➤ **High-performance ceramic braking systems help ensure that safety is maintained while providing additional benefits.**

THE Brake Stops HERE

Most people don't spend much time thinking about their car's brake pads, as long as the car stops when they need it to. The various mechanisms and materials required to brake the car remain a mystery. After all, the world is complicated enough without dissecting every piece of machinery that helps us navigate through the day.

Automobile manufacturers put all of their vehicle components through vigorous testing protocols and trials in order to determine the best materials for specific applications. And that's a good thing, because the materials used in brake pads are complex and vary widely, depending on the type of vehicle and the needs of the driver. Traditional brake pads (based on metallic or occasionally organic materials) might be relatively inexpensive, but they do have some drawbacks, including the potential for dust and noise, as well as a lack of performance under certain circumstances (e.g., high-speed, heavy breaking conditions).

From luxury cars like Lexus, Audi and BMW to sports cars such as those offered by Porsche and Ferrari, people who drive high-end, performance automobiles expect the very best—and they're often quite willing to pay for it. While they can be more expensive, brake systems that incorporate ceramic materials provide the added benefits of improved performance and low noise and dust, which are often worth the added cost. The use of ceramic materials instead of metals also enables manufacturers to reduce the weight of the car, which is becoming increasingly important as the industry continues to move toward higher fuel efficiency standards.

Beneficial Characteristics

The force that enables the brake pad to reduce the car's speed is actually pretty simple: friction. Generally speaking, as the pad presses against the brake disc, which can be made of iron or composite materials (including silicon carbide and other ceramics), the force of the pad slows the disc, which in turn slows the car. The high temperatures that result from this friction can cause metal-based brake systems some serious problems. Ceramics' excellent thermal conductivity and strength means they can handle the heat with less wear while also helping to clean the rotor.

Sourcing a Supplier

When searching for a materials supplier, manufacturers should keep a number of factors in mind, including:

- Is the supplier experienced?
- Does the supplier provide quality products in a reliable manner?
- Does the supplier offer a variety of products to meet a range of specifications/applications?
- Is the supplier willing to ask questions and collaborate in order to find the right product mix for your application?

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Brake pads can be comprised of 20-30 different materials, each imparting certain characteristics to provide optimal performance. Similar to a cooking recipe, the success of the final product depends on the quality and characteristics of each "ingredient," as well as their ability to fulfill their role in the overall formulation.

The most successful mix is optimized through a rigorous testing and trial process. Specific families of materials, including sulphides, oxides and fluorides, can be incorporated in brake pad formulations to address not only thermal conductivity, but additional factors such as oxidation resistance, breaking strength, lubrication and noise reduction (see Table 1).

Sulphides

Iron disulphide (FeS_2) is widely used to impart good thermal conductivity and lubrication action, as well as high breaking strength and oxidation prevention. It is stable to 400°C, and its median particle size distribution (D 50) is 10 µm.

The inclusion of manganese compounds provides these benefits while also increasing the use temperature to 600°C (D 50 = 25 µm). In addition, copper can be incorporated ($CuFeS_2$) to improve heat dispersion and increase temperature stability up to 900°C (D 50 = 20 µm).

Oxides

Oxide materials are incorporated in brake pads primarily in order to regulate the coefficient of friction; they also help with breaking strength. Red iron oxide (Fe_2O_3, D 50 = 25 µm) is stable up to 1,100°C, while black iron oxide (Fe_3O_4, D 50 = 35 µm) can withstand temperatures of up to 1500°C. Using chromite (D 50 = 20 µm) increases the operating temperature even higher, up to 1,800°C.

Fluorides

Calcium fluoride (CaF_2, also known as fluorspar) is used for brake pad purposes to provide noise reduction and increased density at very high temperatures (1,400°C).

Key Components

Despite their ubiquitous and often unnoticed presence in our daily lives, brake pads are complex elements that play a vital role: They slow and stop our vehicles when we need them to, helping to ensure not only our safety, but also that of those around us. Sourcing the best materials—including sulphides, oxides and fluorides, among others—for use in high-performance ceramic braking systems helps ensure that safety is maintained while providing additional benefits such as improved performance and reduced noise and dust. ⊕

For additional details, contact Washington Mills at (716) 278-6600 or info@washingtonmills.com, or visit www.washingtonmills.com.

Table 1. Common material characteristics.

Material	D 50 (µm)	Stability Temperature (°C)	Action/Advantages
Iron disulphide (FeS_2)	10	400	Prevents oxidation, offers good thermal conductivity, resistant to breaking, provides lubricating action
Manganese compounds	25	600	Prevents oxidation, offers good thermal conductivity, higher melting point, resistant to breaking, provides lubricating action
Copper sulphide ($CuFeS_2$)	20	900	Prevents oxidation, offers improved heat dispersion, provides good thermal conductivity, resistant to breaking, provides lubricating action
Red iron oxide (Fe_2O_3)	25	1,100	Regulates coefficient of friction and breaking strength
Black iron oxide (Fe_3O_4)	35	1,500	Regulates coefficient of friction and breaking strength
Chromite	20	1,800	Regulates coefficient of friction and breaking strength
Calcium fluoride (CaF_2)		1,400	Noise reduction and increased density
Carbon (C)		600-700	Lubricating action
Aluminosilicate		1,200	Lubricating action