

Making Electric Vehicles Safer, Lighter and more Sustainable

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NUTRITION · HEALTH · SUSTAINABLE LIVING



DSM

BRIGHT SCIENCE. BRIGHTER LIVING.

Dr. Tamim P. Sidiki

Tamim is Global Marketing Director Mobility at DSM Engineering Materials.

During his career Tamim has built up business and technology experience in positions at Philips Electronics, NXP Semiconductors as well as DSM Engineering Materials. Tamim has more than 25 years of experience in the Electronics and Automotive Industry and is with DSM since October 2007.

Tamim holds a Master Degree in Physics and a Ph.D. in Electrical Engineering obtained at universities in Germany, Sweden and Scotland. He has published more than 20 scientific papers in international Journals and is owner of multiple patents in Semiconductor and Polymer applications.



The automotive industry faces never-before seen change

Technological



Electrification



Connectivity



ADAS/Autonomous Driving

Social



Urbanization



Sharing

Sustainability



Emission Standards

City Regulations



Investors



Public-interest groups

Fossil resource powered



Electric

Human-Driven



Autonomous

Sustainability is a differentiator

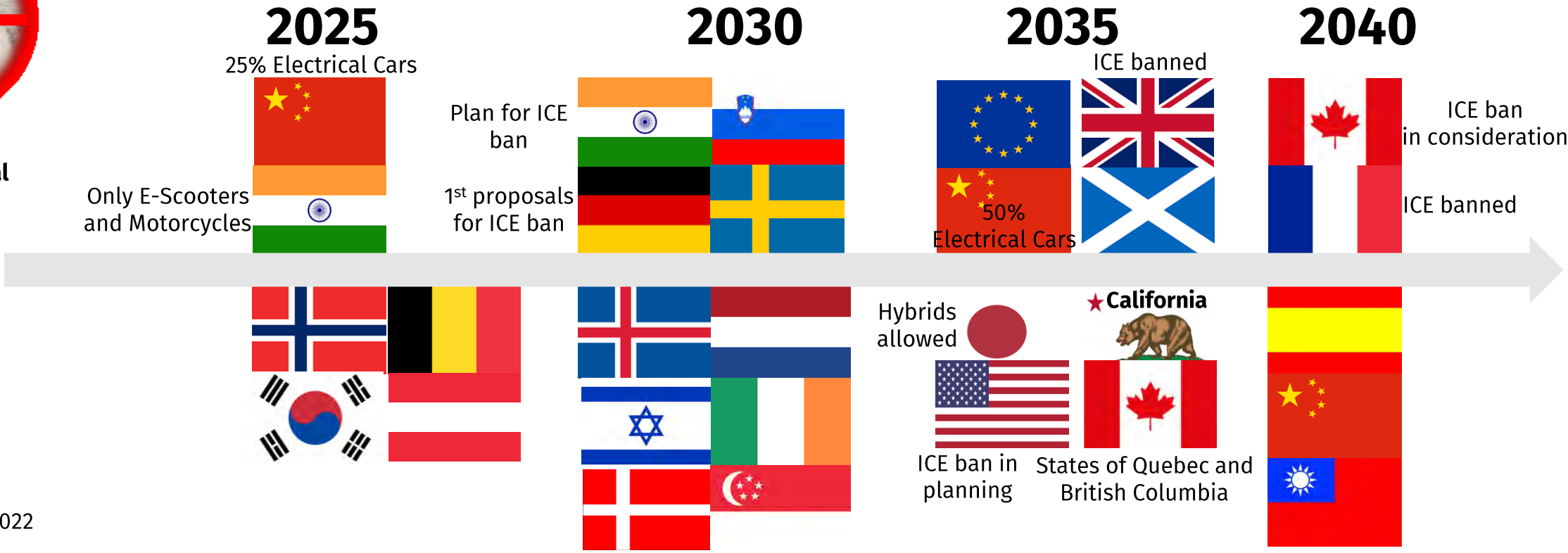


Sustainability becomes a strong qualifier

More than 25 countries plan to ban sales of combustion cars



Governmental timelines

Status August 2022

Key Drivers:

- Governmental regulations and policies on Emission reductions
- Growing Consumer demand
- Growing OEM focus on sustainability



The sun is beginning to set on pure ICE engine's

OEM
timelines



2019



2022

Stop pure ICE, only Hybrid and BEV



2025



2030



2035



2040

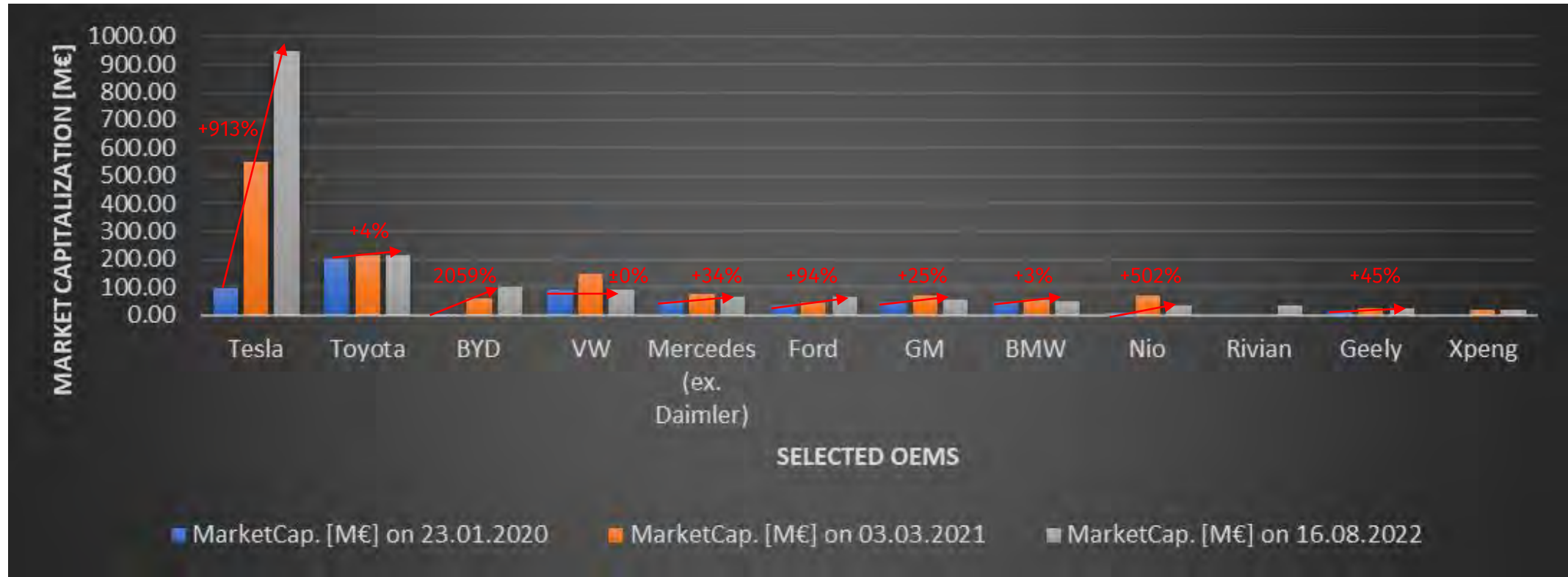
All key markets besides Australia



2050



Electrification and software drives market cap



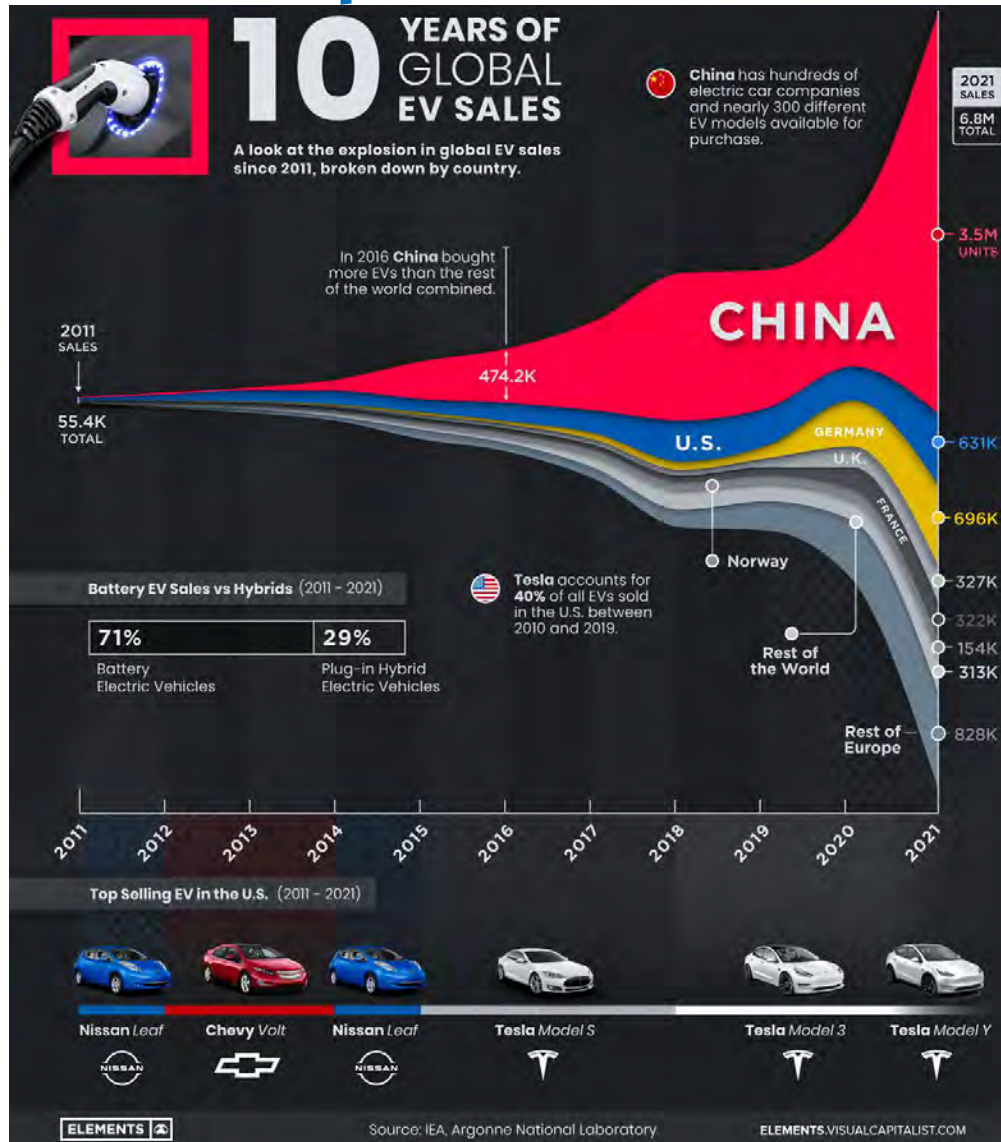
% : market cap delta growth 2022 vs. 2020

Tesla

- More valuable than top 11 OEMs
- Technology leader in e-powertrain and software
- Leader in highspeed charging network



Market penetration of EVs



- 6.8Mio Electric cars shipped globally
- 8.6% share of Electric Cars (more than tripled versus 2019)
- 3 of the global top 5 EV manufacturer are Chinese
- BYD becomes the largest EV manufacturer in H1 2022



Making e-mobility

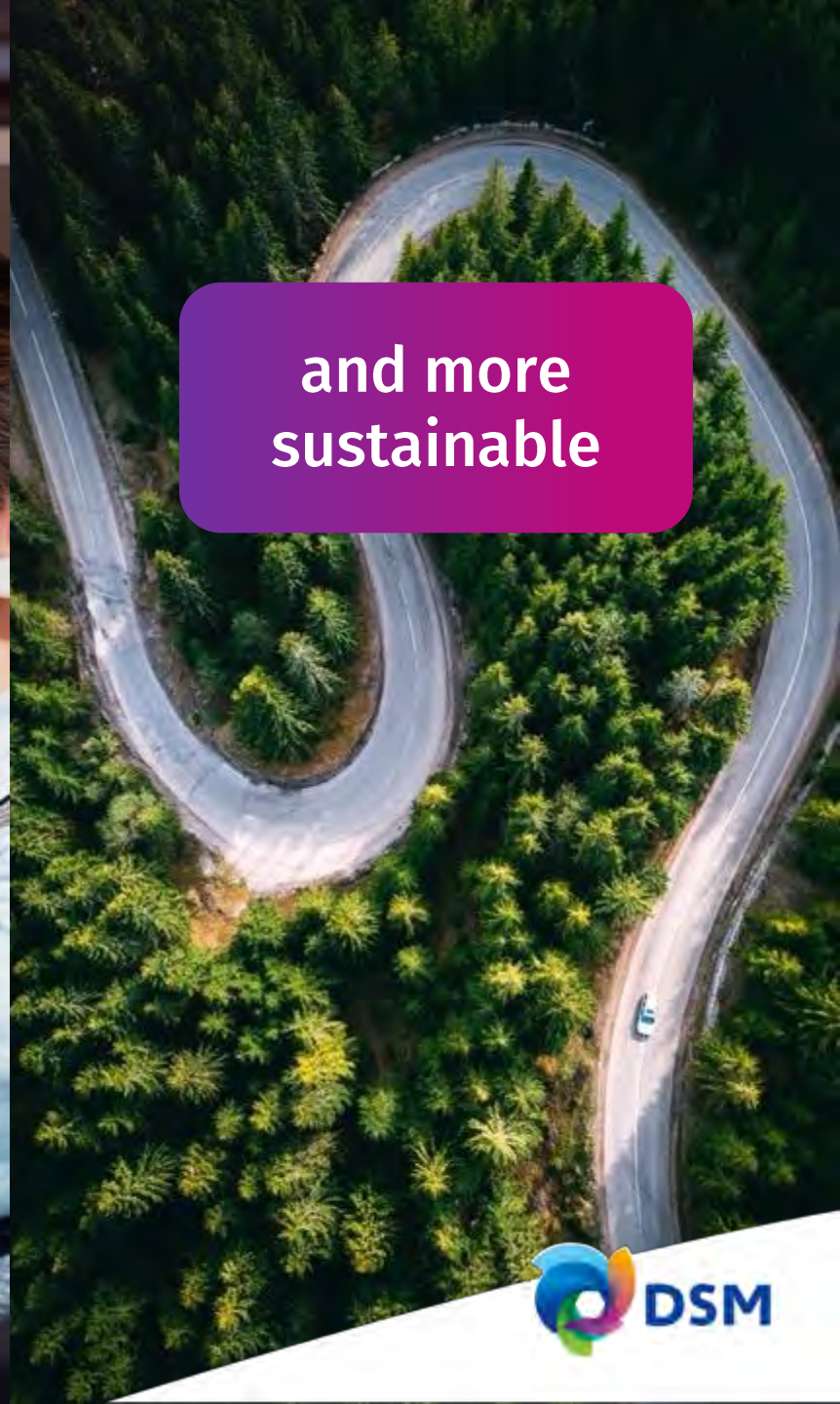
Safer



Lighter



and more sustainable



Making electric vehicles safer



Durable and robust materials for EV charging

Low-permeation hydrogen and gasoline tanks

Cost-effective and safe ADAS radar housings and brackets

Electro corrosion-resistant FAKRA & HSD connectors

Safer thermal management systems

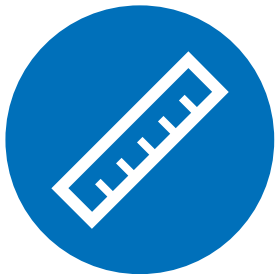
Global leader of material solutions for fuel cells

Making vehicles safer and lighter

Xytron G4024T used in TMS system



Electric Water Pump



Superior dimensional stability,
easy processing



Good hydrolysis resistance and
heat stabilization, excellent
dimensional stability and good
mechanics



Improving the safety of critical connected vehicle systems

Proven corrosion-resistant materials with excellent strength and color ability



JEDEC MSL Level 1 compliant materials offer blister-free reflow processing performance



28% higher mechanical retention after insertion vs other PPAs enables reliable operation after many years and multiple insertion cycles



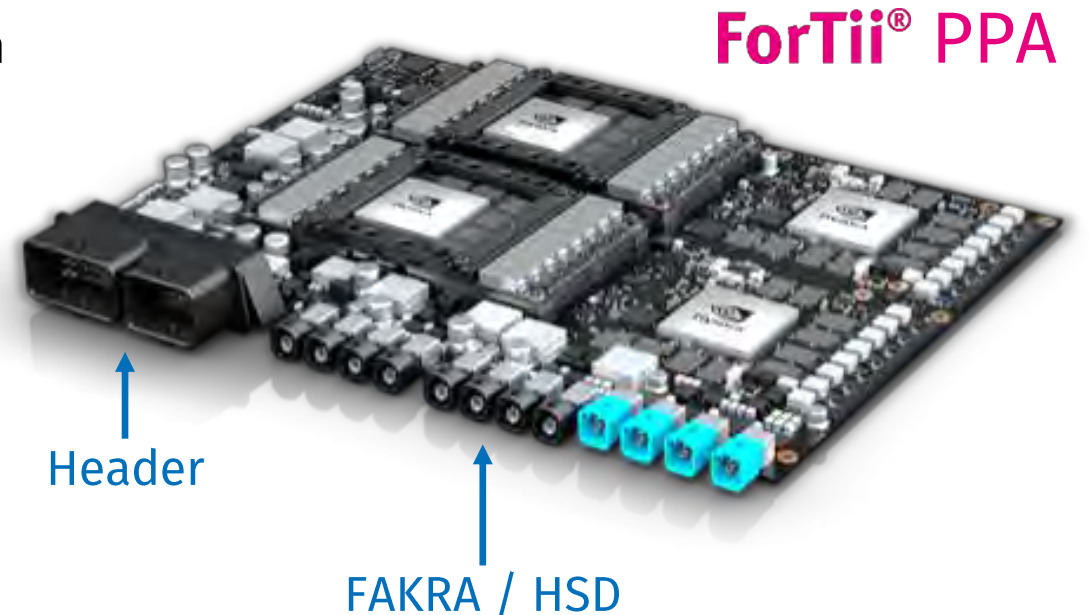
Halogen, halide and metal free materials reduce potential for electro corrosion



Excellent color performance helps identify key connectors for easier vehicle service

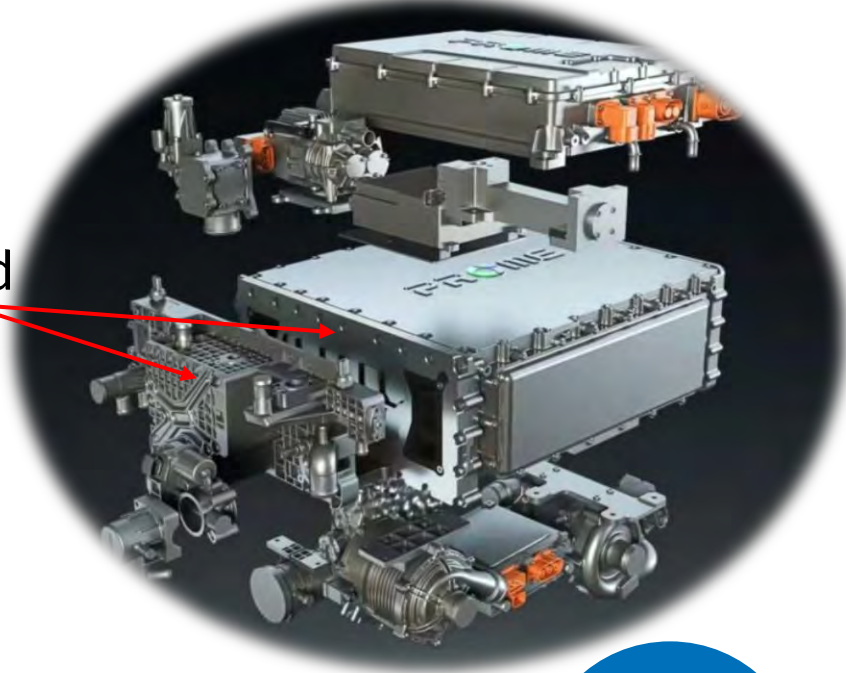


Infinite shelf lifetime for molded components



Making vehicles safer

Xytron 4080HRE used in fuel cells



Integrated manifold
& Insulation plates



High weldline strength
enabling higher durability
and longer life



Lowest ion leaching enabling increased
fuel cell efficiency and lifetime up to
15.000 for trucks and buses



LiB performance and innovation driver

DSM is the world's largest SN producer with a full European supply chain

Energy density

Power performance

Cycle life

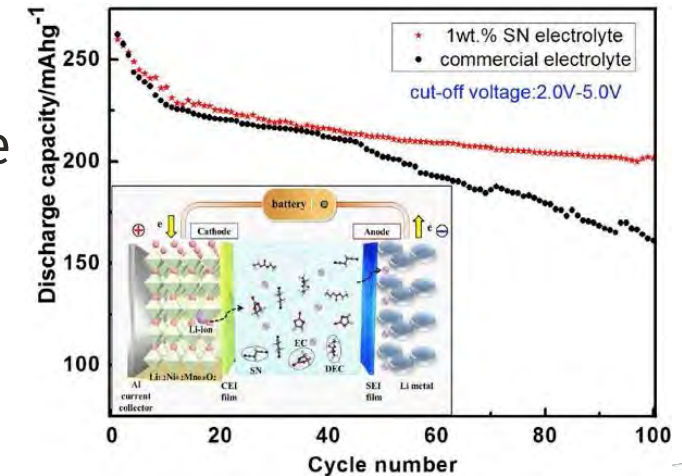
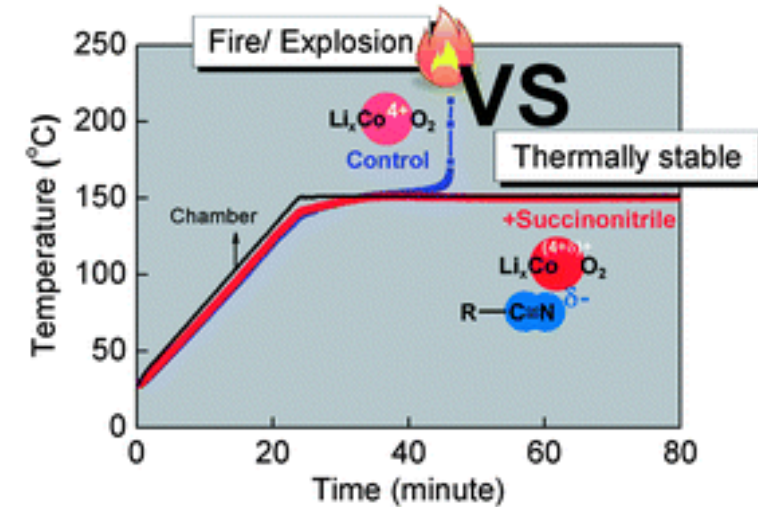
Safety

Cost

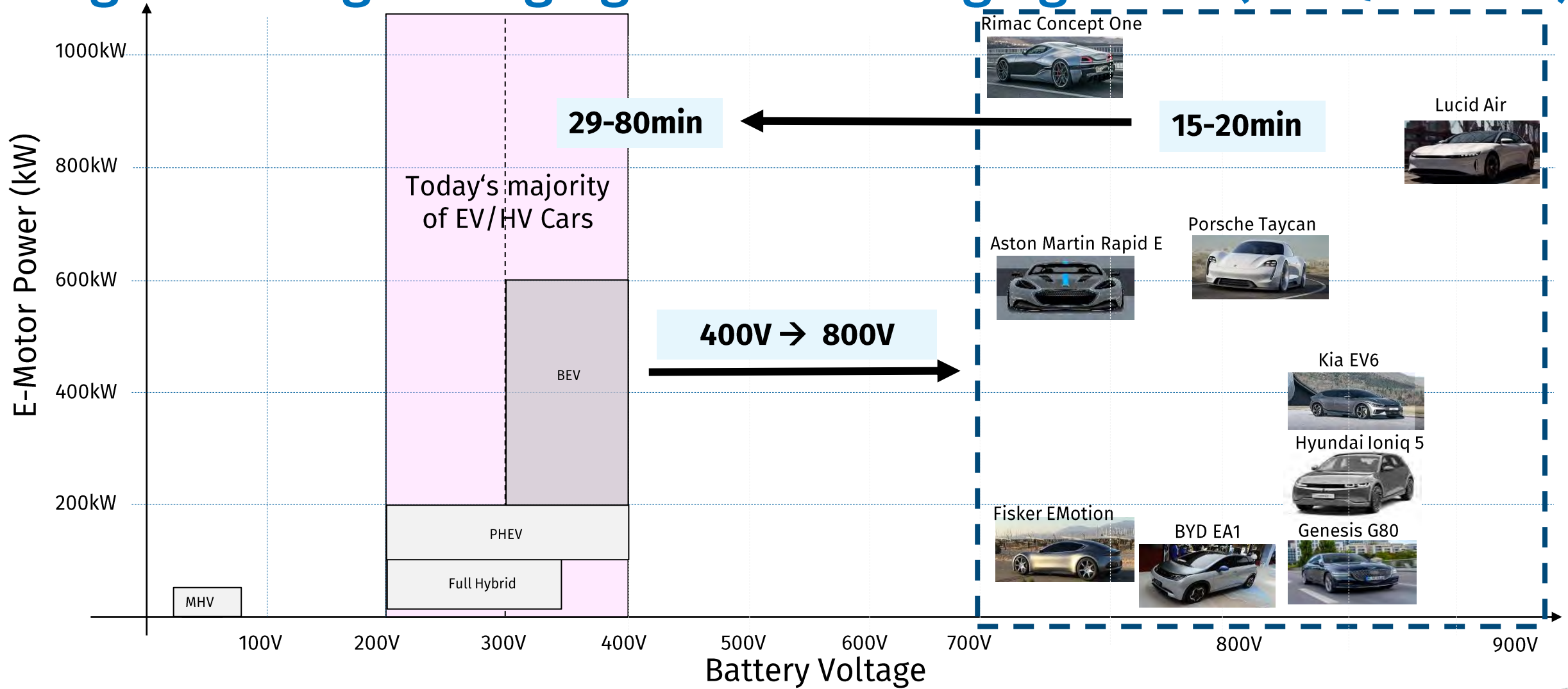
Stanyl SN in electrolytes improves

- thermal stability
- cyclability & capacity retention
- safety and service life of battery

By forming a protective film around the cathode through interfacial reactions between cathode and electrolyte, and hence prevents metal ion dissolution, hydrogen fluoride attack on the cathode and decomposition of the electrolyte.



Higher voltage charging reduces charging times (80%/400km)



Battery voltage increase drives higher rated e-motor and power electronics



Megawatt Charging is coming

Charging at max
1.250V and 3.000A

600-800km
range in few
minutes

Global standard
now defined



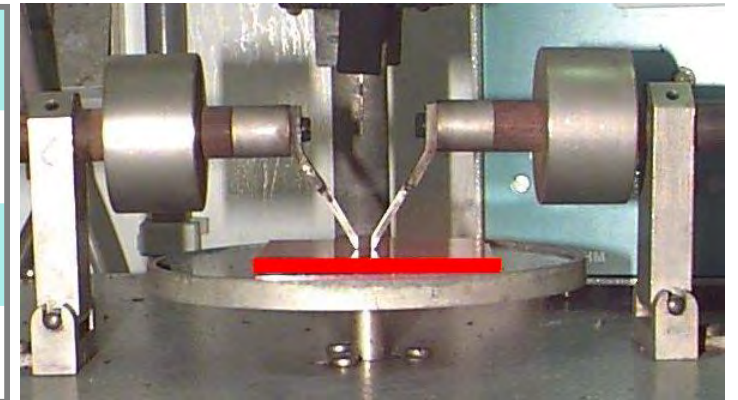
Pictures courtesy of ABB



Most materials limited in comparative tracking index (CTI)

Available CTI materials only qualified for 600V!

Material group I:	$600V \leq CTI$
Material group II:	$400 V < CTI < 600 V$
Material group IIIa:	$175 V < CTI < 400 V$
Material group IIIb:	$100 V < CTI < 175 V$



DSM ForTii™ and Akulon™ certified for CTI >> 600V

ForTii™ TX1 (V0@0.4mm): CTI = 900V

ForTii™ T11 (V0@0.2mm): CTI = 825V

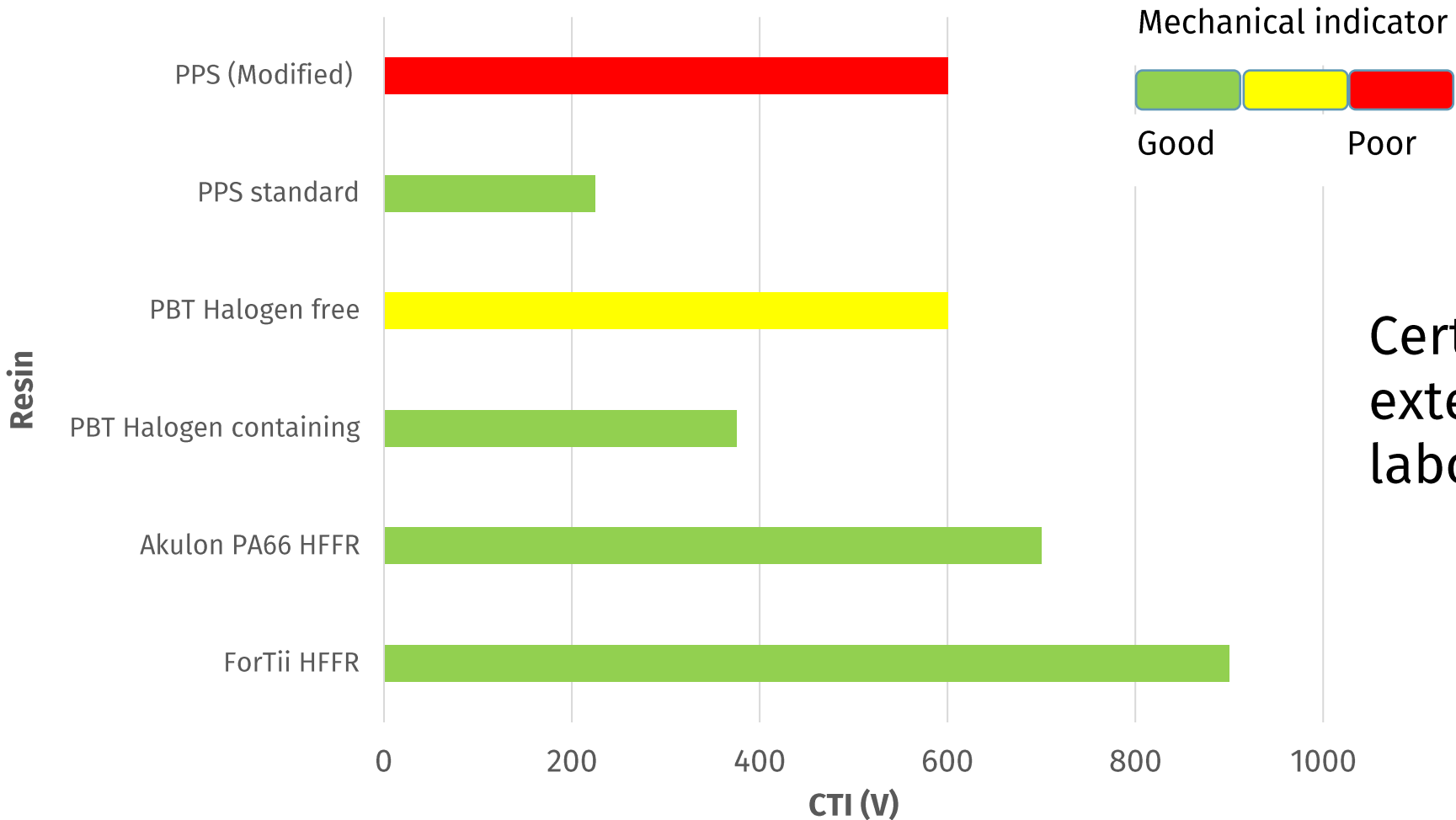
Akulon™ SG-KGS6/HV = 700V

Dedicated CTI test stations up to 1500V

- High voltage CTI measurement equipment by DLG, MTSA and TO fully installed and operational at DSM laboratories in Geleen. A second one in Pune, India scheduled.
- With a range of 100-1500V AC and DC CTI equipment DSM has a unique test capability in-house.
- Since the underlying IEC 60112 standard and measurement is so far described up to 600V, leading customers show significant interest to collaborate in the set up and definition of CTI testing from 600-1500V.



CTI plastic compound benchmarking

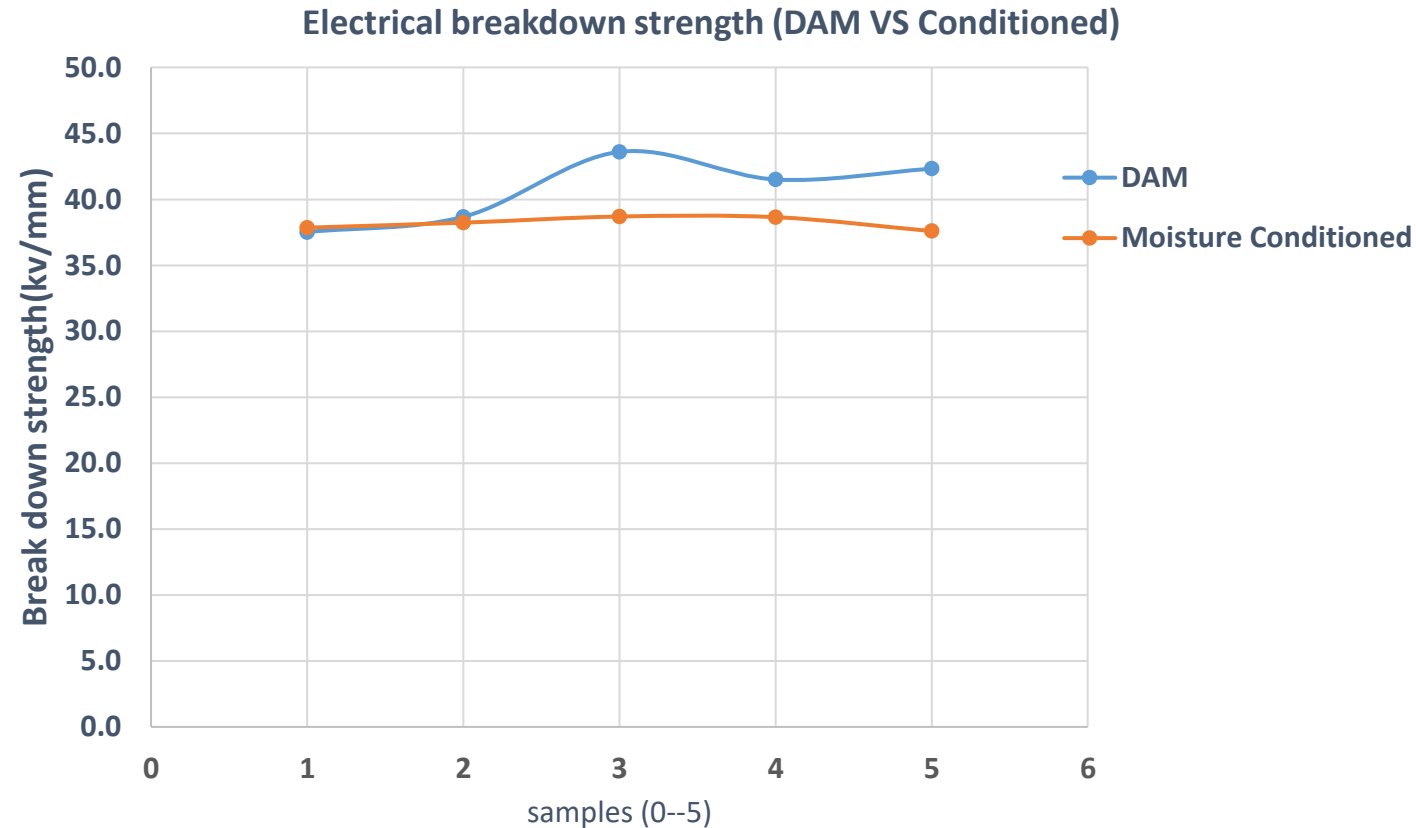
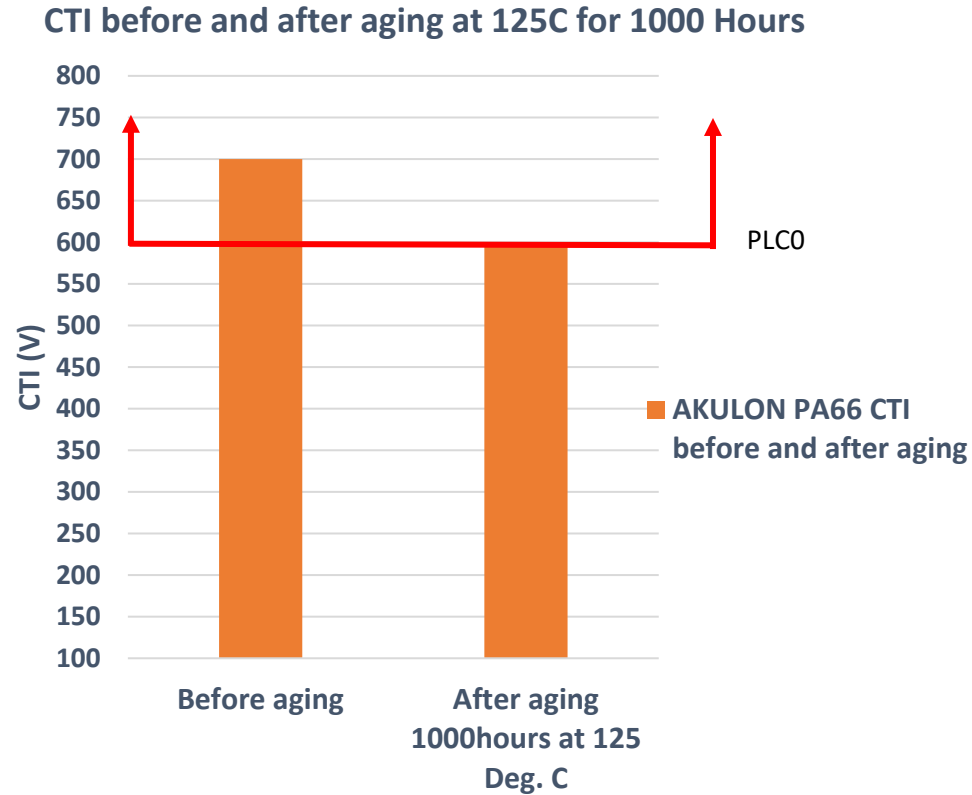


Certified also by external test laboratories

DSM ForTii™ PPA HFFR & Akulon™ PA66 HFFR show the highest CTI of its kind without jeopardizing for mechanical performance

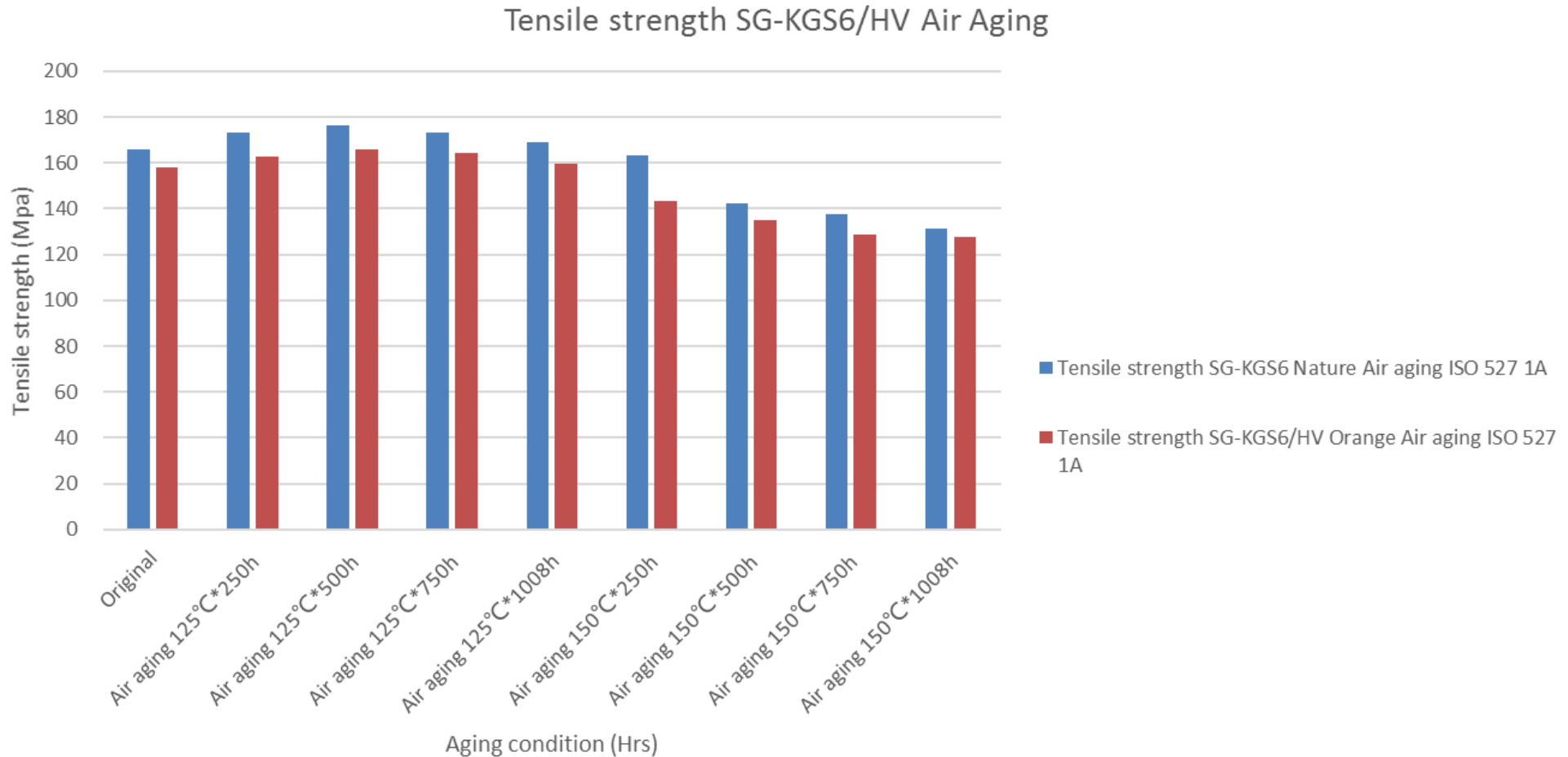


Impact of ageing on CTI



High retention for CTI & minimum drop of electrical strength after aging ensuring PLC0 and good insulation also after ageing

Good mechanical retention after aging



Akulon® PA66 SG-KGS6/HV & SG-KGS5/HV enables long term service life and high confidence in long term part performance

HFHR PBT with superior mechanics and compression set

NEW

Unique characteristics of this balanced grade make it a great choice for EV high voltage applications !

Property	Units	Halogen Free PA6.6 (orange) Dry/Cond	DSM Halogen Free PBT* (orange)
UL94 V-0 @ 0.8		V-0	V-0
CTI	V	600	600
Tensile modulus	MPa	11000/8600	9200
Tensile strength	MPa	155/120	106
Elongation @ break	%	3/3.4	2.9
Charpy notched impact	kJ/m ²	10	6.6
Silicon seal compression set retention (compression of this silicone rubber is 20% with steel/ 150° C for 168 hours)	%	29	23

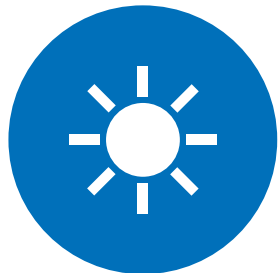


Making vehicles safer

Akulon K224-HG6 & K-FKGS6/B



HV Charging Plug



Superior UV resistance



Best-in-class strength and durability



Fully Compliant with UL and IEC regulations (Yellow Card available) saving time to market



Making vehicles safer

Akulon SG-KGS5/HV



EV Charging
Socket Outlet



Excellent processability and low outgassing enabling high throughput and lower manufacturing cost



Best-in-class strength, durability and flame retardance

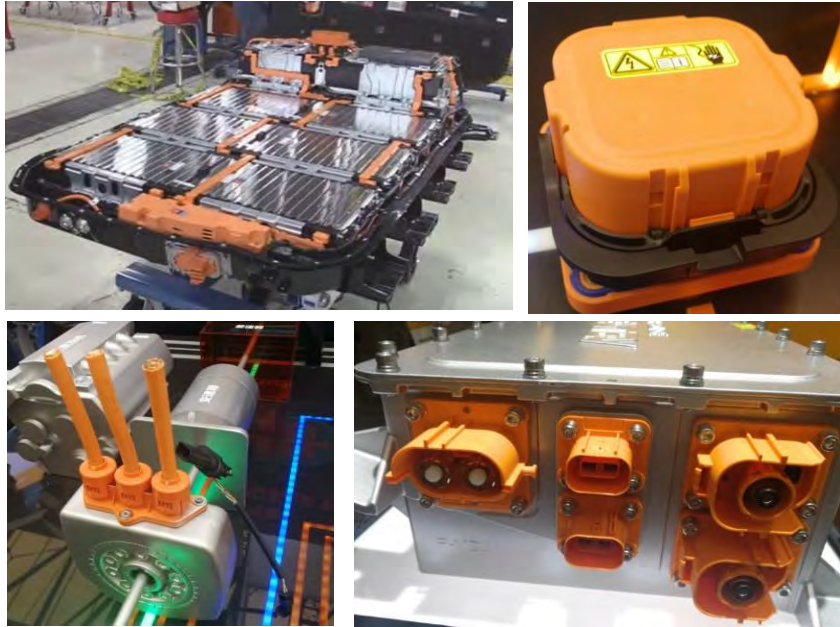


Fully Compliant with UL and IEC regulations (Yellow Card available) saving time to market



Making vehicles safer

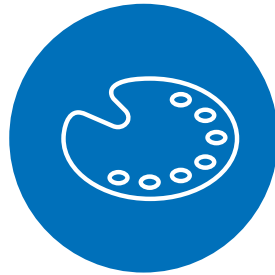
Akulon SG-KGS6/HV



High Voltage
Connectors



Easy processing, low mold deposits, high productivity

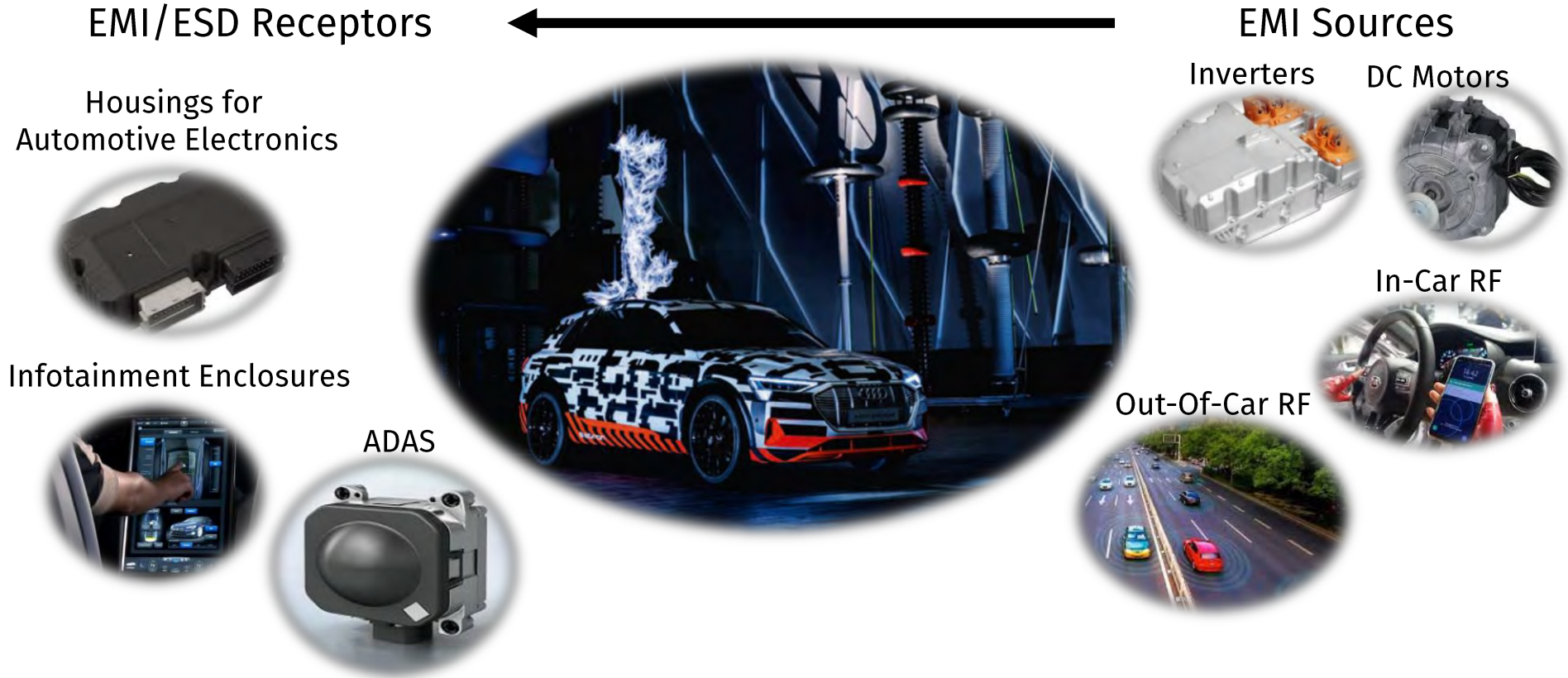


External lab certificated
CTI=700v for orange color
CTI after aging at 125 °C
for 1000h > 600V

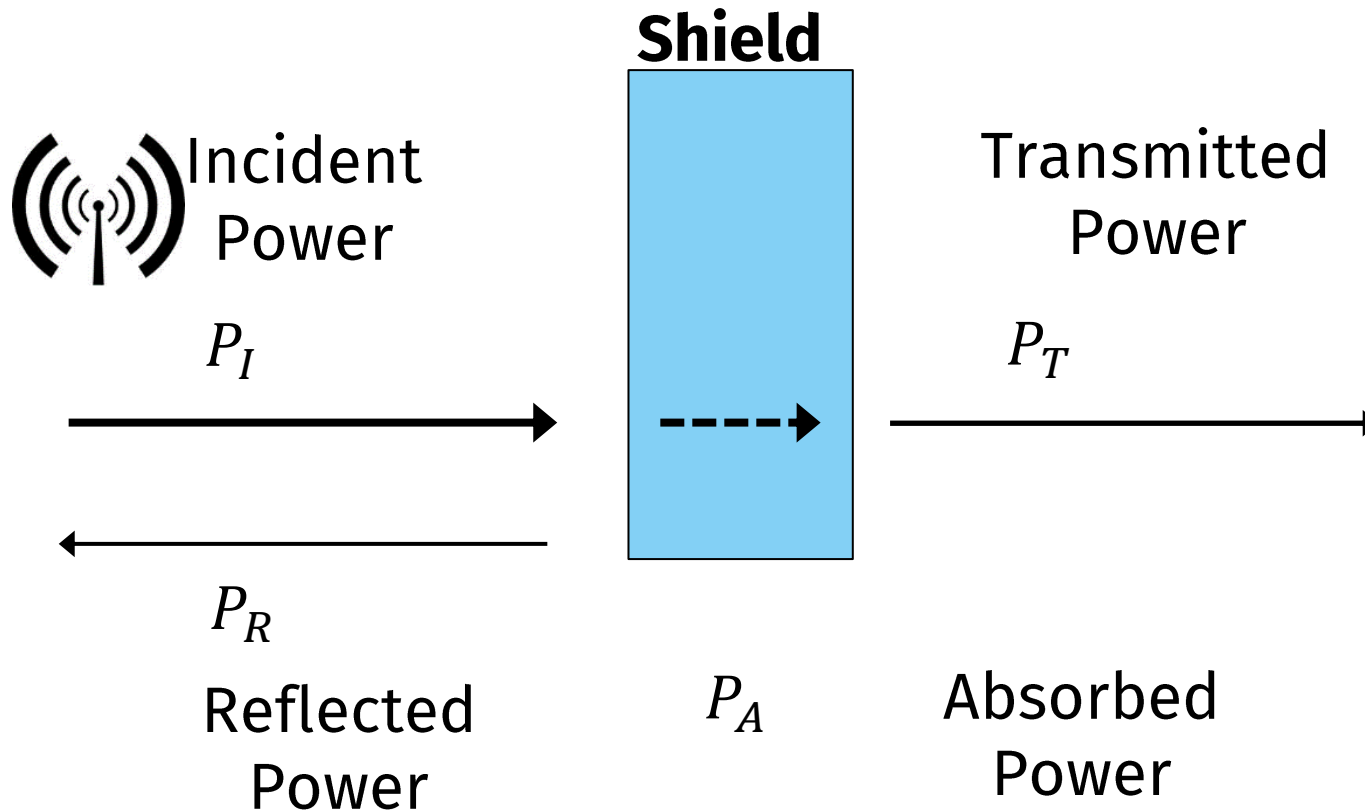


Good electrical and mechanical performance

Sources and impact of EMI in automotive



Application requirements for EMI shielding.

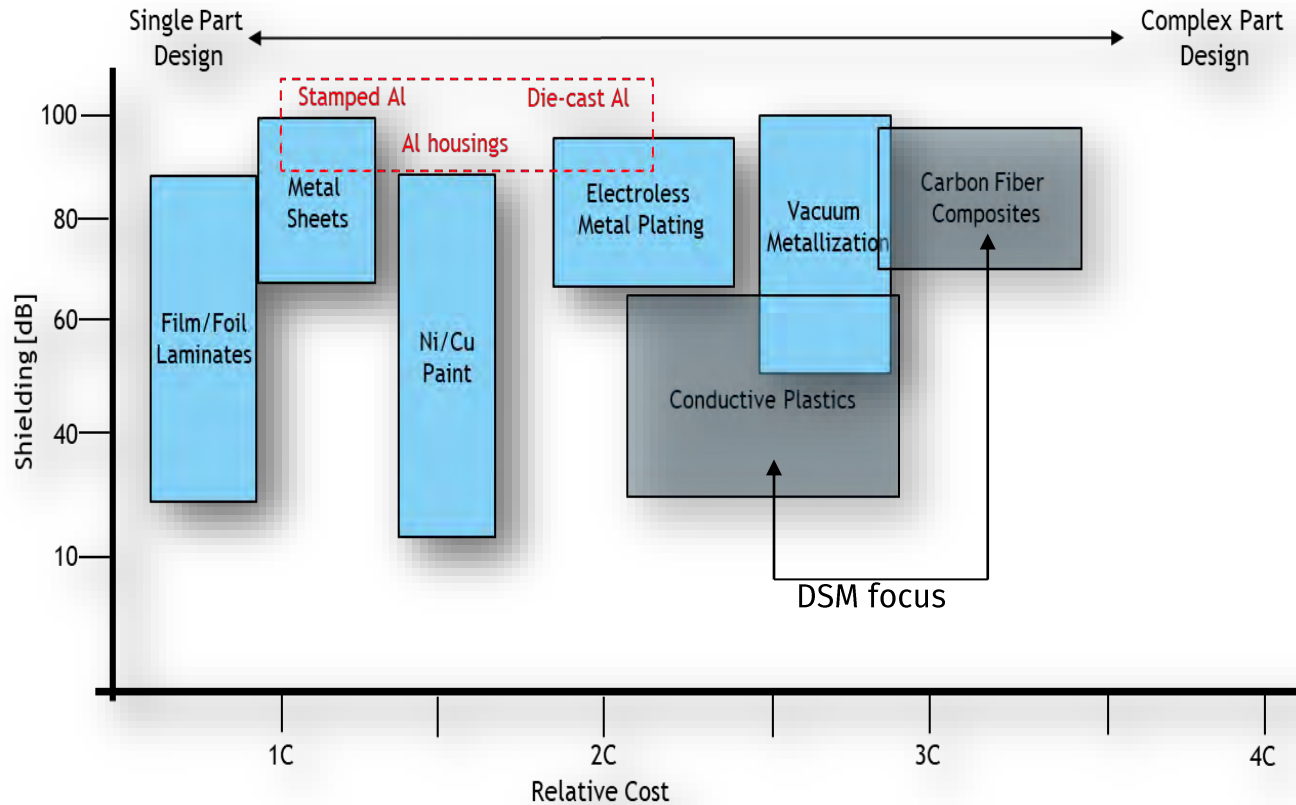


Shielding [dB]	P_I/P_T	P_T
10	10:1	10%
20	100:1	1%
30	1.000:1	0.1%
40	10.000:1	0.01%
50	100.000:1	0.001%

Car Applications	Requirements [dB]
ECU	~40-50 dB
ADAS Sensor	~30-40 dB
E-Motor / Bus bars	~40-50 dB
Inverter/Converter	~50-60 dB
Car Computer	~50-60 dB

40-60dB shielding is sufficient for almost all applications

...define the potential solutions...



Value to Manufacturer

- Lower total cost versus Al die cast
- Increased design flexibility
- Lower weight versus metal
- Increase shielding reliability

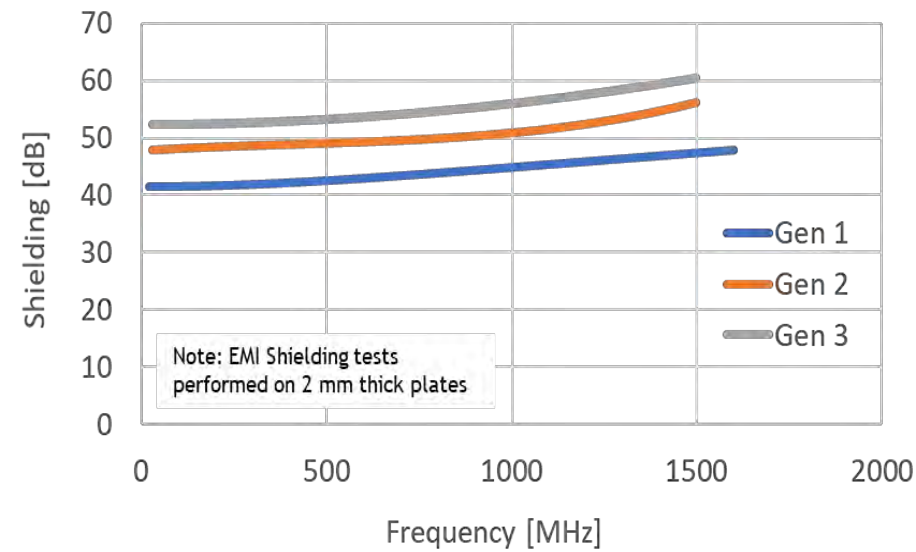
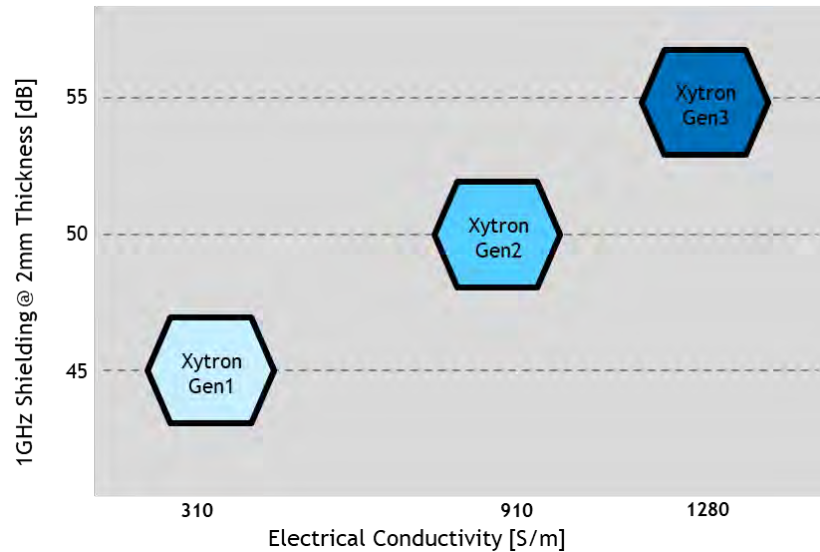
Detailed cost model to compare total cost before project start

Input Parameters	
Part weight in die cast aluminium(grams):	100
Machine costs per hour incl labour(€):	€ 130.00
Operator hourly rates	€ 0.00
Number of cavities:	1
Density die cast aluminium	2700
Density Xytron CF (kg/m3)	1500
Material costs aluminium (€/kg)	€ 1.65
Material costs standard Xytron (€/kg)	€ 27.00
Total Production Other Material (#parts)	100,000
Toolcost Xytron part	€ 100,000
Toolcost Aluminium part	€ 100,000
Replacement tool Aluminium part every	100000
Replacement tool Xytron part every	1000000
Minimum # tools needed due to wear Aluminium part	1.0
Minimum # tools needed due to wear Xytron part	1.0
# holes to be drilled	4
Sum of milling, tapping, turning, deburring inspection operations	1
Average cost per secondary opps per part	€ 1.00
Degating /deflashing time per part	0
Total second opps costs	€ 2.00
Insert costs (simple)	€ 0.06
Insert costs (complex, threaded)	€ 0.10
# Inserts simple	8
# Inserts complex	0

Cost per part Analysis	Al Diecast	Plastic	Savings
Part weight (grams)	100.0	55.6	
<i>Machine cost (moulding + tool amortization/consumption)</i>			
Cycle time (sec)	70	40	
Moulding cost per part (€)	€ 2.53	€ 1.44	
Tool costs per part (€)	€ 1.00	€ 0.10	
Total machine costs per part (€)	€ 3.53	€ 1.54	
Total machine costs	€ 352,778	€ 154,444	€ 198,333
<i>Material Cost</i>			
Material cost per kg (€)	€ 1.65	€ 27.00	
Density	2700	1500	
Part weight (gr)	100	55.6	
Additional insert costs	n.a.	0.48	
Material cost per part (€)	0.17	1.98	
Total material costs	€ 16,500	€ 198,120	-€ 181,620
<i>Secondary operations</i>			
Cost per part(€)	€ 2.00	€ 0	
Total costs sec opps	€ 200,000	€ 0	€ 200,000
Total part cost (€)	5.69	3.53	
Relative savings Xytron solution	38.1%		
TOTAL savings			€ 216,713

..with DSM materials providing excellent level..

Clear material development roadmap...

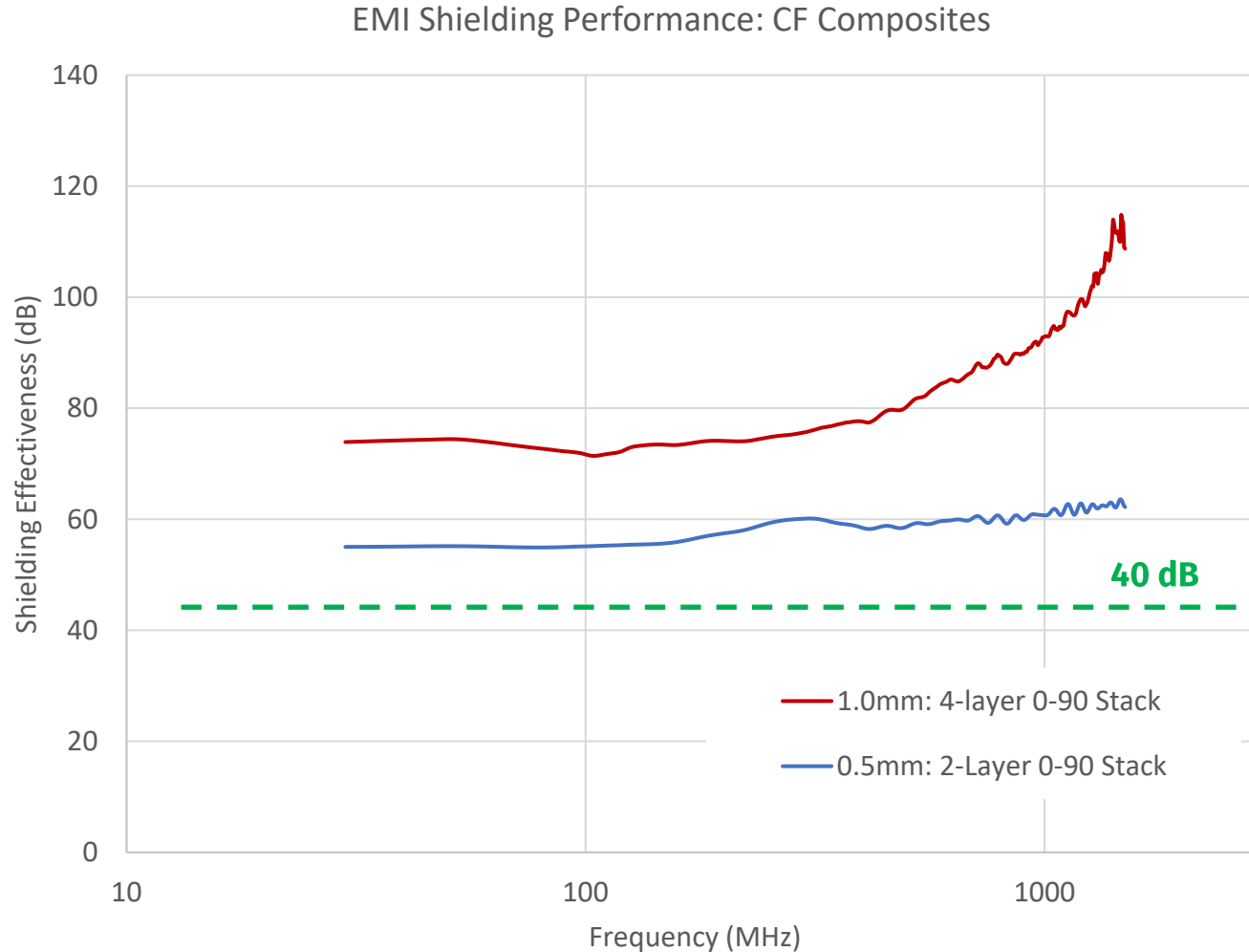


...resulting in industry benchmark!

Xytron Material Parameters	Value
E-Modulus (Mpa)	10544
Tensile stress (Mpa)	118
Tensile strain %	1.4
TC in plan (W/mK)	1.0
TC through plan (W/mK)	0.5
Electrical conductivity [S/m]	1280

Xytron PPS has highest shielding levels and thermal conductivity and good mechanics

..and DSM CF Composites even shielding at metal level



Powerful shielding performance from thin layers

Mechanical properties suitable for structural parts

High-performance lightweight metal replacement



Experimental Samples:
Multilayer CF Composites

DSM conductive material portfolio

	Grade Name	Strain @ break	TC In-plane [W/mK]	TC Through-plane [W/mK]	Resistivity [Ωm]	Electrically Conductive/Insulative	CLTE [$1/\text{C}^\circ$]	UL94
High thermal conductivity	Stanyl® TC502	1.1	14	2.1	1 E5	EC	0.25 E-4	HB
	Stanyl® TC155	0.6	5	1	1E13	EI	0.25	V0
High mechanical performance	Arnite® AV2 370 XL-T	1.5	1.65	0.8	3 E11	EI	0.25 E-4	HB
	Stanyl® TC154	1.0	1.0	0.5	1 E12	EI	0.48 E-4	V0
	Stanyl® TC168	1.6	2.1	0.9	1 E13	EI	0.21 E-4	V0
	Stanyl® TC170	2.4	2.1	0.9	1 E13	EI	0.2 E-4	HB
	Stanyl TW241B3	2	0.8	0.4	1 E6	EC	0.25E-4	HB
	Stanyl TW200B6	2	1	0.5	1 E5	EC	0.08E-4	HB
	Xytron® TC60221	0.7	2.2	1.2	1 E13	EI	0.30 E-4	V0
	Xytron® R-X08885C	0.6	2.3	0.4	1 E3	EC	0.30 E-4	V0

EI: Electrically insulative
 EC: Electrically conductive

Making electric vehicles lighter



Metal replacement



Composite solutions for structural parts



e-Axle



Strong and lightweight seating materials



Airsprings



Smaller & lighter actuation systems

Reducing structural parts weight and cost

Akulon[®] PA6/66, ForTii[®] PPA & Xytron[™] PPS offer proven performance backed by global design support

50%

Up to 50% weight reduction
(vs. metal)

20%

Up-to 20% cost reduction
(vs. metal)



Global CAE support (static part stiffness with anisotropic prediction, NVH and crash performance)



Proven solution at various OEMs



Front End Module



E-Motor Mount



2023 market launch

Cross Car Beam

Making vehicles more sustainable

Ultraflow K-FHG0 PA6 GF-50



Ultrahigh flow formulated for easy processing and weldability



High strength and chemical resistant chemistry



80% lower CFP versus competing PA6 alternatives possible as drop-in material solution without requalification



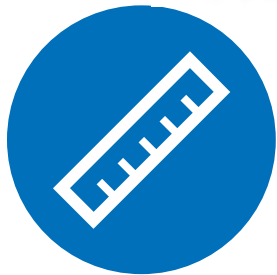
Stanyl enables next gen e-motors

$$\text{Power (kW)} = \text{Speed (rpm)} \times \text{Torque (Nm)}$$

High speed bearings



Source: SKF



Superior stiffness over density at high temperatures allows increase of rotation speeds up to 20.000 rpm without bearing deformations



High ductility, chemical and temperature resistance for dedicated high performance grease with CUT up to 180°C



Smaller e-motor allows ~25% weight and cost reduction by cutting the use of metals and magnets



Making electric vehicles more sustainable

Helping manufacturer to reduce carbon footprint

50%

GHG emissions and product CFP reduction vs 2016

by 2030

100%

renewable electricity used in our plants

by 2025

0%

Zero net carbon neutral scope 1 & 2

by 2040

ENTIRE PORTFOLIO

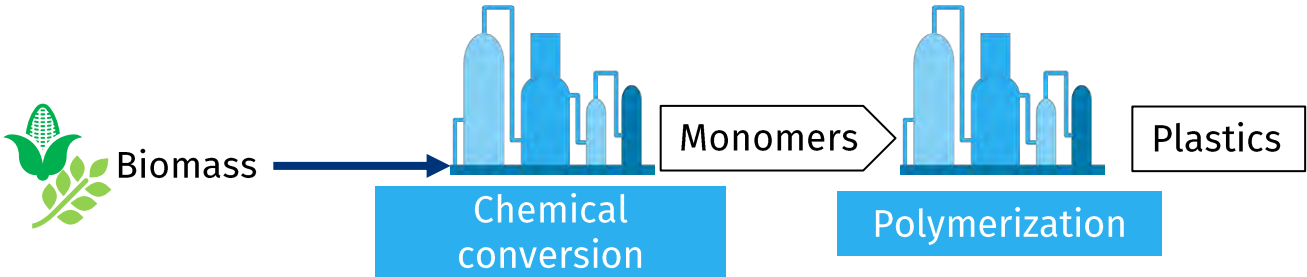
of bio-based or recycled alternatives available*

*at least 25% recycled and/or bio-based content by weight in the final DSM product

by 2030

Helping to reduce fossil fuel use

With EcoPaXX® PA410 & Arnitel® Eco TPE
bio-based material solutions



Biomass balanced materials

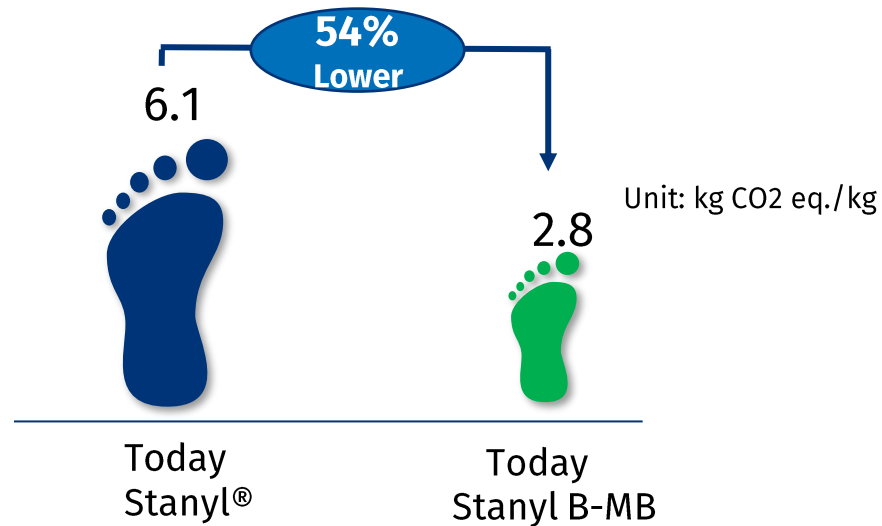
DSM can support significant CO₂ reduction for increased OEM sustainability requirements without design changes or requalification

Akulon PA6

Carbon footprint (kg CO₂/kg base polymer)

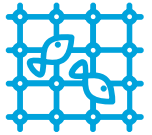


Stanyl PA46



Helping OEMs increase circularity

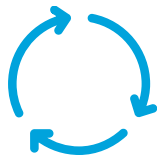
Akulon® RePurposed PA6 offers like-new performance from recycled fishing nets



640K tons of used fishing nets discarded into the oceans each year



Equivalent to the weight of more than 400,000 automobiles



Akulon® RePurposed is a recycled PA6 alternative to fossil-fuel based plastics made from used fishing nets recovered from the Indian Ocean and Arabian Sea



Received 2021 SPE Innovation Award for first use of ocean plastic in a production vehicle (2022 Ford Bronco Sport cable clip pictured)

Akulon® RePurposed PA6 wiring harness for 2022 Ford Bronco Sport



Your proven development partner in automotive

Comprehensive Global Technical Services



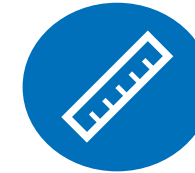
Cost Assessment

- Materials
- Tooling
- Production
- Cycle time



Advanced CAE

- Material data (e.g., fiber content, temp, conditioning, strain rate)
- Static structural analysis with anisotropy for fiber reinforced parts
- Dynamic structural analysis with anisotropy for fiber reinforced parts (NVH, fatigue, etc.)
- Crash simulation
- Processing simulation



Prototyping

- Tool design optimization
- Processing parameter optimization
- Tool try-out support



Materials

- Extensive portfolio
- Thermoplastic UD tapes (CF & GF)
- New material development



Part Design

- Topological optimization
- Plastic part design optimization
- Metal insert design optimization



FMEA Analysis

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