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The advantages of metal fibers for ESD/EMI shielding

CONTENT

WHITE PAPER

The advantages of metal fibers for ESD/EMI shielding

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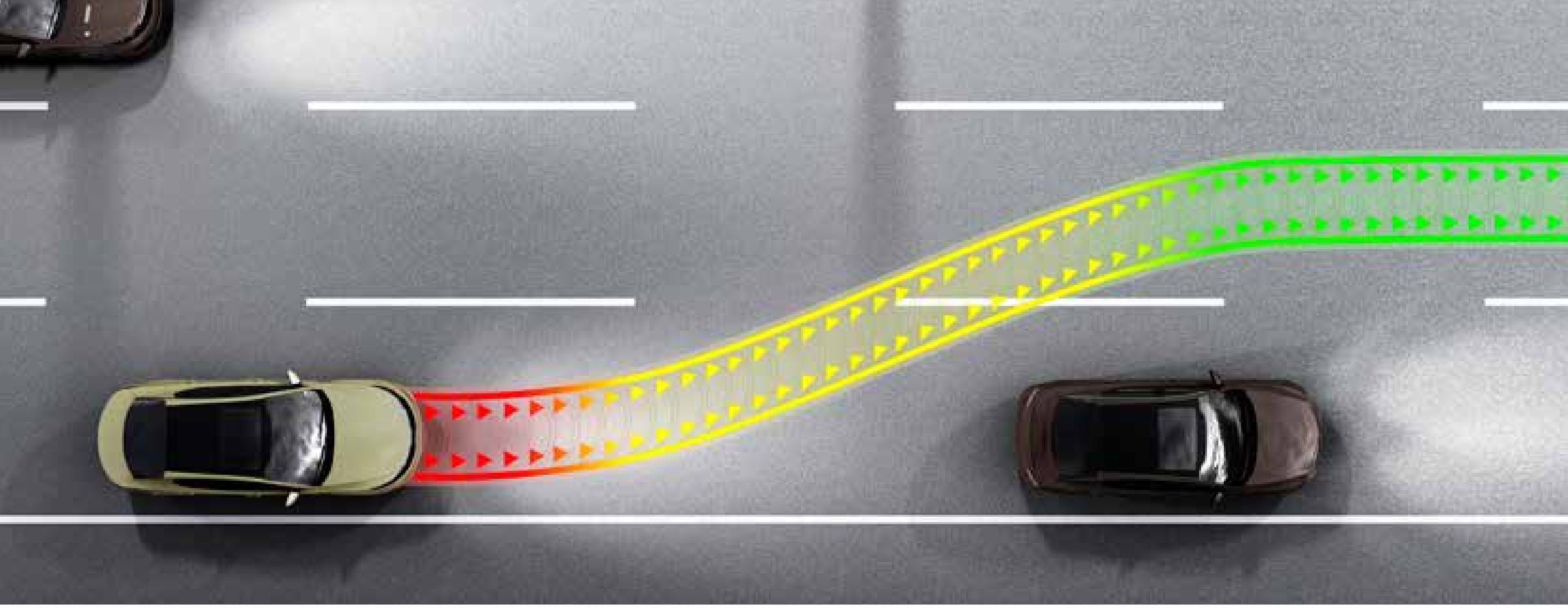
Metal fibers – fiber material with a diameter less than 100 microns – exist in many forms, alloys and sizes. Structures and products incorporating metal fibers display excellent electrical, thermal, corrosion and mechanical properties. Each of these properties makes them suitable for a wide range of specific industrial applications, including filtration, heat resistant textiles, conductive textiles and conductive plastics. This white paper focuses on the use of metal fibers to protect against electrostatic discharge and electromagnetic interference.

Continuous fibers

Grains

Spun yarn

Blends



WHAT IS ESD AND EMI?

Electrostatic discharge (ESD) and electromagnetic interference (EMI) are common phenomena in daily life. Everyone has experienced ESD when receiving a small electrical shock after touching a metal item that is electrically isolated from the ground. It is caused by the difference in electrical charge between an electrically loaded item and the ground. An example of EMI is the annoying buzzing noise heard through old TV speakers when you are on your cellphone. These examples are rather harmless, but this does not mean that ESD and EMI should be ignored; more serious consequences of these phenomena include fires, explosions, accidents, and the malfunctioning of sensitive, important equipment.

ESD

The release of static electricity when two objects of different electrical charges come into contact.

EMI

Electromagnetic energy that affects the functioning of electronic devices.

METAL FIBERS FOR CONDUCTIVE PLASTICS

To prevent electrostatic charges from building up and releasing as sparks, metal fibers can be added to a plastic component to create a conductive matrix in plastic products. In such applications, metal fibers perform an additional valuable role by allowing metal parts to be replaced with lightweight plastic parts, while maintaining the required electrical conductivity. Other advantages of metal fibers for conductive plastics include:

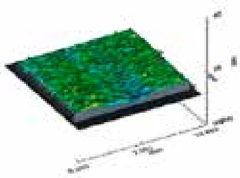
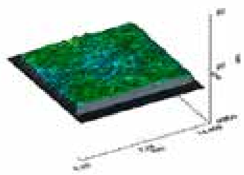
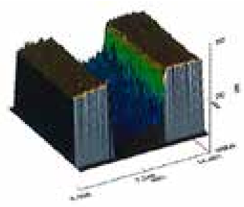
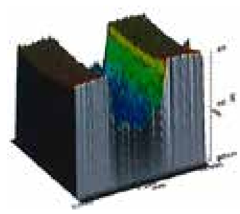
- High electric conductivity at low volume % of metal fiber
- Low impact on physical plastic properties (IZOD impact strength, part shrinkage)
- Durable long-lasting conductivity, non-marking and sloughing
- Easy and safe handling of the material
- Food approved
- Processing in compounding and injection molding, without adapting the process
- No influence on final color; no post-processing needed; any color is possible
- Low volume fraction of metal fibers in the end product
- Large freedom of design.

METAL FIBERS IN PRODUCTION PROCESSING EQUIPMENT

Metal fibers also have a role to play in ESD/EMI shielding of equipment such as injection molding machines used to produce plastic products. Not only do metal fibers achieve a high level of ESD/EMI shielding performance, they also lead to minimal wear and tear of these machines.

Production processing equipment such as injection molding machines experience wear and tear during their normal lifetime. The impact of metal fibers on this wear and tear has been found to be significantly less than the impact of carbon fibers. This was investigated by the research institute Fraunhofer LBF by conducting a standardized test called the DKI platelet wear testing method. The test was performed with platelets of polyamide 66 (PA66) base resin impregnated with 10% stainless steel fiber, 20% carbon fiber and 30% fiber, and compared to a pure PA66 sample. From an EMI shielding perspective, 10% stainless steel fiber results in approximately the same EMI shielding capabilities as 20% carbon fiber. It can be seen that the addition of 10% stainless steel fiber produced minimal wear and tear compared to the significant impact on wear and tear of the carbon fiber.

10% stainless steel fiber results in approximately the same EMI shielding capabilities as 20% carbon fiber

	PA66	PA66 + 10% stainless steel fiber (GR75)	PA66 + 20% carbon fiber	PA66 + 30% long glass fiber
Weight difference*	1 mg	1 mg	13 mg	20 mg
Visual inspection*				

* DKI platelet wear testing method

Metal fibers cause less wear and tear on injection molding equipment because of low required volumetric fiber content.

The key reason is the low volumetric addition of steel fibers compared to the carbon equivalent. The table illustrates the weight and volume percentages in which metal fibers need to be added to achieve a certain performance of ESD or EMI shielding. It clearly shows that a high degree of conductivity can be achieved with low percentage volumes and weights of metal fibers.

Volume % fibers	Weight % fibers (*)	Volume resistivity (Ohm.cm)	Performance (**)
0,25 - 0,5	4	< 10^2	ESD protection
1	8	0,5 - 2	30 - 50 dB EMI shielding
1,5	11	0,1 - 0,5	50 - 60 dB EMI schielding
> 1,5	> 11	< 0,1	> 60 dB EMI schielding

(*) resin density: ± 1 g/cm^3 - stainless steel fiber density: ± 8 g/cm^3
(**) 30-1000 MHz range of shielding

METAL FIBERS TO CREATE A FARADAY CAGE

Electromagnetic waves are a combination of an electrical field and a magnetic field. These can create unwanted noise or interaction with other signals. To avoid disturbance of the proper functioning of critical equipment it is necessary to shield the equipment from electric (dis)charges or radiation. This is accomplished by a Faraday cage. By attenuating the effects of static discharges or radiation within the cage's interior (or vice-versa), a Faraday cage shields its contents from external influences like electrostatic discharges or electromagnetic fields.

Metal fibers can be used to create a Faraday cage, for example by incorporating them into a plastic item surrounding critical equipment.

FARADAY CAGE

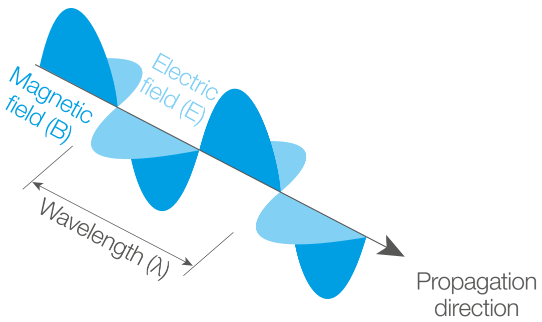
A Faraday cage is a structure that takes electrostatic charges, or even certain types of electromagnetic radiation, and distributes them around the exterior of the cage.

Near and far electromagnetic fields

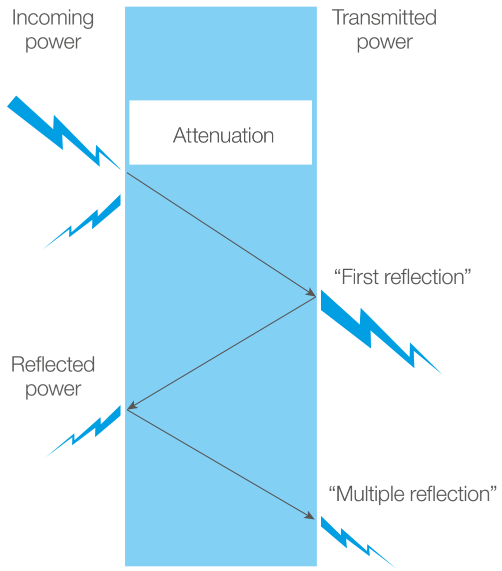
An electromagnetic field can be described as either near or far. Whether an object is in a near or a far electromagnetic field depends on its distance from the source of the electromagnetic wave. The boundary between the near field and the far field is defined by the following equation:

- **Distance from source/(λ/2π)>1 = far field:** shielding is driven by quality of Faraday cage
- **Distance from source/(λ/2π)<1 = near field:** shielding is driven by magnetic permeability

Depending on the distance from object to source, the importance of electric and magnetic fields will be different. In a near field, magnetic characteristics become more important; in a far field, electrical characteristics become stronger. The table displays some near/far field boundaries for certain objects.



Depending on which field the object is in (near or far), some material properties will become more important. In **electrical fields**, high conductivity material will enable induced currents to generate an opposing electromagnetic wave that cancels the incoming wave. The higher the conductivity, the more the wave cancels the incoming wave, and the better the shielding. In **magnetic fields**, the magnetic permeability of the metal fibers will capture the magnetic field lines of the incoming wave and will provide a path via the housing away from the object that needs to be protected. Different alloys with magnetic permeability will provide better shielding in the magnetic field.

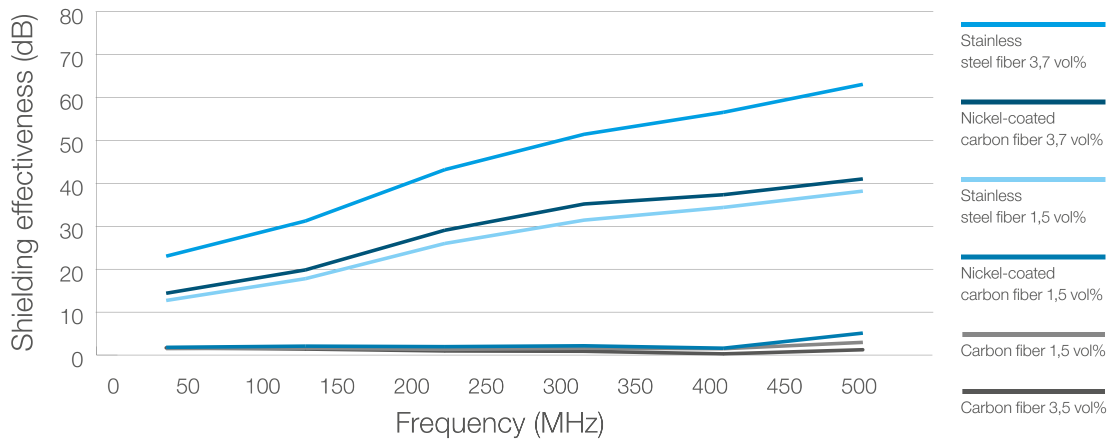


Both in near and far fields, metal fiber conductive plastics display strong shielding effectiveness at low load levels. It is also observed that the required amount of filler material with metal fibers is much lower than the equivalent with carbon fiber or nickel-coated carbon fiber, as displayed in the following three figures.

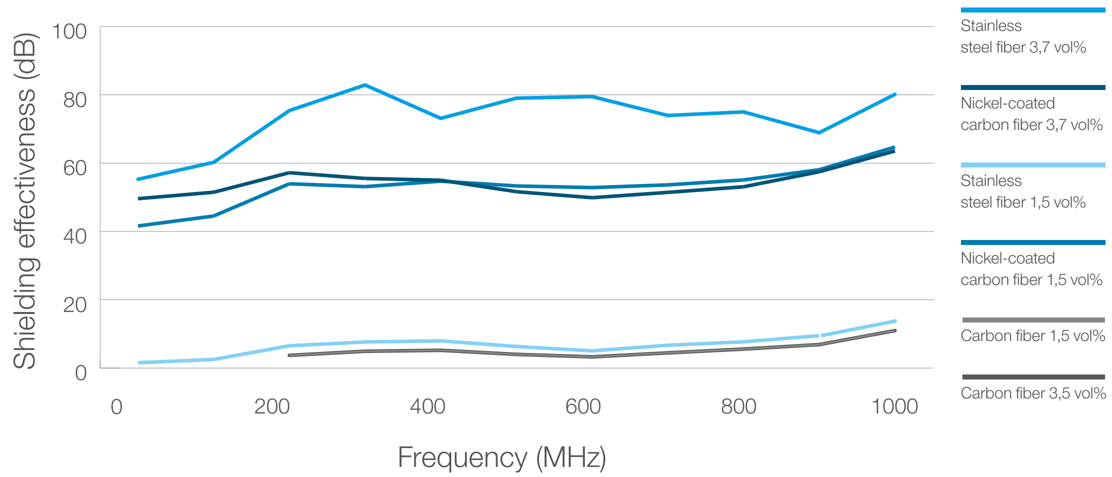
Application	Frequency	Wavelength	Boundary near/far field
Radio communication	100 MHz	3 m	50 cm
Wireless WIFI-5	5 GHz	6 cm	1 cm
Power converter	100 kHz	3 km	500 m

Near/far electromagnetic field boundaries for three common objects.

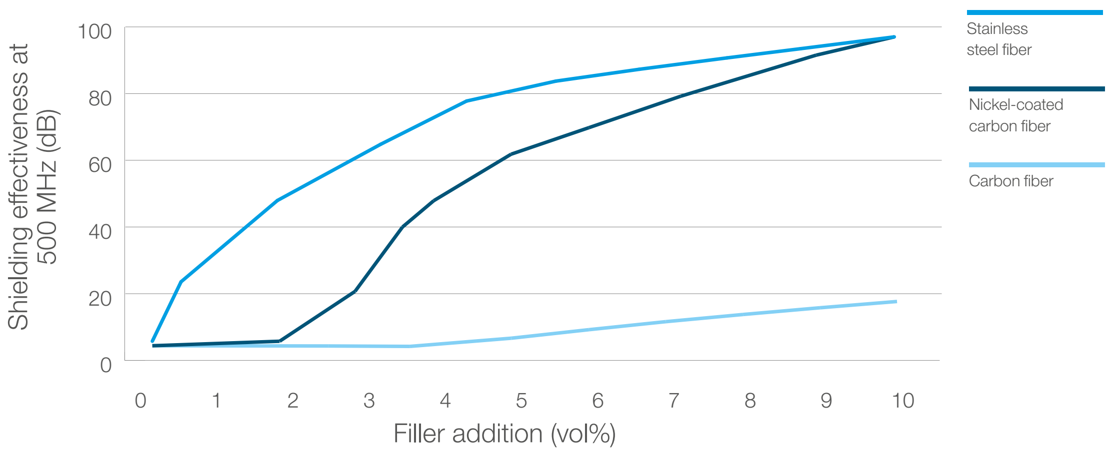
Magnetic near field



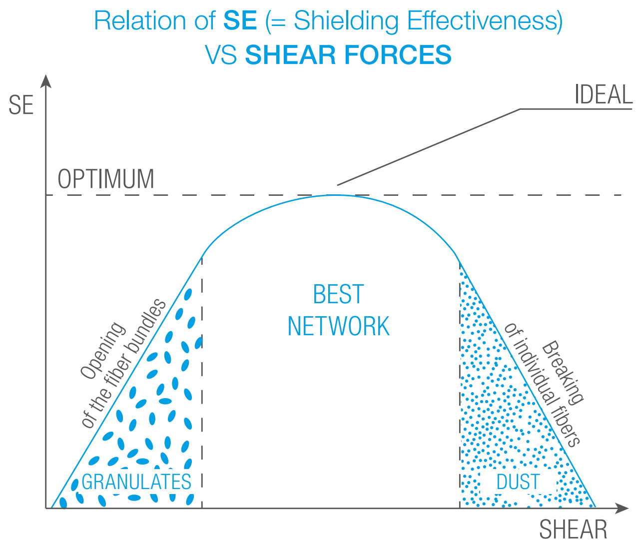
Electric far field



Effect of filler addition (electric far field)



The figure on the right shows the importance of limiting the exposure to shear forces to maintain shielding effectiveness. Insufficient shear forces will not disperse the fibers, nor create the fiber network. If the shear forces are too high, the fibers will break into dust and will not create the fiber network. Recommendations for shear forces for specific applications can be found in Bekaert's product datasheets.



METAL FIBERS AND YARNS FOR CONDUCTIVE TEXTILES

Metal fibers and yarns integrated into textile products can be used to provide ESD/EMI shielding. They can also provide heating or electro-conductive properties in general, heat-resistant or cut-resistant properties, or a conduit to transfer power, data or signals. The main advantages of metal fibers and yarns in conductive textiles are:

- Increased durability/flexlife
- High conductivity
- High flexibility
- Softness and high contact comfort
- Temperature resistance
- Corrosion resistance
- Possibility to blend with other textile fibers.

Metal fibers and yarns can be used to create textile products in various textile processes such as spinning, weaving, knitting, embroidery, braiding, non-wovens and others.

APPLICATION EXAMPLES

Anti-static castor wheels

- ESD functionality needed
- Low load level for high conductivity
- No impact on physical properties
- Easy and safe handling
- Durability: non marking on the floor
- Ideal for clean rooms, hospitals, …


Anti-static castor wheels

Anti-static flooring

- ESD functionality needed
- Low load level for high conductivity
- No impact on physical properties
- Colors for safety lines on the floors
- Easy and safe handling of the material
- Sustained conductivity over time


Anti-static flooring

Anti-static textiles

- Immediate discharge
- Long lifetime, resistant to multiple wash cycles
- No impact on physical properties
- Easy to integrate
- Strong anti-static character


Anti-static textiles

Big bags

- Electro-conductive textile
- ESD functionality needed
- Prevention of sparks
- Conductive fiber to be integrated in textile
- Durability


Big bags

Body sensors and electrotherapy

- Electro-conductive textile
- Washable and durable
- Can be woven into bandages
- Corrosion resistant
- Sudden infant death syndrome sensors
- Heart monitors
- Muscle stimulation

Body sensors and electrotherapy

EMI shielding plastic parts in E-mobility

- EMI functionality needed
- Low load level for high conductivity
- No impact on physical properties
- Sensors, battery casing, dashboards, ...
- Lightweight design for metal replacements
- Freedom of design
- Colors possible for esthetics
- Low impact on wear of processing equipment

EMI shielding plastic parts in E-mobility

EMI shielding textiles

- Superior electrical conductivity
- Excellent electromagnetic shielding performance
- Flame-retardant properties
- Resistant to multiple washing

EMI shielding textiles

CONCLUSION

Stainless steel fibers can be easily integrated into plastics, textiles and yarns to provide excellent ESD/EMI shielding. A highly conductive stainless steel fiber matrix structure prevents ESD from building up and releasing a spark, or creates a Faraday cage offering excellent EMI shielding.

Properties of metal fibers make them an utmost suitable product for ESD/EMI shielding applications. High conductivity, high durability, high flexibility; softness and corrosion resistance are some of the properties making metal fibers the product of choice to achieve your ESD/EMI design goals.

Tom Daniëls

Tom is currently Global Market Manager for Conductive Plastics at Bekaert Fibre Technologies. He is responsible for setting the strategic direction of the department and developing the market in collaboration with the R&D team and regional market managers. Tom holds a master's degree in Industrial Engineering Electro-Mechanics and an additional master's degree in Global Management. He has more than five years of experience in technical sales and strategy implementation in the B2B market with key players in a variety of different industries, including chemicals, aerospace, marine and automotive.

Steve Verstraeten

Steve is Market Manager Electro-Conductive Textiles at Bekaert Fibre Technologies and is active in the European market. His focus is mainly on antistatic and conductive fibers and yarns. He is also involved in the identification and development of new markets. Steve holds degrees in Electro-Mechanical Engineering and in Business Management and Administration from the University of Louvain-La-Neuve. He has worked as an R&D Engineer for 13 years and has over six years of technical sales and marketing experience.

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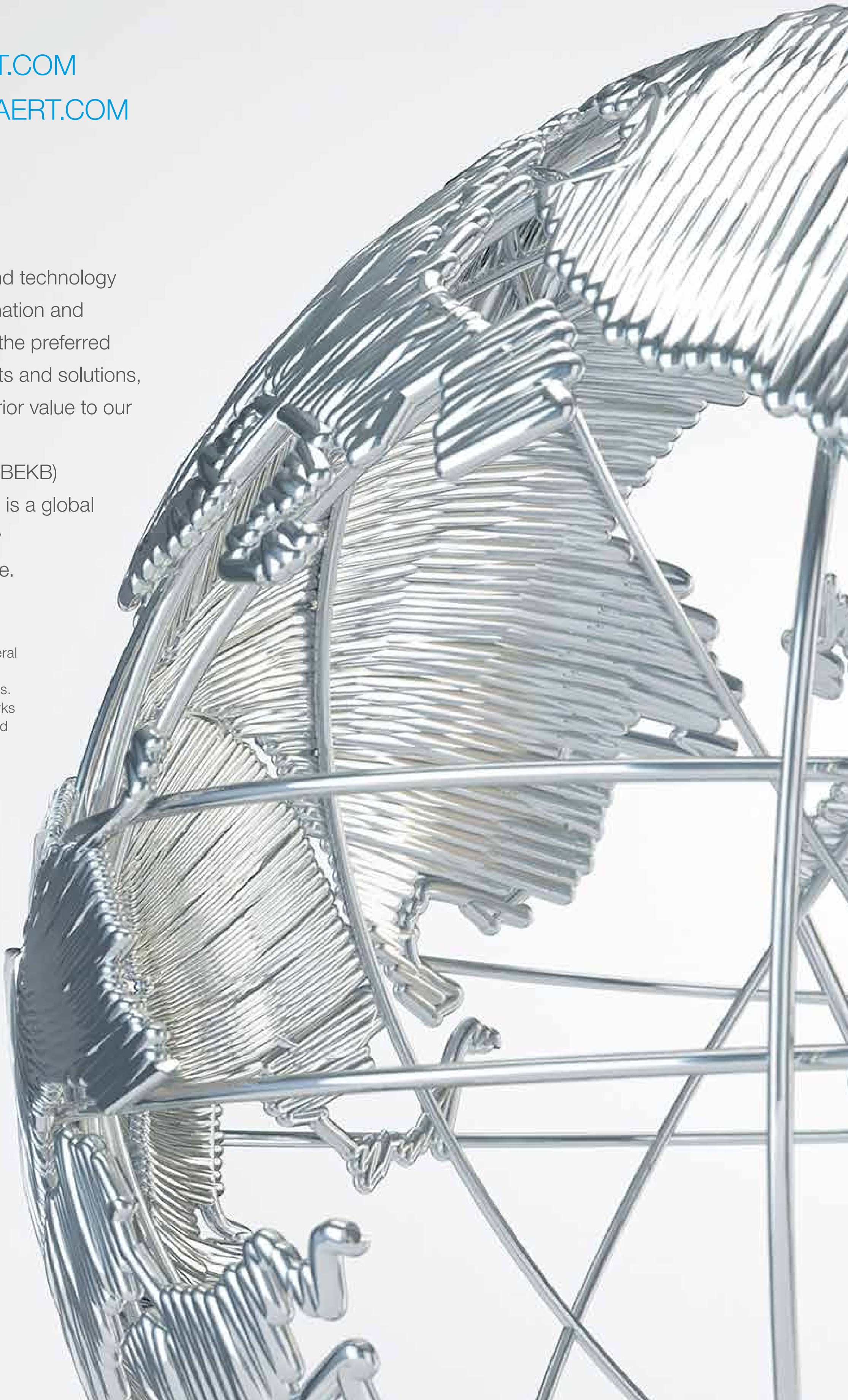

Bekaert is a world market and technology leader in steel wire transformation and coating technologies. To be the preferred supplier of steel wire products and solutions, we consistently deliver superior value to our customers worldwide.

Bekaert (Euronext Brussels: BEKB) was established in 1880 and is a global company with approximately 30 000 employees worldwide.

Responsible editor:
Danny Meekers - 07 2019