like inductors, fuses or resistors, housings, and bodies.
- According to 2018 ACerS, the market for ceramic substrates, driven largely by the electronics industry (especially smartphone industry), is forecast to reach a value of USD 11.6 billion, by 2026, registering a CAGR of 7.2 during 2017–2026.
    - Furthermore, rising adoption of ceramic substrates as an alternative to alloys and metals, miniaturization of electronic devices, rising demand for compact microelectronics packaging solutions, such as high-temperature cofired ceramics (HTCC) and low-temperature cofired ceramics (LTCC), and advancements in ceramic substrates are some of the factors boosting the market growth.

Mobile Manufacturing Factories in units, India, 2014-2017



Source: Statista, 2018

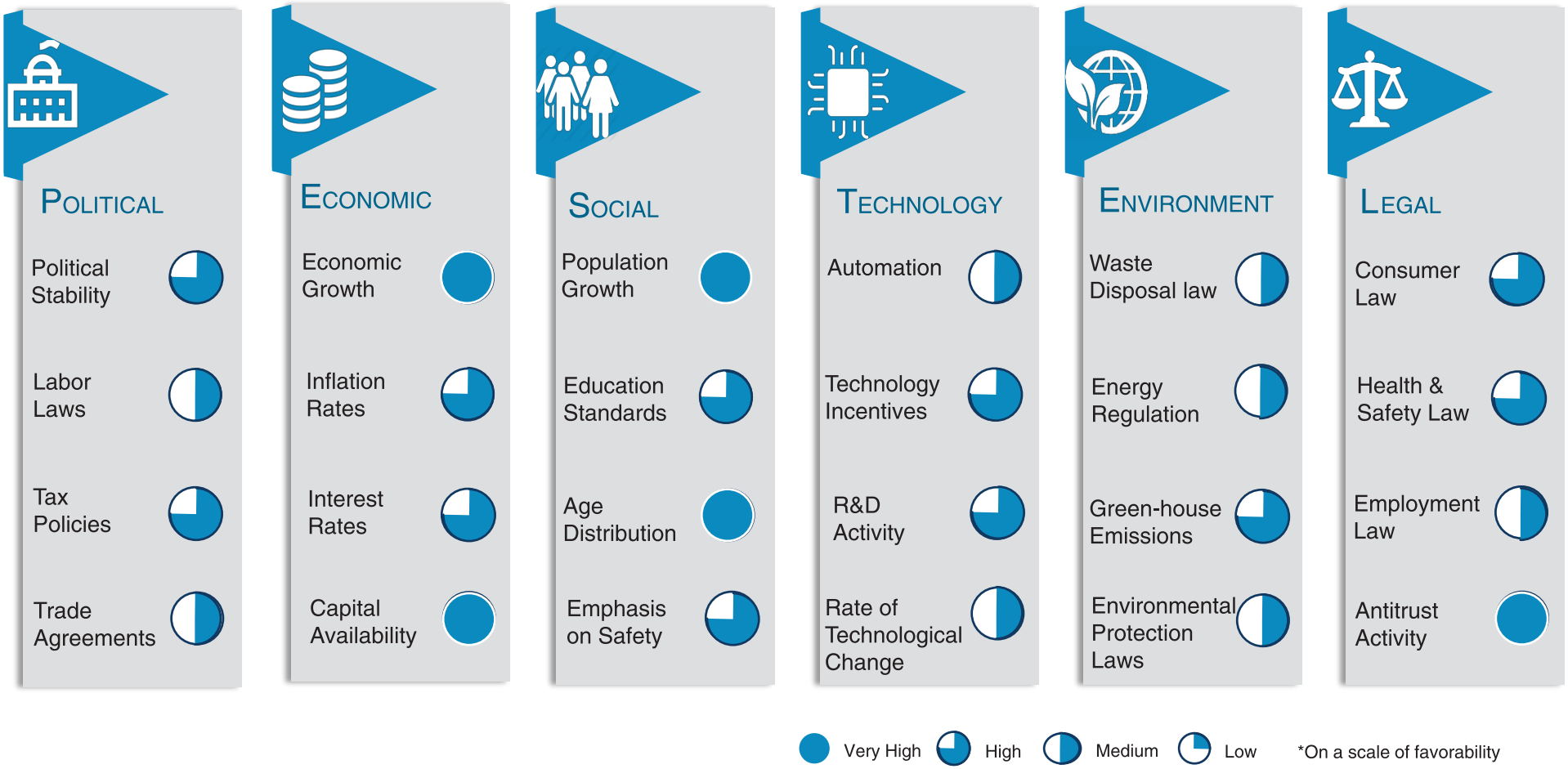
- With global smartphone manufacturing giants, expanding rapidly in India, the smartphone manufacturing is gaining more significance. In 2018, Indian Cellular and Electronics Association reported opening of more than 140 smartphone manufacturing units over last four years (2013-2017). The Indian Cellular and Electronics Association termed this achievement as a result of the “Make in India” policy and stiff duties on imported mobile devices and smartphone parts
- Noida is quickly becoming the hotspot for manufacturing smartphones in India and is now known as the hub where companies are manufacturing anything from smartphones to chargers and headphones.
- In 2018, Samsung announced that it will be investing INR 491.5 billion (USD 786.4 million) in constructing the world’s biggest mobile phone manufacturing plant.
- With this new facility, Samsung will double its current capacity for mobile phones in Noida from 68 million units a year to 120 million units a year, in a phase-wise expansion that will be completed, by 2020. Samsung is also planning to use the Noida plant as a global export hub, which again will put India’s manufacturing prowess on the world’s map.
- Oppo is also building a big smartphone manufacturing plant in Noida, which is expected to be opened in 2019.

Overview of Support Schemes for Rooftop Solar PV in Selective Countries

Schemes						
Direct Capital Subsidy		✓	✓	✓	✓	✓
Green Electricity Schemes	✓	✓		✓	✓	✓
PV Specific Green Electricity Scheme						✓
Renewable Portfolio Standard (RPS)	✓	✓	✓		✓	✓
Solar Set Aside RPS Target			✓			✓
Financing Scheme	✓	✓	✓		✓	✓
Tax Credits	✓	✓	✓	✓	✓	✓
Net Metering/Net -billing Incentives	✓	✓	✓	✓	✓	✓
Sustainable Building Requirements					✓	✓

- The production volume and revenue of the ceramics industry in Gujarat, accounts to 2,000 million sq mtr and INR 2,900 billion, respectively, which is a lion share of total national production volume and revenue (2,200 million sq mtr and INR 3,200 billion). Even, the number of factories in Gujarat is 740 out of 800 located in India. New investments under pipeline in Gujarat, 2018 is estimated around INR 700 billion (INR 825 billion started commercial production). In Gujarat, Morbi is the key manufacturing hub for the ceramic industry and the companies, which involve in ceramics production formed Morbi Ceramic Association and plays a key role in shaping the market scenario for ceramic products in the country.
- In a submission to the Parliamentary Standing Committee on Commerce, it is reported that Morbi is among the 36 Towns of Export Excellence (TEE), as ceramic exports from the city is over INR 50 billion.
    - In order to leverage this huge market value more, Morbi Ceramic Association demands that export incentives are expected to be raised from 2.75% to 5% as China provides 9% export subsidy. This scenario of export subsidy puts the industry in India at a advantage.
    - It also suggested that efforts are expected to be made to improve infrastructure at all the industrial clusters of the country to improve overall business efficiency.
- Ceramic companies realized that certain aspects are increasing the cost of production of ceramic products raising the burden on the end user industries. Moreover, considering the fact that most ceramic products are used by the masses, the Goods and Services Tax (GST) should be reduced from 18% to 12%.
    - The association stated that the government should enable transport of goods through the sea route to reduce transport cost, save fuel, as well as reduce traffic on the highways.
    - The association demanded that the price of natural gas, used as a fuel in the sector, should be controlled as it constitutes 30% of the total input cost of the manufacturers.
    - Lower input cost will improve the competitiveness of local players in domestic, as well as export markets.
    - The association also suggested that India should stop exporting natural resources, instead do value addition within the country to get multiple returns, create more jobs and generate more revenue for ceramics industry.

- The growth in the ceramics market in India is expected to be driven by the rise in the consumption of ceramic tiles and sanitary ware which is likely to lead to volume growth and the increase in production costs which are expected to be passed on to the consumers.
- The ceramic industry in Morbi, Gujarat is likely to witness huge amount of investment of around INR 1,500 crore which involve 50 new wall tiles manufacturing plants by the first quarter of 2019. Therefore, higher production of ceramic tiles is expected in the coming year.
- Once the effect of Real Estate Regulatory Authority (RERA) is smoothened, the launch of new projects is likely to gain momentum and the ceramics industry is expected to benefit from the demand in the building and construction sector. The demand for ceramic products is anticipated to be created with a lag effect as the installation of ceramics comes at the end of the construction project completion.
- Ceramic tiles and sanitary ware industry has witnessed continuous growth in recent years, which follows the real estate and housing industry. In the coming years, the development projects on affordable housing is ready to tap the unmet demand of around 6-8 billion square feet in the country.
- The premium range of ceramic products is a market segment of the ceramic industry in India with few competitors. The organized players is seeking to expand into the premium products segment by the introduction of new designer tiles and sanitary ware. They are targeting to capture the international market and to tap the demand from the projects in the Tier II and metro cities.


POLITICAL
Political Stability
Labor Laws
Tax Policies
Trade Agreements
ECONOMIC
Economic Growth
Inflation Rates
Interest Rates
Capital Availability
SOCIAL
Population Growth
Education Standards
Age Distribution
Emphasis on Safety
TECHNOLOGY
Automation
Technology Incentives
R&D Activity
Rate of Technological Change
ENVIRONMENT
Waste Disposal law
Energy Regulation
Green-house Emissions
Environmental Protection Laws
LEGAL
Consumer Law
Health & Safety Law
Employment Law
Antitrust Activity
Very High
High
Medium
Low
*On a scale of favorability

RECENT PROJECTS

- In the traditional ceramic manufacturing process, there are a lot of sub-processes, like milling, batching, mixing, and drying. Drying is the process of removing the water or binder from the formed material. And in small-scale ceramic industries, ceiling fans are used for this purpose. But, India is staring at a huge energy crisis. So, the ceramic industry in India is looking to incorporate energy-efficiency measures.
- The Ambuja Ceramic, a popular ceramic factory (which especially manufacturers sanitary ware) in the ceramic hub of Thangadh, is the first ceramic factory in India to successfully launch an energy efficient measure, as it retrofit of ceiling fans shows that energy-saving retrofits are practical and profitable and the recovery period is less than a year.
    - In Ambuja Ceramics, the fans are used 24×7, and are switched off only when the plant is shut down for maintenance. The entire factory had fans, which were consuming 80 watts at full speed. Apart from this, the ordinary fans could not sustain the hot and dusty environment, and had to be replaced every 12-15 months.
    - But once, the ordinary fans were replaced by power saving Gorilla fans, the scenario changed drastically. Gorilla fans, using superior BLDC technology, consume just 28W at full speed. This resulted in huge savings in electricity bill. Since, there is no heating of the motors, it could sustain the extreme conditions very easily.
- This technology development have to potential to be handy for the India ceramics industry in the large scale in the nearby future.

	Ordinary Fans	Gorilla Fans
Wattage	80	28
Units Consumption (Kilowatt hour)	28800	10080
Amount of Bill (in INR)	201600	70560
Savings in a month(in INR)	= (201600-70560) = 131040	
Guarantee Period of Fan = 3 years Total Savings in Electricity Bill for 3 years= INR 4717440		

Source: Atomberg and Ambuja Ceramics

- CGCRI (Central Glass and Ceramic Research Institute) is a premier R&D organization, which is involved in harnessing science and technology capabilities in the field of glass, ceramics, refractories, fiber optics, and photonics.
- Chalcogenide glasses provide best alternatives, which are relatively cheaper and provide superior performance in higher working temperature, wider IR window, and lower thermal coefficient of refractive index.
    - ➢ The intrinsic transparency window of these glasses covers much of the molecular fingerprint region of 2-20 μm, which makes them attractive for use in optical sensors, for many chemical and biological species. Apart from this, the high optical nonlinearity of these glasses enables wider application in photonics, such as diffraction gratings, optical data storage, and integrated waveguide circuits.
        - ✓ Taking all this into account, CGCRI established a unique facility for the development and moderate-scale production of chalcogenide glasses (important class of infrared transmitting glass materials by adopting hot-melt quenching technique).
- Ministry of Electronics and Information Technology (MeitY) funded a project to CGCRI, to focus on the development specialty sensors. Under this project, an optical strain sensor, using fiber Bragg grating (FBG) technology, has been developed, which is applicable at high-voltage environment for health monitoring of overhead railway infrastructure, and to prevent catastrophic damage of the infrastructure.
- CGCRI has the expertise on the platinum pot technology for producing homogenous and defect-free high density radiation shielding window (RSW) glass blocks, up to 400×400×100 mm^3 sizes and supplied 20 metric tons of RSW glasses of different sizes to BARC/DAE (Bhabha Atomic Research Centre - Department of Atomic Energy).
    - ➢ Under the MOU with Nuclear Recycle Group (NRG) and BARC, CGCRI also created sufficient knowledge base for fabrication of new generation crucibles that can withstand long duration of glass-melting operations and repeated heating and cooling, without any substantial glass corrosion and penetration.
- Apart from the aforementioned projects, there are many projects of CGCRI, which might open new opportunities to the Indian ceramics industry for market expansion, in the nearby future.

FAST TRACK TRANSLATIONAL PROJECTS	
Title of the Project	Tenure
Development of reaction-based silicon nitride ceramic radome	August 2016 to August 2018
Paper-based ceramic separator for lithium-ion battery applications	August 2016 to August 2018
SiAlON (Silicon, Aluminum, Oxygen, and Nitrogen) inserts for high-speed cutting of hard materials	October 2016 to October 2018
Superior Refractory for induction furnace to enable refining of steel	July 2016 to July 2018

INHOUSE PROJECTS	
Title of the Project	Tenure
Development of low thermal cordierite porcelain cook wares	September 2017 to September 2018
Development of pod printing decoration process for ceramic table wares	September 2017 to September 2018
Quality enhancement of the existing large-size artistic stoneware porcelain platters	September 2017 to September 2018

PROJECTS FROM GOVERNMENT DEPARTMENTS, PUBLIC SECTOR UNDERTAKINGS AND INDUSTRIES		
Title of the Project	Tenure	Funding Agency
Department of Science and Technology (DST) center for the development of waste utilization techniques for the ceramic industries	April 2017 to April 2021	(DST), Government of India
A study on use of fly ash in ceramics	May 2017 to November 2018	National Thermal Power Corporation (NTPC) Ltd
Development of reaction bonded silicon nitride and ceramic radomes	April 2015 to September 2018	Research Centre Imarat (RCI), Hyderabad, DRDO, Government of India

PROJECTS FROM INTERNATIONAL COLLABORATIONS		
Title of the Project	Tenure	Collaborator
Studies of multicomponent glass ceramic-based optical fibers for broadband light sources, beyond 2 micron spectral range	September 2015 to August 2017	Aalto University, Finland
Multifunctional nano-composite materials for low -temperature ceramic fuel cells	September 2014 to August 2017	Lomonosov Moscow State University, Russia

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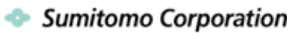



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