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Innovative insulation technology for SiC Power Electronics

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INTRODUCTION

A laminated busbar (LBB) manufacturing today is faced with multiple challenges :

- The need to increase service life of the product;
- Limit the appearance of partial discharges;
- Reduce the cost and energy consumption.
- Endure constraints required by the futur SiC converters (voltage, frequency,...)
- Deal with extreme environmental conditions.



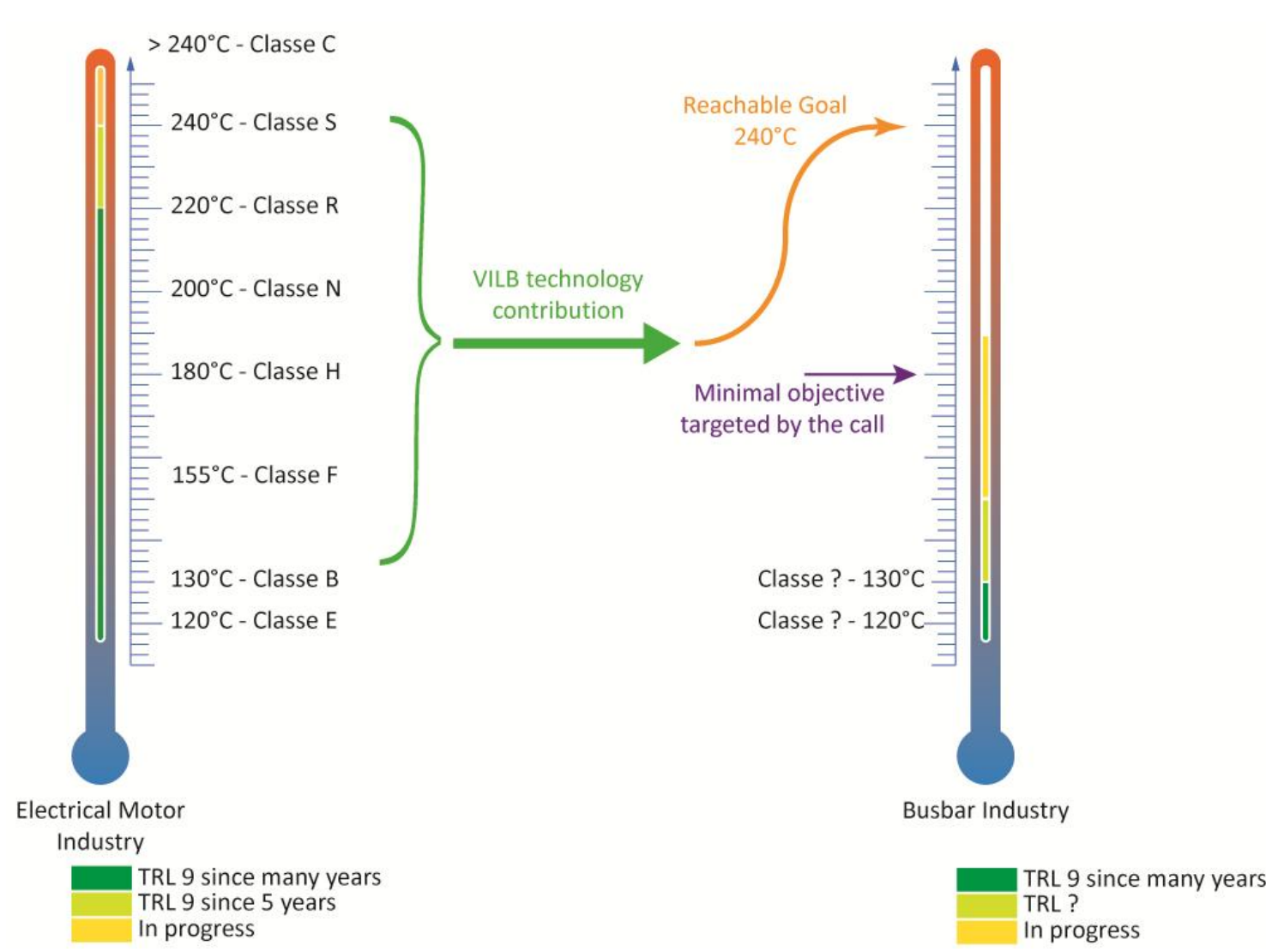
OBJECTIVES

Contribute to the necessary adaptation of **laminated busbars** to the development of new **high power switching devices** operating in **extreme conditions**

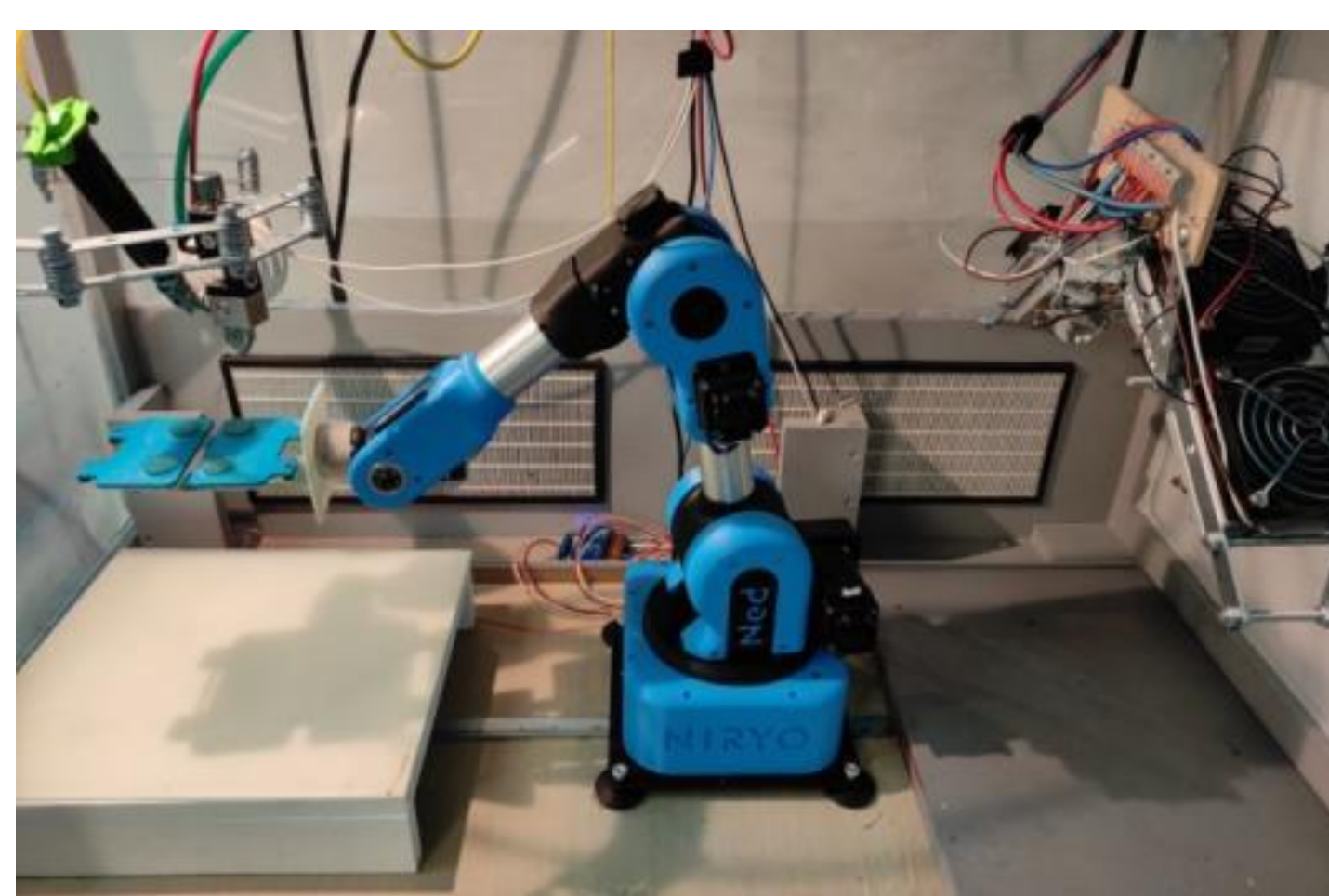
Provide a high level of reliability during the whole exploitation time of the product

VARNISH INSULATED BUSBAR (VIB)

VIB is used for the first time in laminated busbars. This new technology is based on existing varnish insulation in electrical machines.

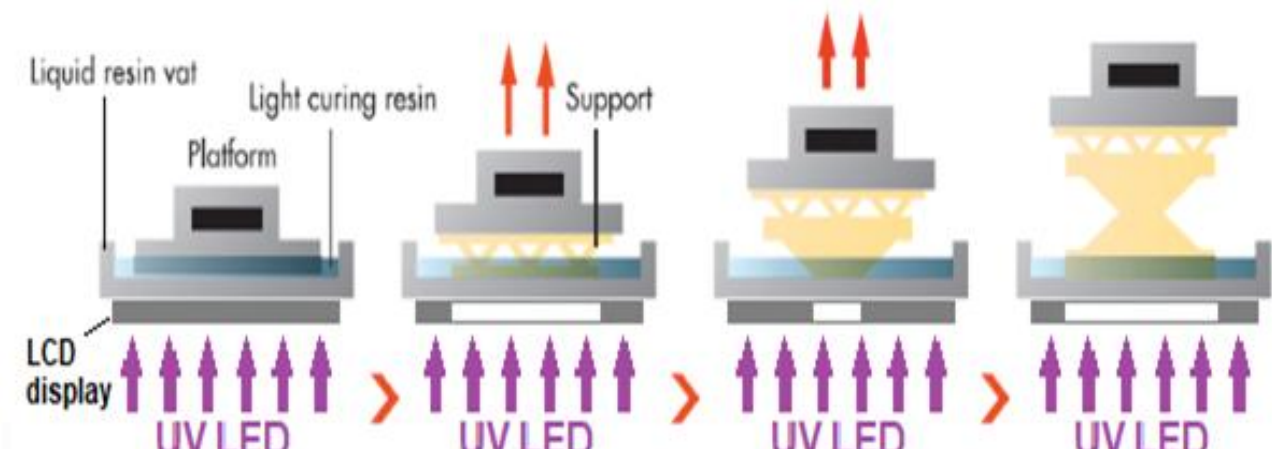
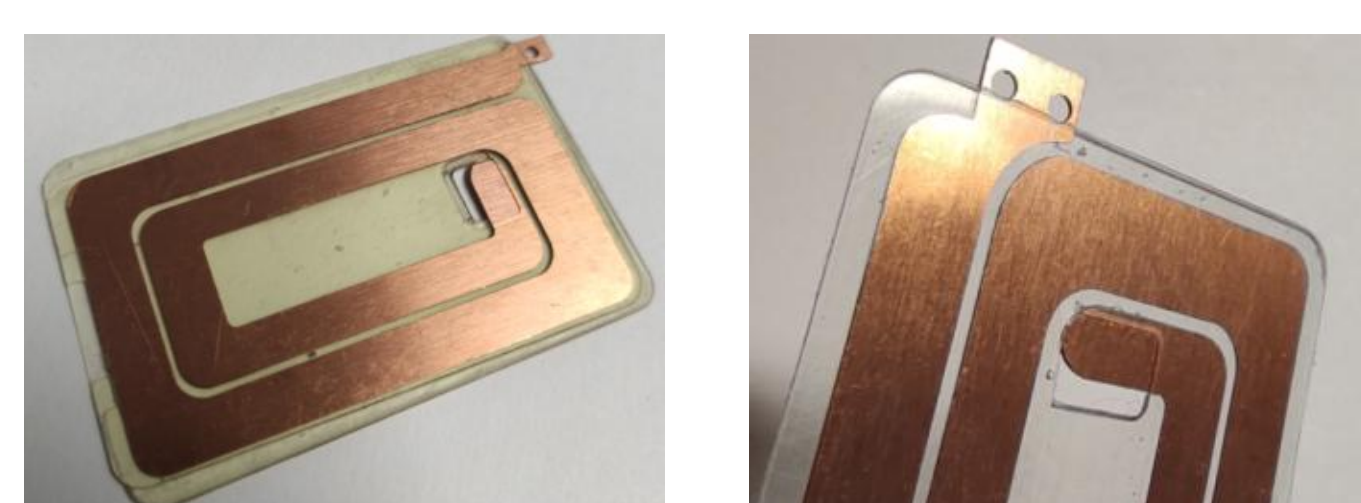
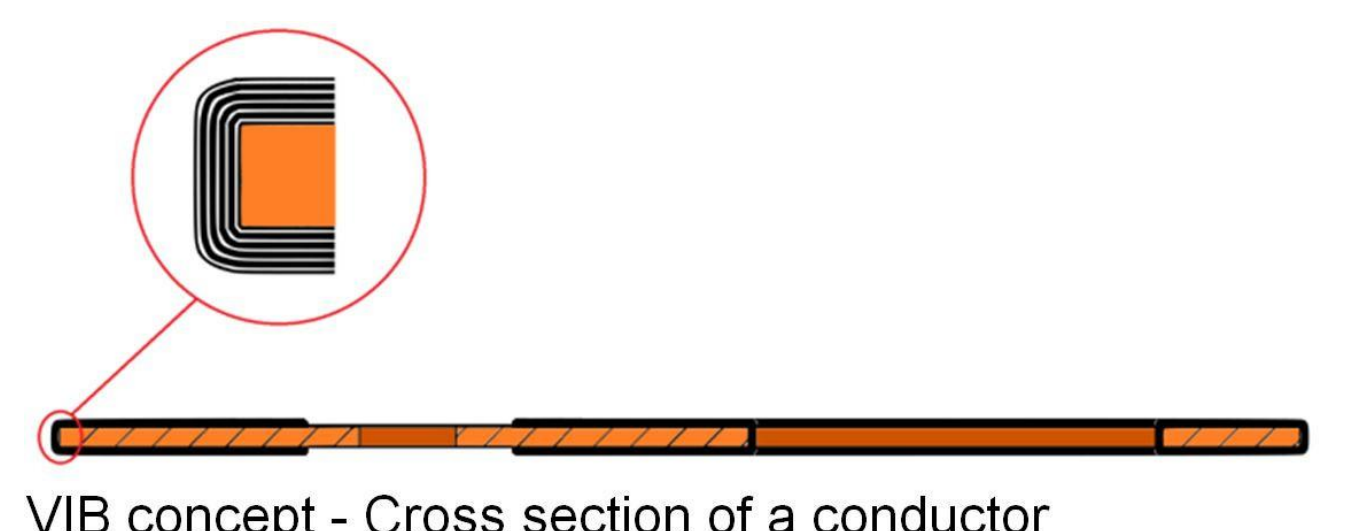
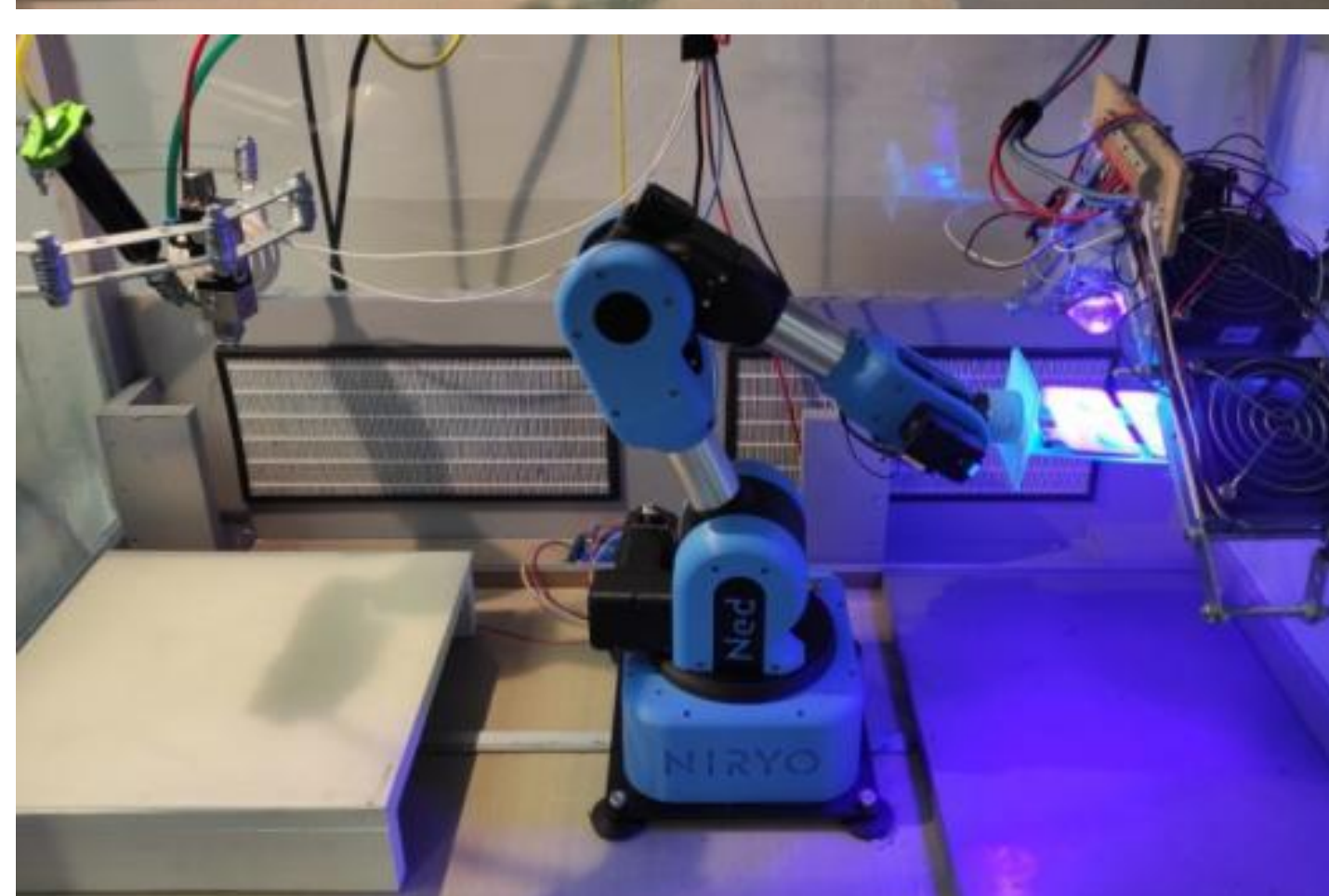


The process consists of depositing multiple very thin layers (~ 10 microns) of varnish using a micro spray gun and curing with UV light after each layer.



few to no air bubbles are encapsulated in the varnish.

high dielectric strength and high PDIV.

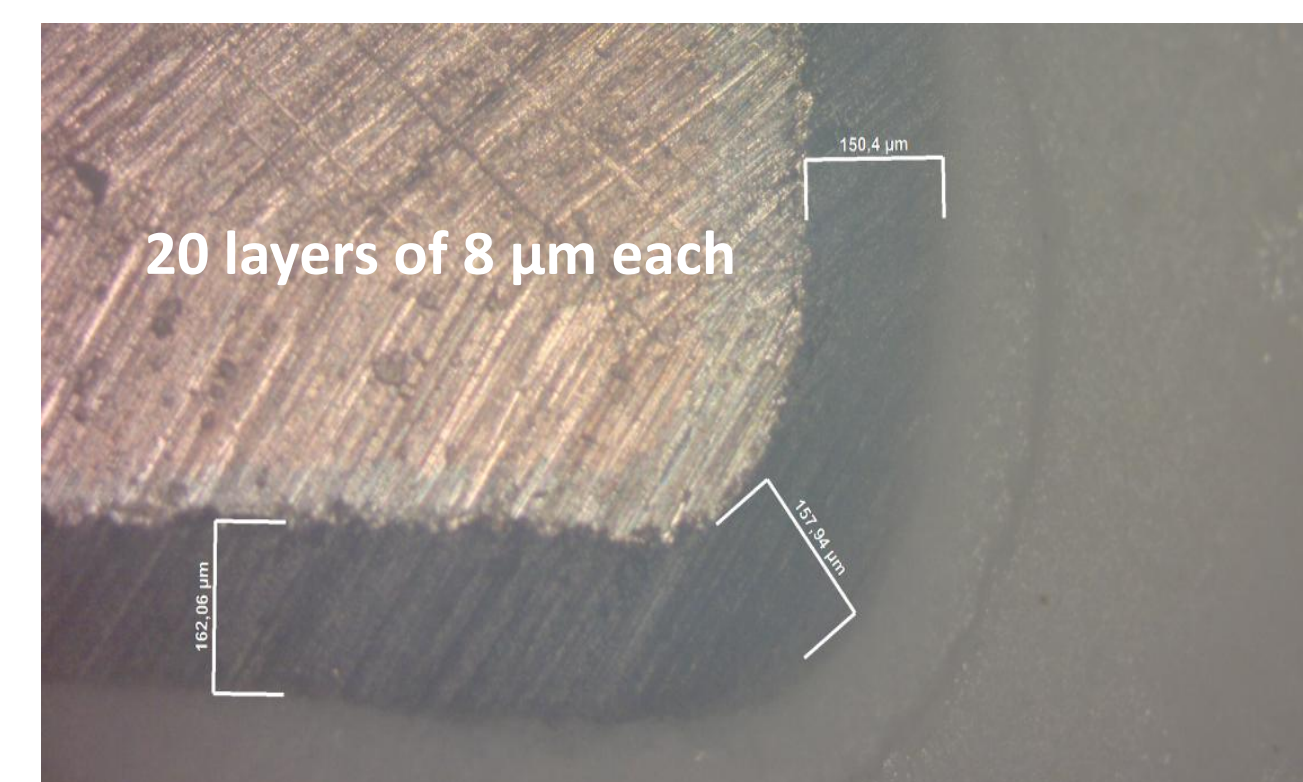
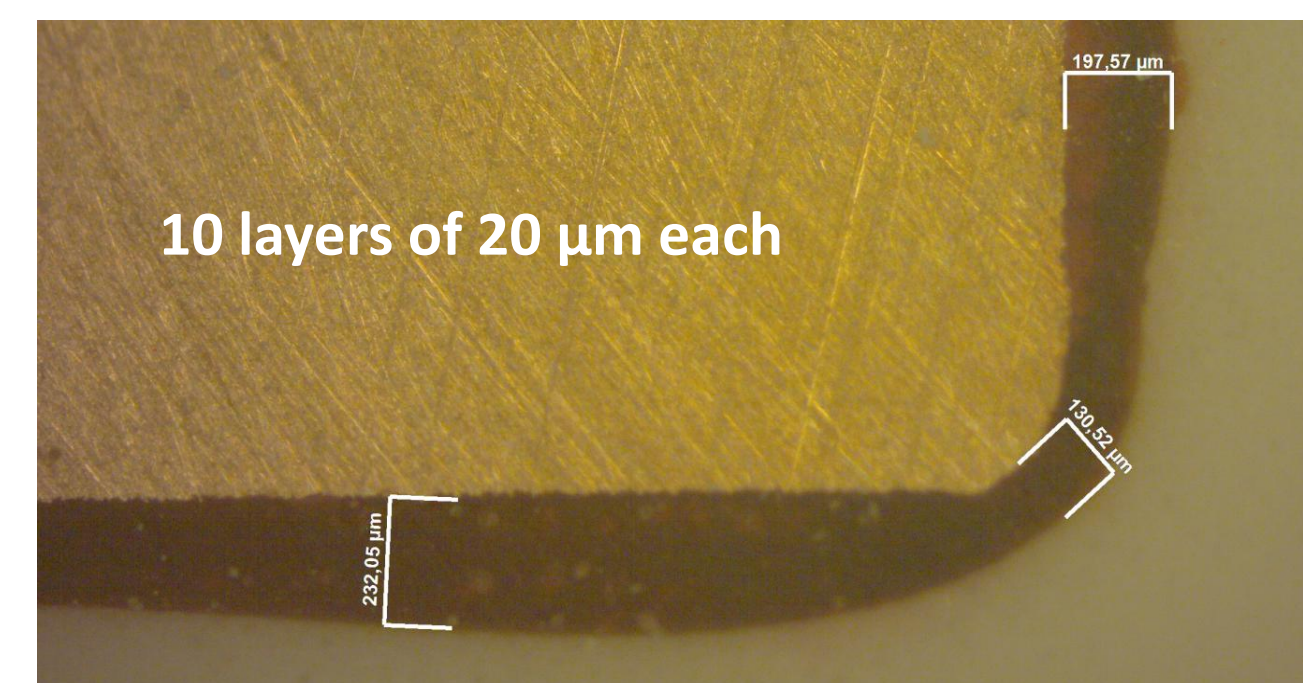


An alternative manufacturing process (patent application filed) is to use additive manufacturing, which consists of 3D printing successive layers using SLA – LCD technology on each face of the conductor. Well suitable for flat busbar (example : conductors for power planar transformer):

- complete encapsulation, including lateral sides (creepage distance, compacity
- bubble-free (partial discharge)

RESULTS

Currently, the varnish insulation is capable of withstanding **180°C** continuously, thanks to various formula adaptations and the introduction of Silane coupling agent that serves as adhesion promoter.

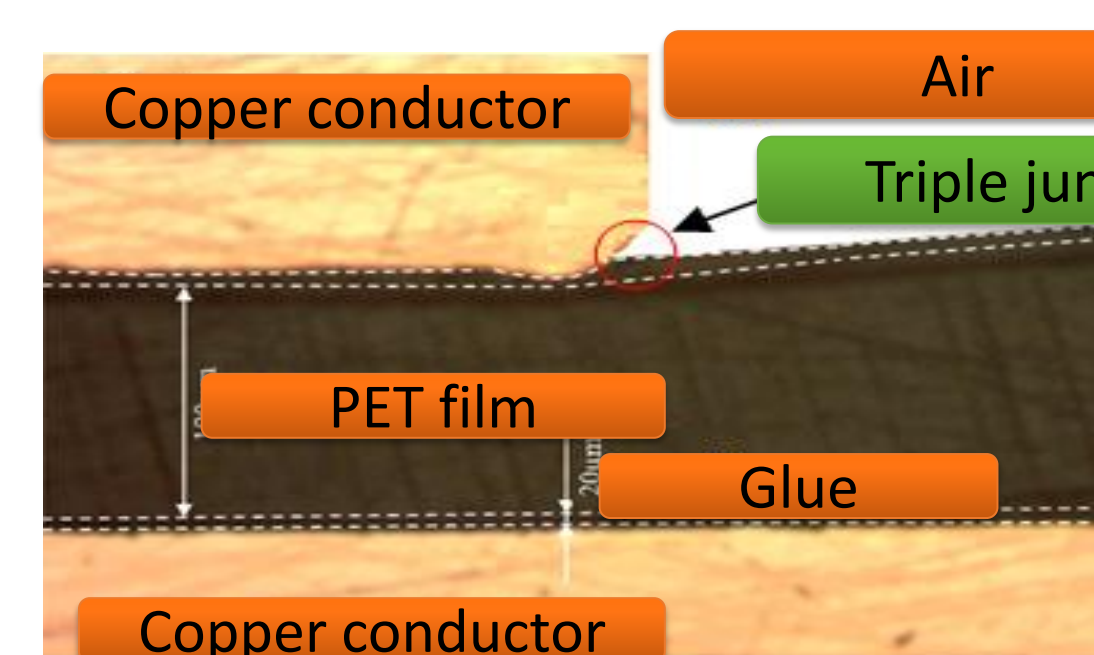


The coating on the edges is particularly important due the high concentration of the electric field in these areas. This coating has been significantly improved thanks to the use of thin layers and a thixotropic agent in the formula.



The breakdown voltage tests performed on the dielectric are rather promising :

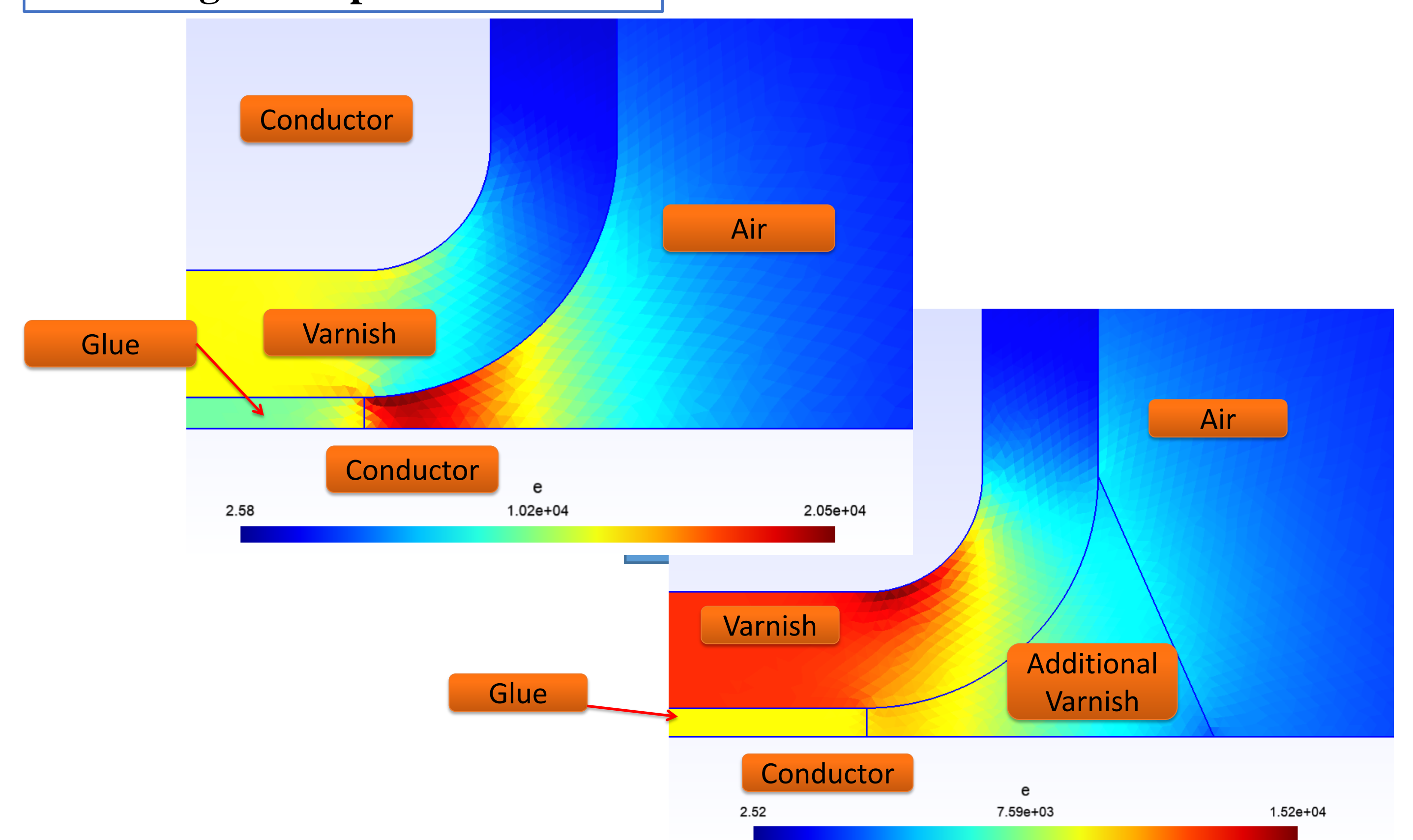
- 9.5 kV AC for 100µm on the surface.
- 2.5 kV AC for 100 µm on the edges.



The insulation the **critical areas of the busbar** needs further improvement

much lower electric field intensity in the air in these areas. **higher PDIV and a longer life span.**

Solution ? fill the triple junction with a dielectric that contains as little air cavities as possible.



PROSPECTIVES

- Introduction of **micro & nano inorganic fillers** (BaSO₄, SiO₂, Al₂O₃, TiO₂) to improve performances in : thermal resistance, creepage discharge performance, corona resistance ...
- Use of an **electret layer** (varnish with BaTiO₃ ferroic filler) in to significantly limit the electric field intensity.
- Combine UV curing with thermal curing using a thermal curing agent.
- Characterization of a laminated busbar performance in a simulated aeronautical environment.

This project leading to this application has received funding from the Clean Sky 2 Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement No 821065. (<https://cordis.europa.eu/project/id/821065>)



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