

THIS ISSUE

Ferro helps Brands to Shine



 **100 YEARS AHEAD**

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EXHIBITIONS 2019/20

VITRUM

Milan, Italy, 1-4 October, 2019

EURASIA GLASS FAIR

Istanbul, Turkey, 4-7 March, 2020

SGCD

Cleveland, Ohio, USA, 18-20 April, 2020

SMTconnect

Nuremberg, Germany, 5-7 May, 2020

CHINA GLASS

Shanghai, China, 22-25 May, 2020

MIR STEKLA

Moscow, Russia, 8-11 June, 2020

GLASSBUILD

Las Vegas, USA, 15-17 September, 2020

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FOREWORD

FERRO IS EVERYWHERE

Welcome to the Autumn 2019 edition of Color & Glass World, Ferro's newsletter designed to keep you updated with our activities and developments in functional and decorative colors and coatings for glass, ceramic, metal and other substrates.

Like many companies in our industry, Ferro experienced reduced demand over the first half of 2019 in some of our end markets and geographic regions, and economic conditions for the foreseeable future remain challenging. However, I am confident that the transformation we have made to our business in the last 5 years, along with the operational improvements that we are continuing to implement, leave us well positioned to withstand such economic headwinds, moving forward. Ferro today is a fundamentally stronger business than it was several years ago. Now, we are a focused, technology-driven functional coatings and color solutions company, using innovation to expand our leadership positions in high-demand, high-margin markets. Thanks also to the acquisitions we have made since 2015, we have an enhanced platform of technologies from which to develop new products that feed our product pipeline, and now have a vitality index in the range of 20%.

In fact, pursuing novel ways to solve challenges is what drives all of us in Ferro forward. The products that surround you in life aren't built by Ferro but our functional coatings and color solutions are part of those products. In more ways than you can imagine.....

Most likely, the smart-phone, tablet or PC you are using to view this on-line contains Ferro electronic materials on its circuit boards. All around your car and in public transportation, from the window glass and sun-rooves on the outside to key components in engines, and sensors in exhaust systems and catalytic converters, you will find Ferro high performing materials.

At home, in the kitchen, Ferro's digital and screen-print color solutions and laser marking materials are present on glass microwave and oven doors, control panels, furniture, splash backs, and cooker tops. Your glass and ceramic dinnerware and tumblers are decorated with our lead-free glass enamels, forehearth colors and/or organic inks. Some of the world's most iconic drinks and cosmetic brands, like Absolut, Coca-Cola, Pepsi, YSL, Givenchy, Corona, and Ralph Laurent, use Ferro colors for their glass packaging to help add value and deliver stand-out shelf appeal.

For both exterior and interior architectural glass, there are thousands of commercial building projects around the world, whose architects have incorporated Ferro and Dip-Tech colors and technology into their designs for offices, hotels, apartments, hospitals, airport terminals and similar buildings.

In this edition, we are featuring stories from Dip-Tech and Diegel, two of the companies we acquired recently, that we believe bring exciting opportunities for future growth. Amongst other features, we highlight our forehearth color technology's contribution to sustainability in glass, and how our innovative materials are used in such diverse applications as electronics and grinding wheels.

As usual, I hope you will find the features in this edition informative, and thank you for your continued support and valued business.

Dieter Binder
Vice President, Europe & Performance Colors and Glass
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FERRO HELPS BRANDS TO SHINE

ORGANIC INKS DEVELOPMENTS



Ferro's organic inks for glass decoration were originally launched in the 1990's in response to the growing environmental concerns particularly surrounding the use of cadmium in the production of bright red colors. Since that time, our technology has advanced enormously to enable significant improvements in glass adhesion, scratch resistance and chemical durability, as well as enhancements in printability, gloss and color intensity.

Today, we supply organic inks for glass that can be cured in a number of different ways, dependant on the type of application and preferred machine. For example, our HTP range offers a complete spectrum of color shades for conventional multi-color thermoplastic screen printing. These can be used on the same machines as used for our traditional lead-free glass enamel printing inks. Our HTP prints deliver good scratch

resistance and durability, without the need for pre-treatment of the glass or a varnish top-coat, a big processing advantage compared to, for example, UV-printing. For single color prints, our RTP inks are the colors of choice. These ranges are supplied color matched, ready to use, and deliver superior dishwasher resistance for tumblers, and good scratch resistance and chemical resistance for single-trip and multi-trip bottles.

Additionally, our UCP line of UV-cure inks are offered for customers with UV-print machines, and display the typical advantages of UV-printing: easy to print, fast cure, good over-printing and color mixing. Opaque colors are achieved by over-printing on a white under-layer. These inks are often used for printing on top of our organic coatings. UV-screen print inks are especially popular for printing of tumblers and cosmetic bottles.

Our HTP line of organic inks are increasingly used where brands are looking for environmentally-friendly bright, intense colors or special effects. Especially reds, oranges and yellows can not be achieved using lead-free glass enamels, without the addition of 'environmentally-unfriendly' cadmium. With our organic systems, brand owners can, in principle, choose from an unlimited range of opaque and transparent color tones, as well as metallics, etch imitation and neon specialty effect colors. Several launches of Absolut flavored vodkas use bottles decorated with Ferro HTP organic inks. These include Absolut Raspberri, and the recently launched limited edition Absolut World, pictured here. According to Absolut, "The design is an expression of celebrating global unity and the values that unite people around the world: love, peace and togetherness." Written messages such as 'Peace 4 all' are scattered across the design, and this is the first time neon colors have been used for an Absolut Vodka bottle design, with the Ferro neon colors contrasted by touches of our metallic gold. Also, Rastal in Germany is decorating a lot of drinking glasses with HTP inks, including a series named H Lager Explorations released by Heineken.

Our R&D teams are constantly working with customers to evolve the properties of our organic ink systems, to ensure that Ferro continues to deliver solutions as your 1-stop shop for decoration colors on glass and ceramic substrates.

demonstrated that Ferro forehearth color (fhc) pearls can balance this loss of quality, linked to a high rate of cullet recycling in glass furnaces.

This physico-chemical consequence of recycling more glass cullet into the tank batch can be overcome with tailored formulations of Ferro fhc pearls, thereby improving the visual attractiveness of flint glass coming from a virtuous process.

To discover more about Ferro fhc technology, please contact our local customer service teams in your region.



DIEGEL INNOVATION

DISHWASHER-RESISTANT ORGANIC COATINGS FOR TABLEWARE

Ferro completed the acquisition of Diegel Creative Coatings, based in Arsfeld, Germany, in 2018. Diegel has a long history of supplying waterborne organic coatings for application on glass substrates, and was a pioneer of this technology, introducing its first qualities for glass tableware decoration in 1996. Since that time, Diegel has developed many improvements and optimizations to fulfill changing market demands and satisfy critical refinements in technical specifications, which are today marketed under the Hydroglasur brand. Our waterborne organic coatings are heavy metal-free, single-component, eco-friendly systems. Not only are they lead-free but additionally BPA-free, NMP-free and DBTL-free.

Due to their outstanding adhesion to glass, and excellent chemical resistance properties, our Hydroglasur coatings are especially suited for the coating of household glass and ceramic tableware, such as tumblers, mugs, cups, plates or bowls, that are cleaned regularly in the dishwasher. Hydroglasur is guaranteed for 500 cycles in the household, family dishwasher, although – dependant on the coloring system – usually far more cycles are

achieved. For industrial dishwashers, 2000 cycles and more are easily reached. Additionally, Hydroglasur coatings are scuff-resistant to the impacts experienced during packaging or transportation. Glass and ceramic items coated with Hydroglasur are certified for direct food contact by external institutes. Coating of glasses, cups and bowls can be recommended without restrictions; for plates, we recommend coating the rim or complete backside area.

Objects coated with Hydroglasur are hard to distinguish from pigmented or etched surfaces. Offering an unlimited variety of colors and effects, Hydroglasur coatings are available in highly transparent to completely opaque forms, and with high gloss to matt surface effects. Our basic color system is available as color concentrates that include all Pantone® color shades. Mixable in any ratio, it enables our customers to achieve any desired color shade. The easy handling

of basic lacquers and color concentrates allows the creation of many shades with different gloss levels in a fast, easy and economical manner. We can also produce custom colors based on color charts, color systems, or specifications, or from the common color reference charts.

Our current systems BGS400 glossy and MGS400 matt can be used on both glass and ceramic substrates, and application is easy and economical within a wide range of machinery parameters. For special application methods, such as electrostatic, high-speed bells and discs, drying-optimized versions BG450 glossy and MG450 matt are also offered.

With the addition of Diegel Creative Coatings to the Ferro family, our line of decorative colors is significantly enhanced, helping you to add further value to your products and brands.



FOREHEARTH COLORATION HELPS SUSTAINABILITY

Glass has an amazing capacity to be durable, while being 100% recyclable, virtually inert and preserving the original taste of the products it contains. By making fully integrated glass recycling an essential part of its industrial processes since decades, and advocating for separate collection systems of glass across the EU, the European Container Glass Industry is a pioneer of the circular economy. Through the European container and tableware glass manufacturer's federation FEVE, the industry continues to be a loud voice to encourage the re-use of glass and to increase recycling rates. Here at Ferro, we endorse and support this policy, and our research teams investigate how we can positively impact the sustainability of glass in the circular economy.

For example, we pioneered the use of forehearth color technology as a cost-effective way to manufacture colored glass in shorter campaigns and to produce specialty colors, compared to coloration in the glass tank... and in fact, this technology can also be used to help glass producers increase their recycling rates.

One downside of increasing the percentage of glass cullet introduced into the glass during manufacturing is a potential reduction in the end quality of the glass containers or tableware. Cullet may carry organic materials with it, which causes the glass melt to be slightly more reduced, resulting in discolored glass which can create greyish to greenish shades of flint glass. Our research teams have

BUILDING A MARKET FOR INNOVATION

A FERRO/DIP-TECH ROAD-MAP

For glass fabricators contemplating investment in a new technology, a well-planned roadmap that extends long beyond the actual installation is essential for success. Adding an innovative technology is more than making room on the production floor for a new machine. Nor is it simply a matter of delivering the same product or service, only faster or better. It's about taking strategic actions. Adding new expertise and capabilities. Building a market. Creating demand. Reaching new customers.

For early adopters, the journey can be challenging, and this is particularly true for digital printing technology, which can require some fundamental business adjustments compared to screen printing. As such, it's not one that any glass processor should navigate alone. Rather, your technology supplier should be willing and able to assist throughout the journey, fully committed as a partner for mutual success.



While every company defines partnership differently, at Ferro we think there are **5 key criteria** that help differentiate genuine collaborators and partners from mere suppliers. Whilst our focus here is on digital printing, the same principles apply to any new technology introduction:

Look for great innovation and proven technology: Most importantly, start with the technology itself. Look for a truly innovative solution that answers a clear need for your business. This could be to satisfy an immediate customer demand – for example, adopting digital printing to introduce design and/or functional innovation, production and/or service flexibility – or to position yourself for future growth. Consider if the solution is easy to use and fast and simple to maintain. An easy onboarding process will reduce the time and effort for your team to become proficient with the new technology, and overall ease-of-use and maintenance will empower them to work productively. Next, explore other crucial elements about the company itself. For example, does it have proven experience and success stories, preferably in your target markets, both



vertical and geographic? Does it continue to innovate? Not only with its ability to introduce new solutions but also to upgrade legacy solutions – for example to support new ink formulations, higher resolution, or other advanced capabilities made available with newer systems – so that new equipment does not soon become outdated.

Expect a deep understanding and knowledge of your business and market: To help you succeed with a new technology, your partner must understand your business, as well as your market. This begins in the purchase process, as they work with you to pinpoint the exact solution from within their portfolio that best suits your business needs. Then, once installed, it's important that your partner is able to help you market your new technology, together with its capabilities. So, for example, if you're making a first-time purchase of a digital glass printing machine, not only will you want to introduce this option to existing customers, you will also want to attract new clients in new markets. A true partner will help you position your new offering with existing clients and also work with you to better define



your wider market. Your technology partner should be familiar with your target market, their varied options, and the type of information potential clients may need to influence their decision to work with you.

Talk with successful users: More than likely, you are not the company's first customer. Even a leading-edge technology will have existing users you can query. We strongly recommend that you request testimonials about working with the company and its technology, as well as challenging the resulting improvements to overall business and workflow. Ideally, ask for a live meeting and/or demonstration at a busy customer's site. Seeing the technology in action in a real glass fabrication environment will likely trigger more questions as you learn and watch. We understand that not everyone will invite in a competitor, but at Ferro we have found that many of the companies we partner with for advanced glass solutions are happy to showcase their capabilities to others in their industry. For example, WOON-TECH, a Massachusetts, USA-based glass fabricator, explains the benefits this way: "We're willing and able to teach prospective users – even competitors – about our digital glass printing division, creating new awareness of the technology and its



merits. As we see it, our identity as a Dip-Tech partner, not just a user, creates exposure in positive and productive ways. This includes opportunities for networking and discussions that drive us to up our own printing game."

Demand end-to-end support: No more "buy and goodbye"! A partner must aim to be around for the long-haul, and provide end-to-end support. In addition to providing stellar technical support and on-site training, your technology partner should be ready and able to assist you in building a team of skilled personnel to work with and maintain the new technology. Installation should be merely the beginning of a collaborative relationship throughout which your partner is easy to reach and continually delivers 360-degree support. For example, Dip-Tech provides customers with technical support, spare parts, design and graphics support, marketing support, and ready-to-use sales tools such as brochures, videos and presentations. Likewise, your partner should 'stand by you' in joint marketing events, offering its experts for seminars, conferences and the like, helping you to raise your profile and expand your market reach within its wide network.

Look for local support: Most companies will offer some form of support, but for a new technology installation, local presence of personnel who speak your language can make a significant difference. Additionally, wherever you are in the world – the Americas, Europe, MENA, or Asia – it would be preferable to partner with an organisation which has a local parent or subsidiary company rather than only third-party representation in your area; a local in-house team will be trained and dedicated to deliver the company's values, and will have the global reach, market knowledge and expertise that you will need along the journey.

At Ferro, we believe that success with a new technology depends on collaboration. And finding the right partner is as important as identifying the right equipment or product. A true partner will help you to navigate new markets, garner expertise and sell your services better. Beyond narrowing your learning curve, this saves you time, money and human resources every step of the way. In other words, when adopting a new technology, don't face the challenges ahead alone, partner with the experts who have a proven track-record ... **Because at Ferro, we believe that when our customers succeed, we succeed.**



CHINA GLASS 2019 REVIEW

Since its inception in 1986, China Glass has become one of Asia's premier showcases for suppliers of materials, equipment and machinery to the glass industry. The annual exhibition alternates between Shanghai and Beijing. We have supported the event since 1999, and, alongside Dip-Tech, our world leading digital glass printing subsidiary, we were again present at China Glass 2019, which was held this year in May at the Beijing Exhibition Centre. Celebrating Ferro's centennial at the show, our booth which was our largest ever, showcased our comprehensive offering of colors and coatings, and Dip-Tech digital printing solutions, for all glass markets, including automotive, architecture, appliance, container and tableware glass.

The show was a perfect platform to demonstrate live our NEra D Plus digital printer, our latest dedicated printer for architectural glass, showcasing high resolution designs, excellent throughput, and exceptional results. We also unveiled our digital print solution for precious metal inks, ideal for creating finely detailed metalized highlights, as demonstrated on architectural glass samples printed with gold-based inks. The solution is based on a new dedicated ink system, tailored for use with luxurious high-end inks, that reduces waste to a minimum.

Visitors were able to view examples of automotive glass produced with Dip-Tech's NEra V Plus digital printer, the fastest and

most versatile printer designed for a wide variety of automotive glass formats, as well as appliance glass samples printed with our VEra digital glass printer. Powered by ULTRA-FIX technology and supported by the newly-developed Ferro ULTRA-FIX inks, the Dip-Tech VEra is the first ever digital glass solution for appliances. It redefines the possibilities for appliance glass decoration, by uniquely enabling multi-color appliance glass printing in a single run.

Dip-Tech's latest tools for architecture and design were also previewed at the show. These included the exclusive Dip-Tech Digital Design e-shop with more than 500 ready-to-print files designed specifically for glass applications.

Our booth highlighted exceptional advances in Ferro's organic coatings and inks for containers, as well as traditional glass enamels for automotive, appliance, building, tableware and bottle glass.

At the show, Luca Pecorara, Ferro Vice President, Asia-Pacific commented: As Ferro embarks on its centennial celebrations, we are proud of the glass challenges we've solved and the reputation we have built through 100 years of innovation and expertise. While China Glass was an excellent opportunity to display our latest materials and Dip-Tech digital printing technologies, it also served as a catalyst for the continued progress we anticipate for ourselves, for our customers and for the glass industry as a whole."



NEW PRODUCTS INTRODUCED BY FERRO IN THE LAST THREE YEARS

FLAT GLASS		BENEFITS
UV Strippable coating	Architecture and Appliance	Coating to protect glass surfaces from impacts and scratches during transport and assembly
s1de ONE matt and metallics	Architectural	New design opportunities for external surface application on buildings
System TEA (True Edge Application)	Architectural	TEA allows structural glazing with glass enamels at the edge of PVD-coated glass
LustReflex coating	Appliance and Architectural	Almost invisible coating to enhance durability of glass and ceramic glass surfaces
Cool Color coatings	Architectural and Appliance	Enamels with IR-reflecting properties for cool surface and energy saving
High Opaque/High Durability Black	Appliance	Bismuth-free, cost-efficient, passes appliance chemical durability and foodstuffs testing
AUTOGLASS		
Conductive silver pastes for coated windshields	Laminated glass	Especially designed to be compatible with different coatings on laminated glasses
Black inks for digital printing	Digital Printing	Exclusively for use with Dip-Tech digital printers or LPKF LaserTransferPrinters. Printing of inks on laminated and tempered glasses with high chemical durability, non-stick properties and more
Conductive silver inks	Digital printing	Exclusively for use with Dip-Tech digital printers or LPKF LaserTransferPrinters. Printing of silver inks for fine line conductive tracks, bus bars and antennae
High resistant conductive silver paste	Laminated/Tempered Glass	Especially designed to pass 20 cycles of PV1200 ageing test
Conductive silver paste for lead-free soldering	Laminated/Tempered Glass	Especially designed for the use in leadfree soldering process
High resistant black enamels	Tempered glass	Excellent antistick and silver hiding properties, deep black color, passes 140 hours H ₂ SO ₄ Toyota test
Black inks for LaserTransfer Printing (LTP)	Digital printing	Exclusively for use with LPKF LTP printers. Printing of edge bands, logos, serialisation
Conductive silver inks (LTP)	Digital printing	Exclusively for use with LPKF LTP printers. Printing of fine line conductive tracks, bus bars, antennae
CONTAINER GLASS		
VNS series Metallic-effect colors	Beverage bottles Cosmetic bottles/Giftware Tumblers/Tableware	Special effect metallic shades with good scuff resistance
Organic HTP neon inks	Beverage bottles Cosmetic bottles/Giftware Tumblers/Tableware	Intensive neon color shades with good dishwasher resistance
Fluorescent effect forehearth colors	Beverage/ Cosmetic bottles/Tableware	Feeder frits or pearls to create fluorescence under UVA and Laser
Chrome pearl forehearth colors	Beverage/ Cosmetic bottles/Tableware	Environmentally friendly, allows to achieve a yellow shade (Cr ⁶⁺) in compliance with REACH
CERAMIC DINNERSWARE		
7 Color Digital Process Inks	Dinnerware	Application onto the unfired glaze (earthenware, stoneware, bone china)
Matting agent 69600	Dinnerware	Allows matt appearance with very smooth finish
New Colors for Inglaze series Sky100	Decoration	Lead content < 100ppm
New Colors for Onglaze series Samba100	Decoration	Lead content < 100ppm
Starlight100 Metallic colors for high temperature fast-firing	Dinnerware	Lead content < 100ppm
INDUSTRIAL		
ZTH rings prefired	Process Temperature Control	Application for container glass firing cycles
ETH/ETL rings prefired	Process Temperature Control	Application for fast firing cycles, e.g. tiles
STH/STL rings prefired	Process Temperature Control	Application for fast firing cycles, e.g. tiles
Ultrafine filler Glasses for Dental	Dental Composites	0,4-0,7µ to get higher filling grades in dental composites
Phosphate glasses	Dental	Dental cements



high velocities at > 80 m/s. However, for modern industrial applications, grinding wheels with a high degree of technical sophistication are required to satisfy performance demands. The inclusion of glass in the bond provides an excellent solution; glass in a bonding system has the advantage of lowering firing temperatures, with a better uniformity, better interaction and coating of the abrasive materials.

Since using sol-gel corundum in the grinding wheels, the use of glass has become even more important. Because sol-gel corundum is limited regarding the firing temperature, due to its different crystal structure, higher performance glasses are needed. The requirement for a higher bonding strength, different surface tension and low viscosity with a very good wetting behavior to the sol-gel grain is given by glass during the firing process. Specially formulated Ferro glasses are specifically adapted to sol-gel application with a low firing temperature cycle.

The supra-abrasive materials, CBN and diamond, represent different types of materials. Firing temperatures are limited. CBN and diamond are inactive materials and require glass with specific attributes to create hard bonds. The glass must achieve a low viscosity at firing temperatures below 900°C. Additionally a resoftening at 600°C during the grinding process must be avoided. Ferro offers special glasses with a high tendency of crystallization to achieve these requirements. With the possibility to use glass in combination with supra-abrasives, the vitreous bonded supra-abrasive grinding wheels have become more and more attractive. The advantages of longer tool life, precision grinding, and feasible speed velocities of >120 m/s have greatly expanded this market.

Additional to our range of specialty glasses, Ferro also offers a pigment range to color the wheels in every color shade. Main colors are blue, yellow, green and red. Some customers are using different wheel colors to classify different kinds of applications. For example, everyone in the grinding business links blue with a cool grinding.

The trend to lower firing temperatures, combined with a high requirement for bonding strength and high velocity in the grinding process, places very high demands on the glasses. Ferro is tracking these trends and we are constantly working on new solutions to satisfy demand.

AT THE CUTTING EDGE OF GRINDING TECHNOLOGY

GRINDING AND CUTTING WITH FERRO GLASS AND PIGMENTS

Grinding wheels have a long tradition, and in ancient times were known as milling stones. Today, grinding wheels in a wide range of shapes, sizes and composition are used in all kinds of applications. For example, as consumers, we will encounter the smallest wheels on a visit to the dentist, or in the kitchen when sharpening our knives. And on an industrial scale – in transportation for example – grinding wheels are used to grind crank shafts for our cars, or in the production of tracks for our trains and trams. Grinding wheel dimensions vary from 0,5 cm to 1.5 m in diameter, and their velocity in use can reach speeds greater than 120 m/s. Additionally, special tests are made to guarantee the safety of the grinding wheel during the work process.

Grinding wheels are today highly technical formulations, classified by either the abrasive material or by the type of bond employed. Typical abrasive types are corundum, sol-gel corundum, silicon carbide, or the family known as supra-abrasives, comprising CBN (cubic boron nitride) or diamond. Typical bonding classifications are resin, metal, or vitreous.

Generally, a grinding wheel needs a bonding system, the abrasive material and fillers to create porosity. The porosity has two important functions, firstly taking out the abrasive dust, and secondly to bring cooling agent to the work area. Traditionally the grinding wheel producers used raw materials like feldspar, clay, quartz and corundum to construct vitreous grinding wheels. In such constructions, the raw material bonds are limited in their performance; the firing temperature is high, 1300 – 1400 °C, and the connection of the bond to the grain is low. The result is a low bonding strength and no chance of achieving

FERRO CONDUCTIVE GLUE ACCELERATES PRODUCTION PROCESSES

Ferro teams strive to go beyond the status quo to think differently about every aspect of our customers' businesses and products.

A typical recent example of this began with an enquiry from a customer of Ferro's Electronic Materials business. This customer had employed an existing product, a two-component adhesive used in bank card manufacturing, to electrically connect the card chip to the embedded antenna used to communicate financial transactions.

However, a 24- hour cure time of the adhesive limited the customer's production throughput. Our challenge was to find a faster-cure alternative product.

After receiving a functional requirement from the customer, Ferro's R&D teams in the U.S. and Germany innovated a new product with enhanced properties. The result is a novel Conductive Glue, a one-component adhesive that now provides a cure time of 8 seconds compared with 24 hours for the predecessor product.

The development of this new solution was driven by a focus on understanding our customer needs – a Ferro hallmark – and leveraging the technical expertise of our R&D teams.



Ferro Corporation is a leading global supplier of technology-based functional coatings and color solutions. Ferro supplies functional coatings for glass, metal, ceramic and other substrates, and color solutions in the form of specialty pigments and colorants for a broad range of industries and applications.

Ferro products are sold into the building and construction, automotive, appliances, electronics, household furnishings, and industrial products markets.

Headquartered in Mayfield Heights, Ohio, USA, the Company has approximately 5,900 associates globally and reported 2018 sales of \$1.6 billion.

Our associates work in 30 countries, speak more than 17 languages and bring a wealth of knowledge and cultural perspective to our offices, laboratories and plant facilities every day. While we learn and benefit from the unique experiences that arise from our diversity, we also share a common set of core values and operating philosophies. We believe that our long term success will be determined by who we are and how we act.

Our core values apply equally to all interactions with customers, suppliers and colleagues:

- **Customer Focus:** Our customers are why we exist; we want to build trusting relationships that make customers successful.
- **Accountability for Performance:** We work to achieve the highest performance standards, to create value for customers and shareholders.
- **Innovative Thinking:** We seek new ideas for technologies and business processes, and are always striving to improve and serve our customers better.
- **Teamwork and Collaboration:** we are committed to a work environment of trust and respect, working together to consistently deliver value to customers and shareholders.

Where innovation delivers performance.

	KEY PRODUCTS	END-USE APPLICATIONS
PERFORMANCE MATERIALS	Tile coatings and digital inks; Porcelain enamel coatings; Structural and fine ceramics coatings; Glass enamels; Conductive metal pastes, powders and flakes; Forehearth colorants; Specialty colors and glasses; Organic coatings and inks; Electronics packaging materials and multilayer materials; Inorganic colored pigments; Organic pigments; High-performance polishing materials	Ceramic floor and wall tiles; Appliances; Dinnerware; cookware; Roof tiles; sanitaryware; Water heaters and industrial products; Automotive, architectural, furniture and container glass; Dental products; Electronics packaging; Semi-conductor wafers and capacitors; Paint & plastics; Vinyl siding, pipe and flooring; Touch sensitive displays; Ophthalmic lenses



Diegel Headquarters, Germany



Dip-Tech Headquarters, Israel



Pinturas Benicarlos, Spain

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YEARS **AHEAD**

For outstanding color and coating technologies – both
decorative and functional – Ferro are global market leaders.

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