

# Applications for Alumina in the Automotive Market

Alumina, due to its powerful physical, thermal and electrical properties is by far the most used and cost-effective ceramic material in technical applications. As a result of the high mechanical strength, excellent chemical resistance, electrical properties and dimensional stability at high temperatures, alumina ceramics makes an ideal material for many parts in automotive applications. Some of the typical applications include catalytic substrates, electronic substrates, various mechanical wear parts, spark plugs and polishing. Almatris offers the broadest alumina portfolio in the industry with a broad variety of product solutions for the industry.

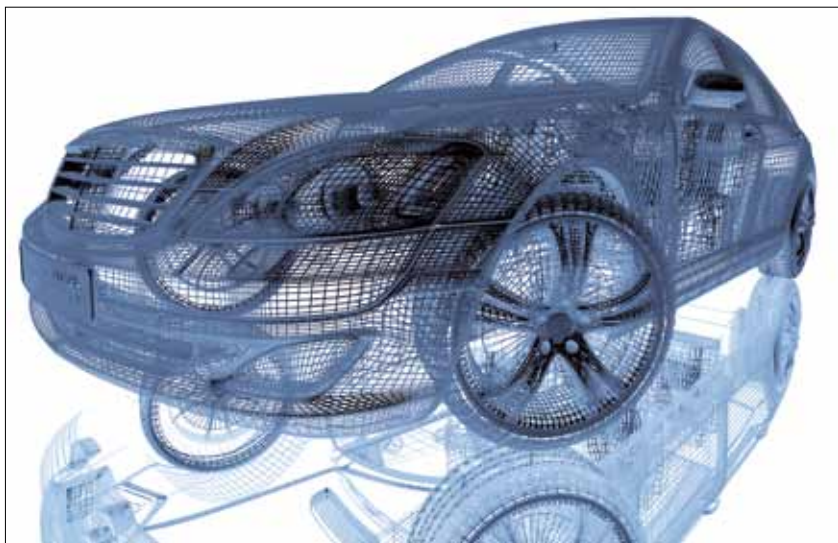


Fig. 1  
Car body

## Introduction

More than 85 million vehicles are produced in the world every year [1]. Since 2005, that represents an increase of approx. 20 million vehicles.

Modern vehicles have evolved to the point that smart technology, electronics, fuel efficiency, low emissions and improved reli-

## Keywords

alumina, automobile, market trends

ability are becoming standard features and expectations. This trend will continue to grow as technological advances allow integration of on-demand capabilities with our daily life.

Automobiles contain a number of ceramic parts, such as valve plates, oxygen sensors, electronic substrates and displays, catalytic converters and filters, spark plugs, heat sinks, resistor cores, fiberglass, and more. Alumina is also used in the emerging field

of electric vehicles, as a separator in batteries, and in many of the electronics and thermal management systems.

Ceramics provide critical passive and functional support to these parts, as well as in upstream the manufacturing processes used to make them. Kiln refractory, wear plates, cutting tools, riser tubes, glass fiber, substrates and electronics are all part of the upstream alumina ceramics supply chain process.

Furthermore ceramic powders are used for automotive polishing applications. Alumina is used to buff and polish metals, plastics and paints, and as an abrasive in upstream manufacturing. Both in the OEM and after-market segments, alumina has applications in aluminum rims, paints plastics, and brake pads.

Almatris has a broad portfolio of calcined aluminas for the automotive industry, with tailor-made products for any application. In

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this article, an overview will be given about current trends and developments in technical ceramics and polishing for the automotive industry.

### Alumina market

The overall production of chemical grade alumina is ~6 Mt/a. More than half of this volume is used in the form of aluminum hydroxide and ~2,8 Mt is used as specialty alumina [2]. Besides the technical ceramics market which is consuming about 600 000 Mt of specialty aluminas, about 1,7 Mt of alumina based products are regularly used in refractories, about 400 000 t in abrasives and about 70 000 t in polishing applications.

Alumina is the ceramic powder with the highest share in the field of technical ceramics. The main reason is that it provides exceptionally high performance value, combining very good ceramic properties with low cost. SiC, which cost-wise is closest to alumina, already has a price multiple times higher [3].

As many mixed oxides like cordierite or mullite can also contain alumina, more than 70 % of the annual usage of ~850 000 t in the field of technical ceramics is covered by alumina.

The definition of “technical ceramics” is not entirely clear and it is difficult to clearly categorize the markets that it covers. In this article we will concentrate on some specific markets and their recent trends.

The market figures presented here are estimates and are always related to the ceramic raw materials business only.

### Catalytic substrates/filters

For automobile catalytic converters, the core is usually a ceramic honeycomb substrate manufactured of cordierite or SiC.

The base substrate is then covered with a wash coat containing the catalytic materials [4]. The total value of the ceramic honeycomb is USD 715 million in the US and EU and the expected growth is 1,5 % [3, 4]. Beside the catalyst, which is transforming CO and NO<sub>x</sub>, Diesel engines also need particulate filters to remove soot. The majority of particulate traps for diesel vehicles use cordierite, aluminum titanate or silicon carbide, with the former two phases being formed during processing. The total value of ceramics for particulate traps is assumed to be USD 1,3 billion [3].

Main driver for growth is the general trend to tighter emissions legislation. In the US the EPA decided in 2004 to introduce the Tier 4 regulations in the period 2008–2015 [5]. The new EURO 6 norm will most likely lead to gasoline engines needing particulate filters as well [6, 7]. Asia and especially China will follow the EU regulation. A global growth of >3 %/a is expected [3].

Developments for both catalytic and diesel applications are focused on lowering emissions, while reducing backpressure and increasing fuel efficiency. The general trend in substrates is to increase internal surface area, resulting in higher cell densities and thinner walls. For filters, it will be essential to control the median pore size and overall size distribution in the substrate walls. To be successful in these developments, it is extremely important to use consistent and reliable raw materials. Almatris offers a variety of partially and fully ground calcined aluminas with consistent particle size distribution and chemistry control (Tab. 1).

### Spark plugs

Spark plugs are another application impacted by recent trends in engine technology. Alumina is used in the insulator of the spark plug, which insulates the central electrode and must have high dielectric strength. The total value of the spark plug market is ~USD 2,8 billion and is expected to grow slightly below that of global car sales [8]. The reason for slightly lower growth expectations is the trend for higher

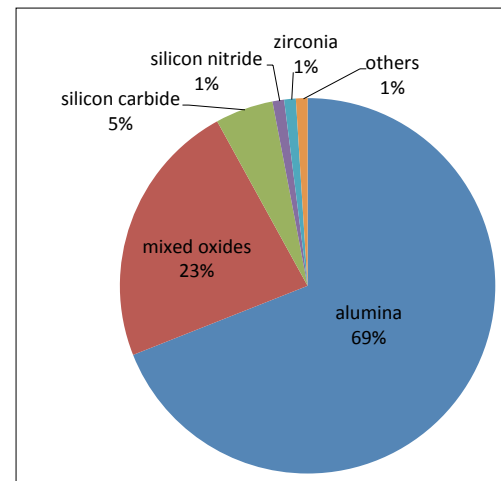


Fig. 2  
Distribution of usage of ceramic raw materials for technical ceramics

performing, longer lasting, smaller and fewer sparkplugs per engine. The latest engine technologies have resulted in higher voltages across the spark plug electrodes and defined access via a narrower and deeper channel in the engine itself. The insulator geometry has had to adapt accordingly, therefore developments have trended towards very thin walled and long spark plugs with increased dielectric properties. Due to the geometry changes, concurrent improvements in the tensile strength, especially at the insulator tip, has become essential for a long life time.

From standard bodies to high performance insulators, Almatris calcined aluminas perform consistently, and are the dependable

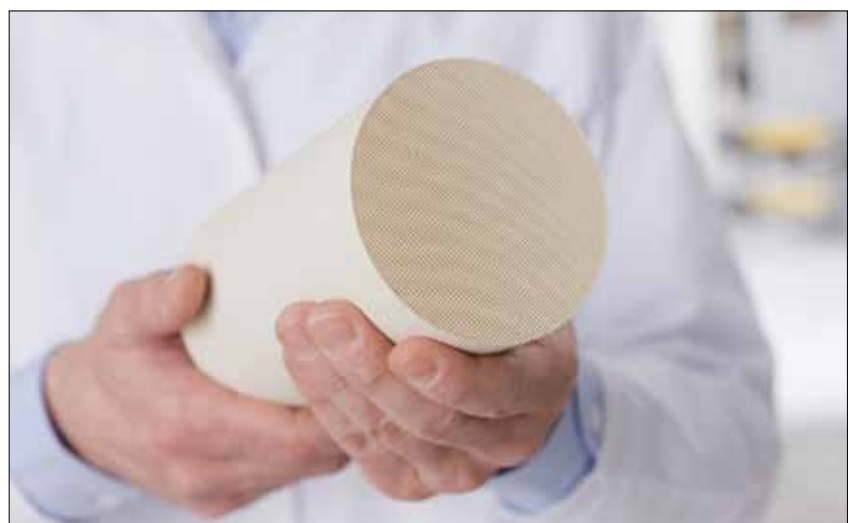


Fig. 3  
Catalytic substrate made of cordierite

Tab. 1  
Almatis products for honeycomb substrate applications

	Continuous Ground Aluminas				Batch Ground Aluminas		
	CT800 SG	HVA FG	A2 -325CR	A10 -325	CT3000 SG	A1000 SG	A3000 FL
Surface Area [m <sup>2</sup> /g]	1,0	0,7	0,7	0,5	7,5	8,2	2,5
Ground D <sub>50</sub> [µm]	3,2	4,8	5	8,0	0,4	0,6	2,7
Wet Mesh <45 µm [%]	99,8	99,4	99,2	99,0	99,9	99,8	99,9
Al <sub>2</sub> O <sub>3</sub> [%]	99,7	99,7	99,6	99,7	99,8	99,8	99,8
Na <sub>2</sub> O [%]	0,12	0,12	0,3	0,08	0,08	0,07	0,07
SiO <sub>2</sub> [%]	0,02	0,02	0,02	0,04	0,03	0,03	0,02

Tab. 2  
Almatis products for spark plug application

	CT1200	CL2500	CL3000	CT700	A10
Surface Area [m <sup>2</sup> /g]	1,1	0,9	0,7	0,6	0,2
Primary Crystal Size [µm]	1,2	1,7	1,8	2,0	4,8
Green Density [g/cm <sup>3</sup> ]	2,19	2,22	2,27	2,30	2,36
Al <sub>2</sub> O <sub>3</sub> [%]	99,8	99,8	99,8	99,7	99,7
Na <sub>2</sub> O [%]	0,06	0,06	0,06	0,12	0,08
SiO <sub>2</sub> [%]	0,01	0,01	0,01	0,01	0,04

choice to meet the ever-increasing industry requirements (Tab. 2).

**Electronic Applications**

Perhaps the largest growth trend in the automotive industry is the addition of electronics. Today's cars have evolved to contain electronic systems and devices that improve both comfort and safety. Examples such as touchscreen displays, navigation,

entertainment systems, and WIFI provide assist with lifestyle comfort, while cameras, fuel management systems, ABS, and a variety of smart-sensors have greatly improved safety. Alumina is used for electronic substrates, thermal management solutions, various resistor functions, battery separators, and in the processing equipment to produce these parts. Electronic substrates represents the largest share, by volume, of

alumina and are the base supports for production of electronic circuits used in computer chips, multi-chip modules and circuit boards.

Besides alumina, silicon nitride and aluminum nitride are common raw materials for substrate applications, due to their high thermal conductivity values.

The total value of the IC substrate market is ~USD 7 billion, but automotive applications only stand for some share of that value [9]. Strong growth is expected in this market, which is driven by the trend to more electronics per vehicle, higher power density and further miniaturization (Tab. 3).

Almatis offers a range of alumina products to support the electronics market. These products are used to increase strength, hardness, thermal and electrical properties and overall integrity. Strict quality control measures with a focus on tight specifications on particle size distribution, green density and reactivity help the industry to achieve consistent results.

**Wear parts**

Certain automobile parts face more severe operating conditions than others, as is the case with bearings, pumps, valves, and seals. These applications benefit from the



Fig. 4  
Electronic substrate

Tab. 3  
Almatis products for electronic applications

		Unground			Continuous Ground		
		CL2500	CL3000	A10	CL2500 SG	CL3000 FG	A10 -325
Surface Area	[m <sup>2</sup> /g]	0,9	0,7	0,2	1,1	0,9	0,5
Primary Crystal/Ground D <sub>50</sub>	[µm]	1,7	1,8	4,8	3,5	3,9	8,0
Al <sub>2</sub> O <sub>3</sub>	[%]	99,8	99,8	99,7	99,8	99,8	99,7
Na <sub>2</sub> O	[%]	0,06	0,06	0,08	0,06	0,06	0,08
SiO <sub>2</sub>	[%]	0,01	0,01	0,04	0,02	0,02	0,04

Tab. 4  
Almatis products for automobile polishing

	P2 FR	RAPOL500	P10 feinst	P815/P816	ULTIMATE P1500
Surface Area	[m <sup>2</sup> /g]	9–17	~4	10–18	~5
Top Cut	[%]	>90 µm <0,5 %	>90 µm ~0,1 %	>20 µm <3 %	>45 µm ~1 %
Oil absorption	[%]	40–50	~35	30–40	~40

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Fig. 5  
Polishing of clearcoat paint

thermal, mechanical and wear properties of alumina ceramics as they lead to improved reliability and less maintenance over the lifetime of the vehicle, as compared to traditional metal parts.

The overall market for ceramic parts used in exhaust port liners, pump seals and bear-

ings is ~USD 250 million [3]. This market figure does include some non-automobile applications. As reliability is getting more and more important, especially in the automobile sector, and traditional metal parts are replaced with higher performance ceramics, the market is expected to grow.

### Polishing

Most external areas and features of vehicles need to be polished, whether before their initial sale, or during their lifetime. One of the key raw materials used in OEM and after-market automotive polishing is alumina. The diversity of aluminas used in automotive applications and production processed is greater than in most other markets. Alumina products typically used range from white fused aggregates to hard-burned calcines to soft-burned and transitional calcines. The overall market for white fused and calcined alumina for abrasive and polishing applications is ~400 000 t/a, and ~50 000–70 000 t/a, respectively [11, 12]. The portions of each used for automobile polishing is only a small share of that volume.

There are essentially two different market segments of application within automotive polishing, retail and professional (OEM and body shops). Within these two segments, there are applications including the polishing of clear coat paints, plastics (headlights), fiberglass and metals (aluminum wheels).

Almatis offers a broad range of polishing aluminas suitable for different automotive applications ranging from very soft to very hard burned aluminas (Tab. 4). Beside calcination degree the major focus is on a tight control of particle size distribution to enable our customers to achieve consistent superior polishing results.

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