Solutions for wire and busbar stripping

A new era in electrical manufacturing

Louise May

Because of their advantages over standard electric wire and cable, laminated busbars and flat wire are now used extensively in modern power distribution systems in applications such as electric vehicles, solar and wind energy systems, data centers, and industrial machinery. However, a major challenge in using these conductors in mass production is the need for a fast, clean and accurate process to remove sections of the insulation to ensure a clean and precise electrical connection with electrical components. In this article, we look at how Luxinar, a leading UK manufacturer of sealed CO_2 lasers, is addressing these challenges and helping companies across multiple sectors to modernize their manufacturing processes and stay ahead of the curve in an increasingly competitive market.

A brief history of busbars

A busbar is a solid strip of copper or aluminum used for transporting an electric current from one location to another with minimal energy loss. They were first introduced in North America during the 1930s as a replacement for cables, which were proving problematic for on-site installation in skyscrapers and for the development of production technologies in factories.

The term ‘bus’ derived from omnibus (meaning ‘for all’ in Latin) a term coined by Stanislas Baudry who introduced the first public bus system in Nantes, France, in 1826. In the same way, busbars can carry all the currents in a particular system, because compared with cables their wide and flat design offers much more surface area for conducting the electricity.

As a side note, for similar reasons, the term ‘bus’ was adopted by computer designers in the 1970s as the name for a component that connects various subsystems, allowing data and instructions to flow between them.

Fig. 1 Ablation of a busbar coating with a Luxinar CO_2 laser. For a video, please see the e-special version of the article at https://indd.adobe.com

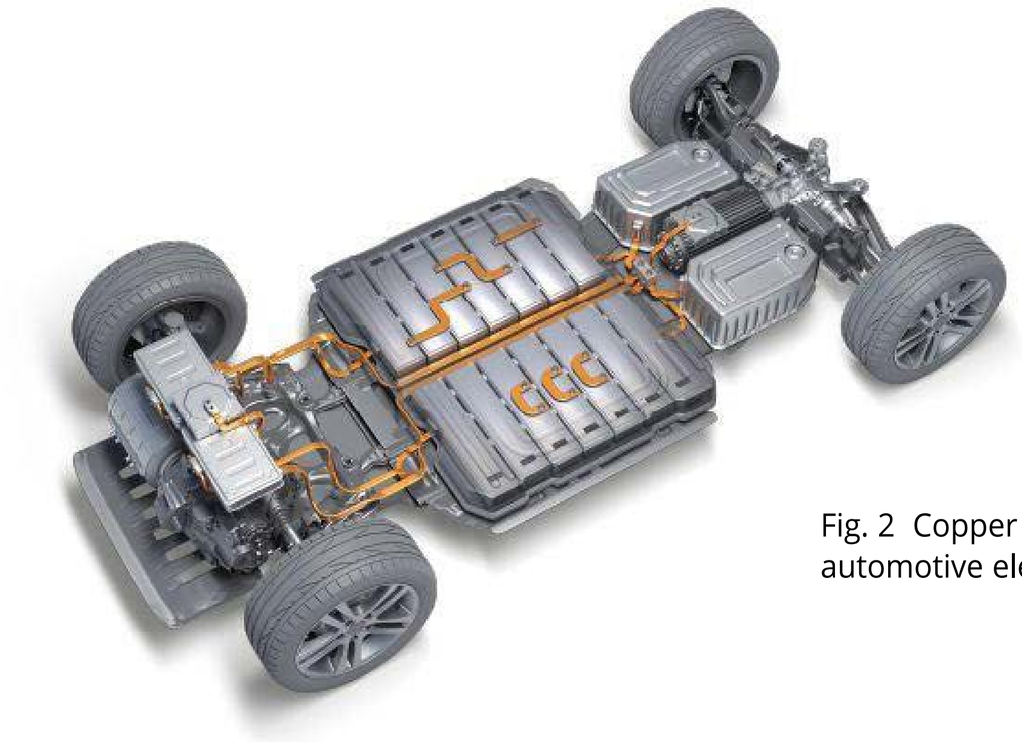

Fig. 2 Copper busbars in exemplary automotive electrical system

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Types of busbars and their applications

Compared with standard electrical cable, busbars provide numerous advantages such as improved electrical efficiency, easier installation, and greater flexibility, especially in environments that require high power distribution and scalability.

As a result, busbars are now essential components in electrical power distribution systems, with applications in buildings and data centers, and for managing the high currents that flow between the battery, inverter, and motor in electric vehicles.

Busbars are typically flat or rectangular in shape, made from copper or aluminum. Although aluminum has a lower conductivity than copper, it is both cheaper and lighter, which is advantageous in applications where weight and cost are significant considerations such as solar or wind farms and in electric vehicle production.

For automotive applications, particularly in electric vehicles (EVs) and hybrid systems busbars need to be lightweight and flexible with a current capacity from 100 – 800 A, depending on the design of the battery system and output of the motor. In EV production, busbar material is often supplied in long lengths on a spool, just like a traditional wire. The car maker cuts off the required lengths and bends them to the necessary shapes so they can be routed around a variety of other parts and structures within the car to get the power to where it's needed.

Challenges for busbars in mass production

While most industrial busbars are unlaminated, the busbars used in electric vehicles, solar and wind energy systems, data centers, and some types of industrial machinery are typically covered with insulation to prevent accidental contact, ensure safety, and improve performance by minimizing the risk of short circuits or electrical interference.

However, at the connection points where busbars meet electrical components like transformers, circuit breakers, or distribution boards, it's necessary to remove sections of this insulation to expose the conductive material and ensure a clean and precise electrical connection.

Traditionally, this stripping process has been performed using mechanical tools, such as knives or specialized cutting equipment. But the drawbacks with these methods are that they can lead to inconsistent results, potential damage to the busbar, and a slower production process, as well as having limitations in accessing small or complex areas.

Luxinar's solution: high-speed CO_2 laser busbar stripping

In recent years, Luxinar has made significant strides in busbar stripping by laser ablation using CO_2 lasers that are optimized to improve precision, efficiency, and reliability in de-coating processes.

CO_2 lasers are ideal for busbar ablation because they produce far-infrared light, which is very strongly absorbed by most of the plastics used for insulation, but highly reflected by the copper. This means that the laser light rapidly vaporises the insulation, but then automatically stops removing material when it reaches the conductor because the copper reflects the laser light back rather than absorbing it.

Key advantages of Luxinar's CO_2 laser de-coating methods

Firstly, as it is a non-contact process, the laser does not physically touch the wire or busbar, thus reducing the risk of mechanical damage and maintaining the integrity of the busbar – a critical factor in applications requiring high conductivity and low resistance, such as electric vehicles and renewable energy systems. Furthermore, being contactless this process eliminates stoppages due to tool wear and breakage thereby drastically reducing downtime and production time loss.

Secondly, laser ablation is a digital process enabling fine precision and control over the depth and area of the material being stripped or de-coated. This makes the processes extremely flexible so that changes in the design and geometry of the busbars can be implemented immediately, with no need for costly new tooling.

Thirdly, Luxinar's CO_2 laser ablating processes are fast. A galvanometer scanner passes the laser beam rapidly over the required area, so that two lasers can be used to process all sides simultaneously. This high-speed laser process can dramatically reduce production times while ensuring high-quality results.

Fig. 3 Busbars inside the battery compartment of an electric vehicle

Finally, there are environmental benefits as the process is clean, producing minimal waste compared with mechanical methods. Please watch the demonstration **video**.

Luxinar's recommended products for busbar stripping

A popular choice for busbar stripping is Luxinar's OEM series of sealed CO_2 lasers, which range in power from 450 – 1,000 W and come in 10.6, 10.25, and 9.3 µm wavelengths.

Busbar stripping requires the laser parameters such as power, mode, wavelength, and polarization, to be very stable. For this reason, Luxinar's sealed OEM CO_2 lasers incorporate unique cavity and electrode designs to ensure the required level of stability and pulse-to-pulse consistency. Additionally, they have a high quality, round, symmetrical beam for high processing speeds, and a short optical pulse with high peak power, which combine to ensure optimum process quality and minimize the heat-affected zone.

Luxinar

Headquartered in Kingston upon Hull, UK, Luxinar has been at the forefront of laser technology for more than 25 years and is a leading manufacturer of sealed CO_2 and ultra-short-pulse laser sources. The company has an installed base of over 25,000 lasers worldwide in industries including automotive, electronics, packaging and textiles for applications such as ablating, cutting, drilling, marking, perforating, scribing and welding.

Furthermore, these OEM CO_2 laser sources are based on the well-proven slab principle, with no need for gas recirculation equipment such as vacuum pumps or pressure control systems. As gas exchange is unnecessary before 20,000 operational hours, the running, maintenance, and service costs are minimal – resulting in a long lifetime and trouble-free operation throughout.

They are also a compact solution that can be easily integrated into industrial processing production lines as the OEM series can be sited in confined spaces in any orientation with or without covers.

Wire stripping

Luxinar's CO_2 laser ablation processes are also particularly well-suited for wire stripping and are ideal for delicate or complex wires, such as those found in the aerospace or medical device industries. The laser's precision allows for high-quality, consistent results, even with very fine wires or intricate designs.

A case in point is flat wire, a type of electrical wire that is flat in shape rather than round. It is typically insulated to prevent electrical shorts or interference and is often used in applications like transformers and inductors where space is limited or where a flat surface area is beneficial for heat dissipation and efficient power flow.

Fig. 4 Enamelled flat copper wire

Another type of wire are 'hairpins', rectangular copper wires up to 6 mm wide coated with a dielectric enamel (PEEK, PFA-PI, PA), to provide electrical isolation for electric vehicle motors; this enamel must be partially removed so that the hairpins can be welded for electrical contacting. As with busbars, Luxinar's laser processing of hairpins is contactless, without ablation or loss of copper, and with very little downtime or tooling needed for any changes. Removal rates depend on the type and thickness of coating, as well as the coating method (cross layer), but the use of a CO_2 laser ensures no material loss of the conductive metal.

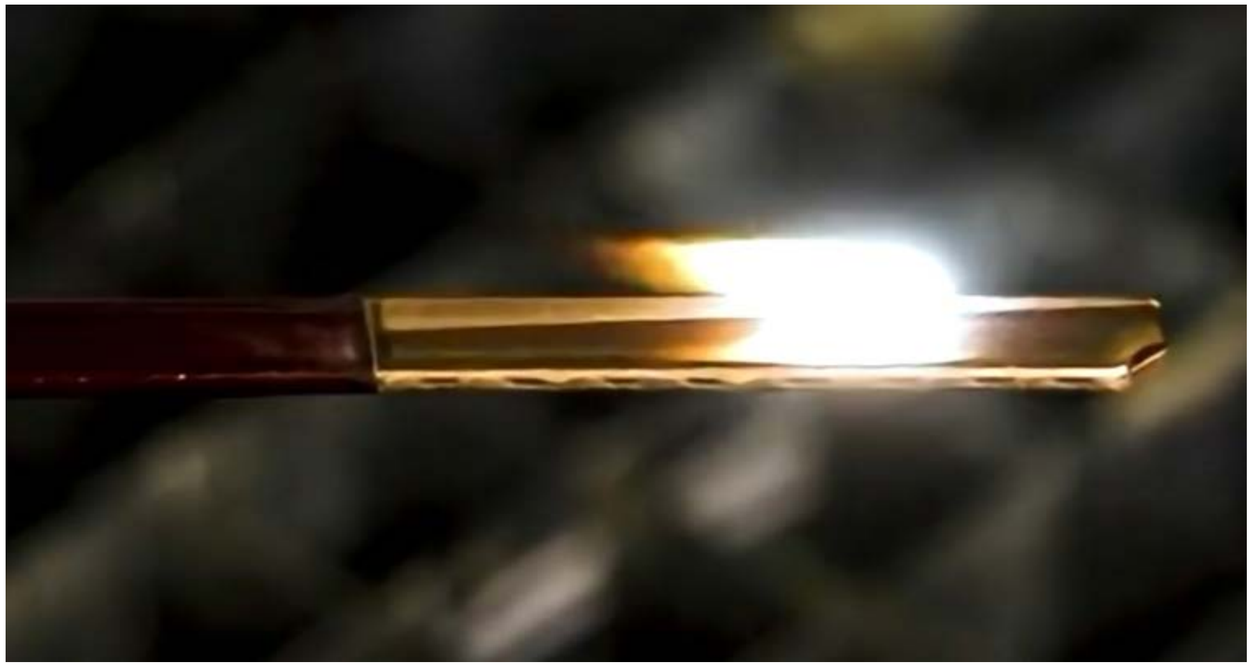

Fig. 5 Ablation of a hairpin with a Luxinar CO_2 laser. For a video, please see the e-special version of the article at https://indd.adobe.com

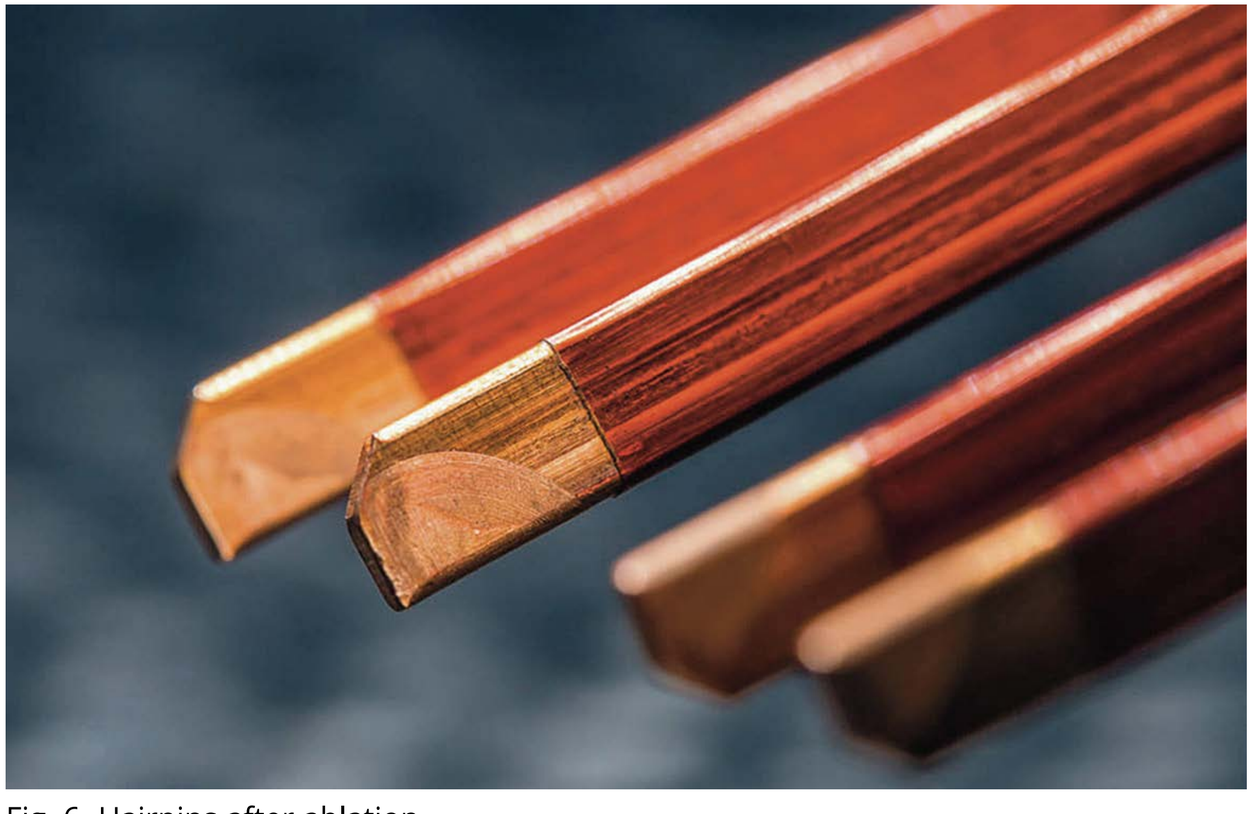

Fig. 6 Hairpins after ablation

Luxinar's recommended products for wire stripping

A good choice for wire stripping is Luxinar's SR series of sealed CO_2 lasers. They come in three wavelengths: 10.6, 10.25, and 9.3µm, and are integrated with field replaceable RF power supplies. The minimum shipment power is 20 % higher than rated power and this series can be easily integrated into laser-based processing machines.

As with the OEM series, Luxinar's sealed SR laser sources are based on the slab principle, with no need for gas recirculation equipment, and gas exchange is unnecessary before 20,000 operational hours, so that the running, maintenance, and service costs of the lasers are minimal.

Another option is Luxinar's 125 W CO_2 laser systems, the MULTISCAN HE and MULTISCAN VS. These systems each comprise a 125 W laser with an articulated beam delivery arm, a built-in galvanometer scanner and control software.

Future outlook

According to a recent market report [1], the global laminated busbar market is estimated to grow from $ 863 M in 2023 to $ 1,296 M by 2030, growing at a CAGR of 6.0 %, driven by increased demand for renewable energy, electric vehicles and advanced charging stations [2].

Increased demand for EV motors and other electromechanical systems used in renewable energy is also predicted to drive the global enamelled copper hairpin and flat wire market – from $ 418.7 M in 2023 to $ 556.8 M by 2030 [3].

These market trends suggest that the future of wire stripping and busbar de-coating using CO_2 lasers is exceptionally promising, and with ongoing advancements in precision, speed, automation, and environmental sustainability, CO_2 laser technology is poised to become the gold standard in these processes. And as industries continue to demand higher efficiency and flexibility, particularly in areas like electric vehicles, renewable energy, and advanced electronics, Luxinar's CO_2 lasers will enable manufacturers to meet these challenges head-on, delivering faster, cleaner and more accurate manufacturing processes, with better quality control.

[1] https://www.gminsights.com/industry-analysis/busbar-market
[2] https://www.businessresearchinsights.com/market-reports/flatwire-hair-pin-motor-market-105774
[3] https://reports.valuates.com/market-reports/QYRE-Auto-31T13075/global-enamelled-copper-flat-wire