UV EB SOLUTIONS THAT DRIVE GHG SAVING AND SMALL FOOT-PRINT AUTOMOTIVE PAINT SHOPS

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SAE INTERNATIONAL

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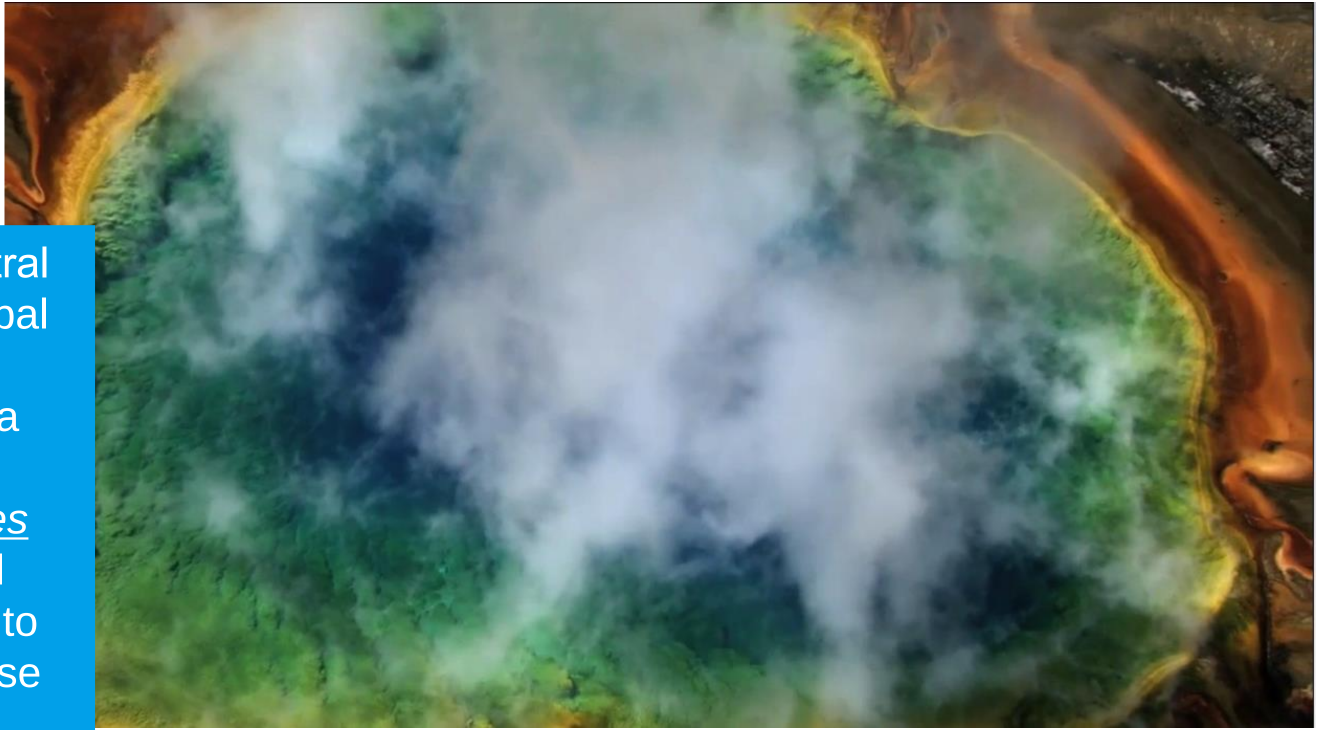
Global Goals GHG Reduction – Paris Accord

United Nations
Framework Convention on
Climate Change

The Paris Agreement's central aim is to strengthen the global response to the threat of climate change by keeping a global temperature rise this century well *below 2 degrees Celsius* above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius.



visit http://www.un.org/sustainabledevelopment/climate-change

Global Goals GHG Reduction – Paris Accord

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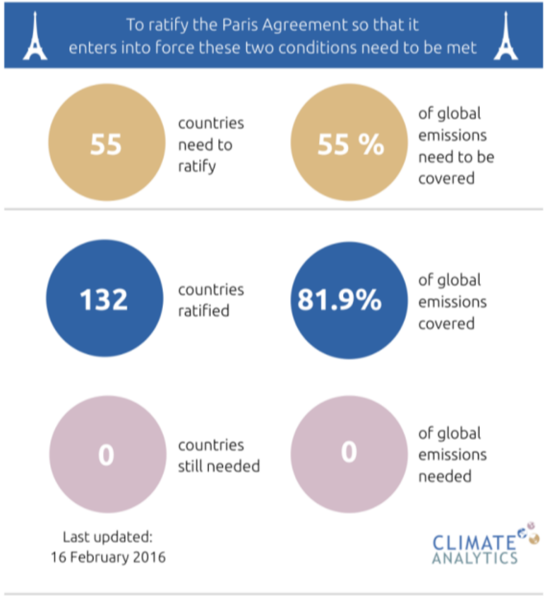
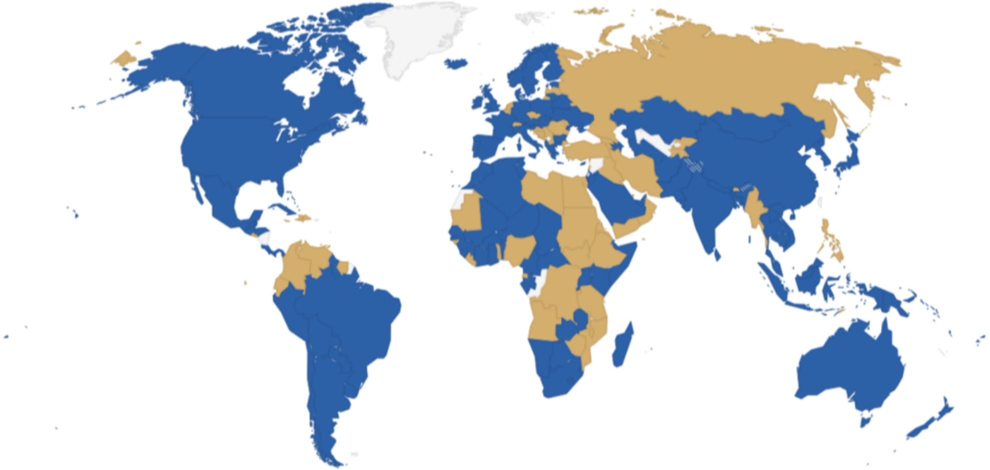




As of 16 February 2017: 194 Parties **signed the Agreement,** 132 Parties **ratified.**

Automotive Industry Goals GHG Reduction

https://www.globalfueleconomy.org/media/203446/gfei-state-of-the-world-report-2016.pdf

January 31, 2017
Categories: GFEI Partner Updates, Air Quality

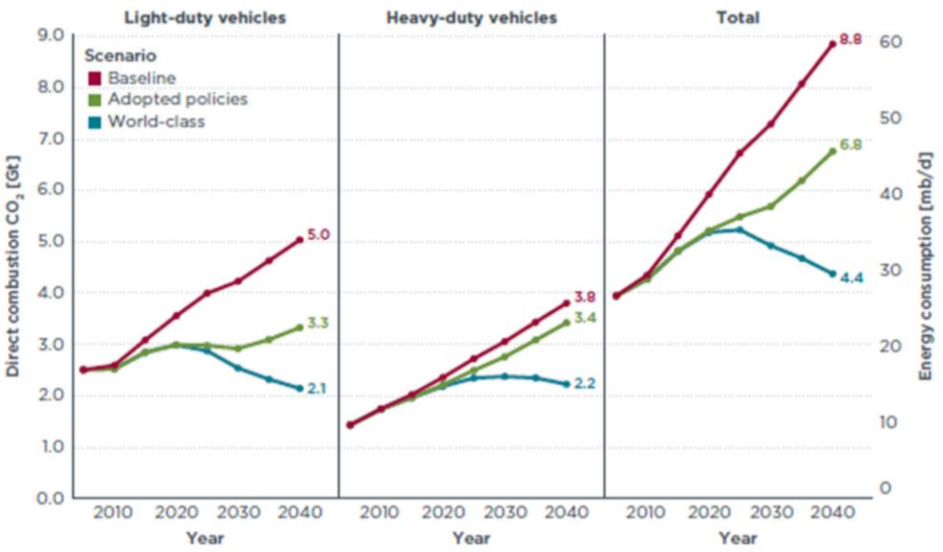
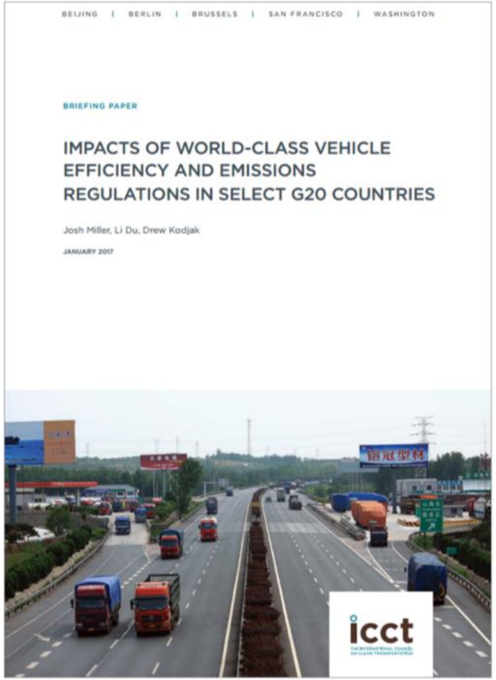


Figure ES-1. Direct combustion CO_2 emissions of light- and heavy-duty vehicles in TTG+EU member states under baseline, adopted policies, and world-class efficiency scenarios, 2005-2040. Figure shows historical and projected emissions for Australia, Brazil, Canada, China, the EU-28 (including TTG members Germany, Italy, and the United Kingdom), India, Japan, Mexico, the United States, and Russia.



ICCT's new report: Impacts of World-Class Vehicle Efficiency and Emissions Regulations in Select G20 Countries.

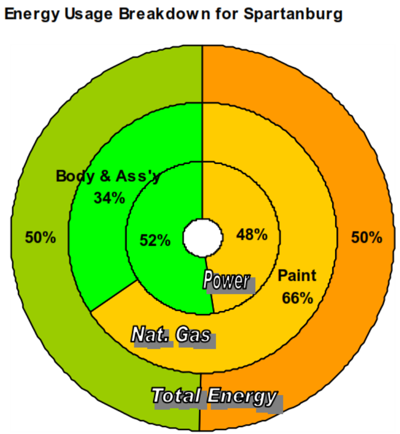
Standard Auto Paint Shop impact on Energy Use (GHG Emissions)

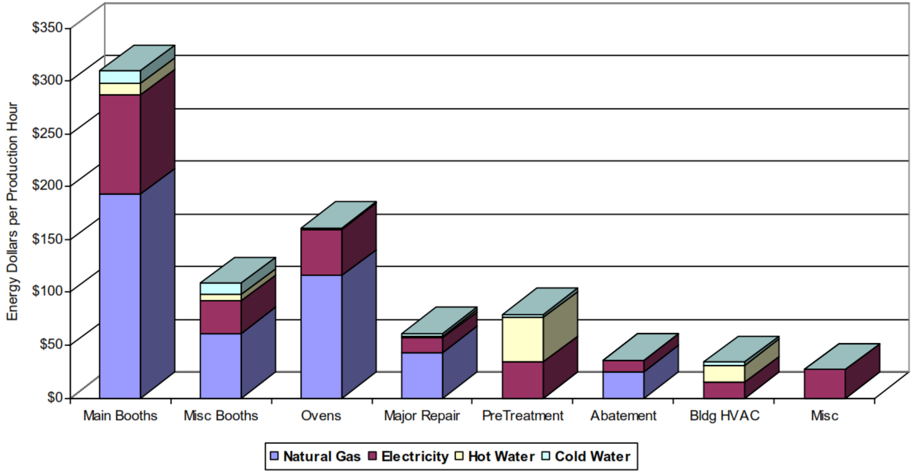
Auto Paint Shop

- Environmental Impact
- Electrical 48%/ Natural Gas 66% -
- Lean Manufacturing – Small Foot Print

Dürr Study – BMW Spartanburg Plant

- Paint Shop confirmed as single largest energy consumer
- Process Equipment Consumption characterized

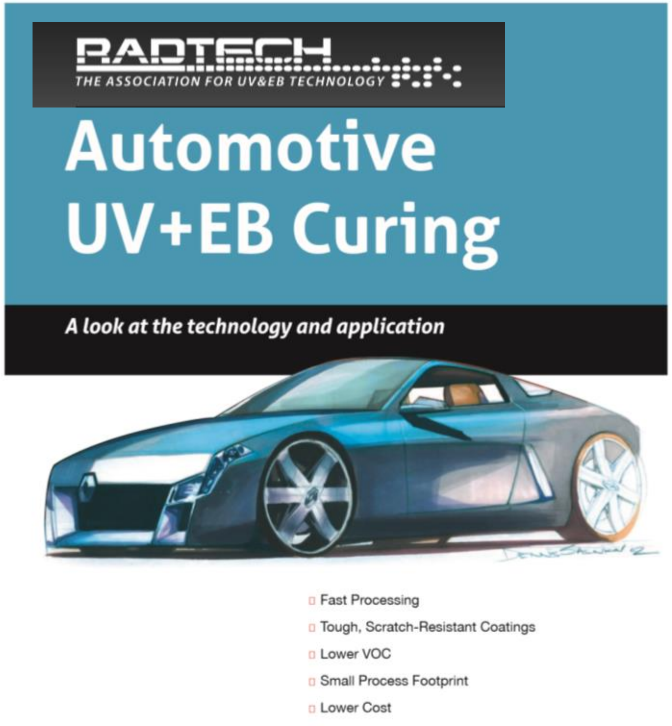




The Role of Ultraviolet and Electron Beam Cure

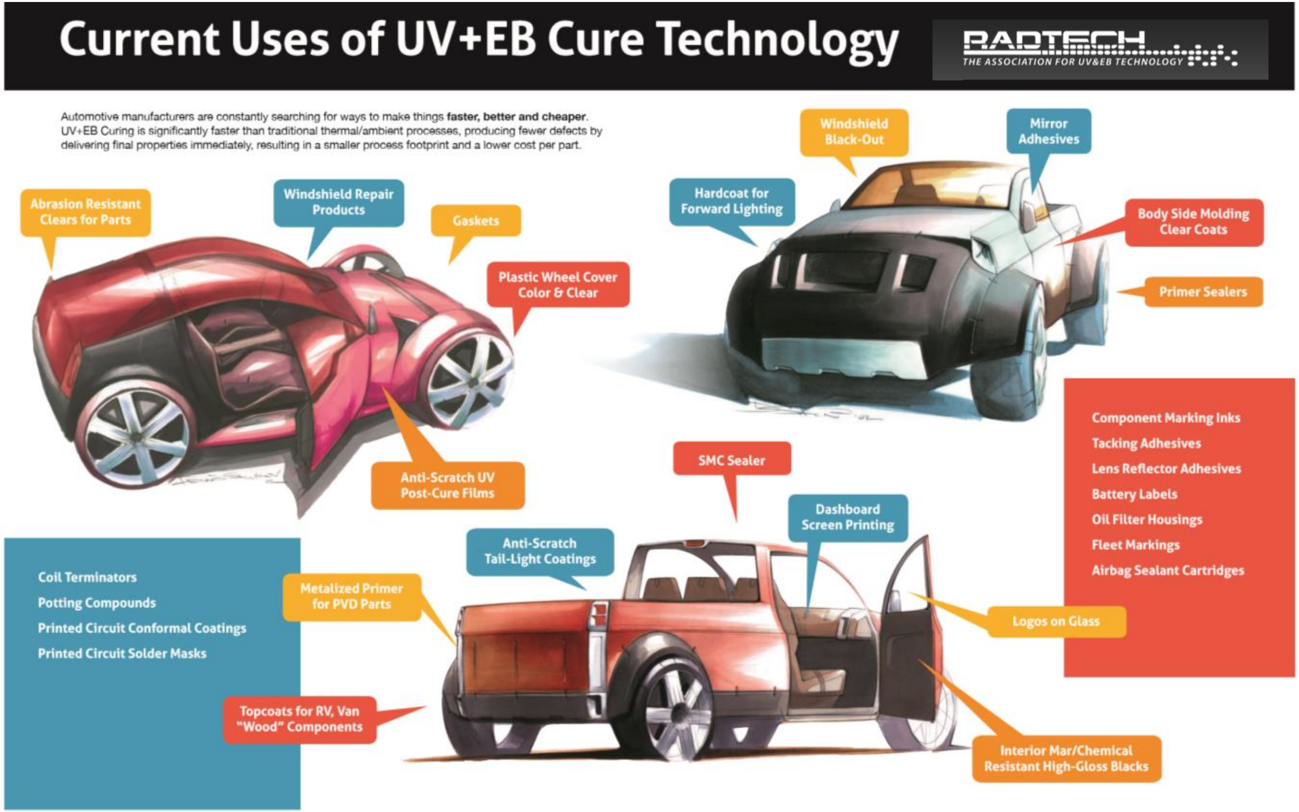
Advantages:

- Small Foot Print Paint Shops
- High Speed Curing reduced Paint Shop Cycle Time (10^6 X free radical reaction versus convection oven)
- Facility Energy Savings - Low Pollution; Environmentally Friendly Coatings (GHG / CO_2 emissions 50-90% savings)



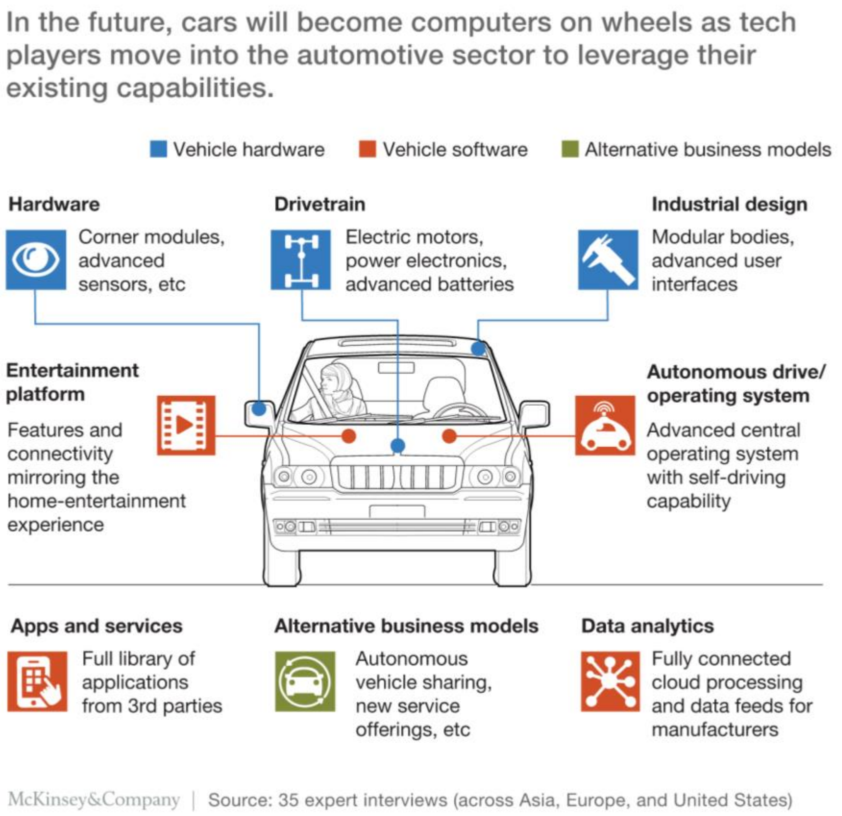
The Role of Ultraviolet and Electron Beam Cure

- Lightweight Substrates
- Vehicle Electrification/ Connectivity / Autonomous Vehicles – Electrical Systems
- Innovative Processes – Liquid Spray Coatings, Powder Coatings, Coil Coatings, Decals, Printing
- Optimum Coating Properties – durability, scratch resistance, chip performance at low coating weights (Tough, Scratch Resistant)



Vehicle Design – MMLV Multi Material Lightweight Vehicle

- Future Strategies for Automotive Design & Assembly
- Cars become computers on wheels
- Horizontal versus Vertical Integration



Beiker,S., Hansson, F., Suneson, A., Uhl, M., "How the convergence of automotive and tech will create a new ecosystem", McKinsey & Company, Automotive & Assembly, Nov 2016 [3]

Vehicle Design – MMLV Multi Material Lightweight Vehicle

- Mechanical hardware

Subassemblies get standardized, and players merge to benefit from scaling up—ie, chassis components, body substructures shared across models/brands

A couple of specialized players will probably dominate each niche of the future automotive ecosystem.

Future scenario as a horizontal move for players

• Mechanical hardware	Subassemblies get standardized, and players merge to benefit from scaling up—ie, chassis components, body substructures shared across models/brands
• Drivetrain	3–5 players with competitive advantage scale up production—ie, batteries for electric vehicles, fuel cells, drive units for modular cars
• Industrial design • Branding	Vehicle interiors and exteriors remain a key differentiator, and importance of brand value rises in an increasingly commoditized sector
• Operating system	2–3 standard operating systems for autonomous drive (and potential other systems—eg, onboard communication architecture) as a plug-and-play solution
• In-car entertainment	2–3 large-scale multimedia ecosystems present attractive opportunity for 3rd-party development, probably established mobile platforms (iOS, Android)
• Cloud • Data analytics	Analytics skills and server technology are leveraged to create services that facilitate the usage of big data for commercialization and customer satisfaction
• Apps and services	Built-in navigation and media get replaced by apps provided by 3rd-party developers, curated via app store and more widely connected via online services
• Alternative business models	Vehicle provided to consumer just for duration of ride and specific to trip purpose, making mobility the actual product, beyond vehicle

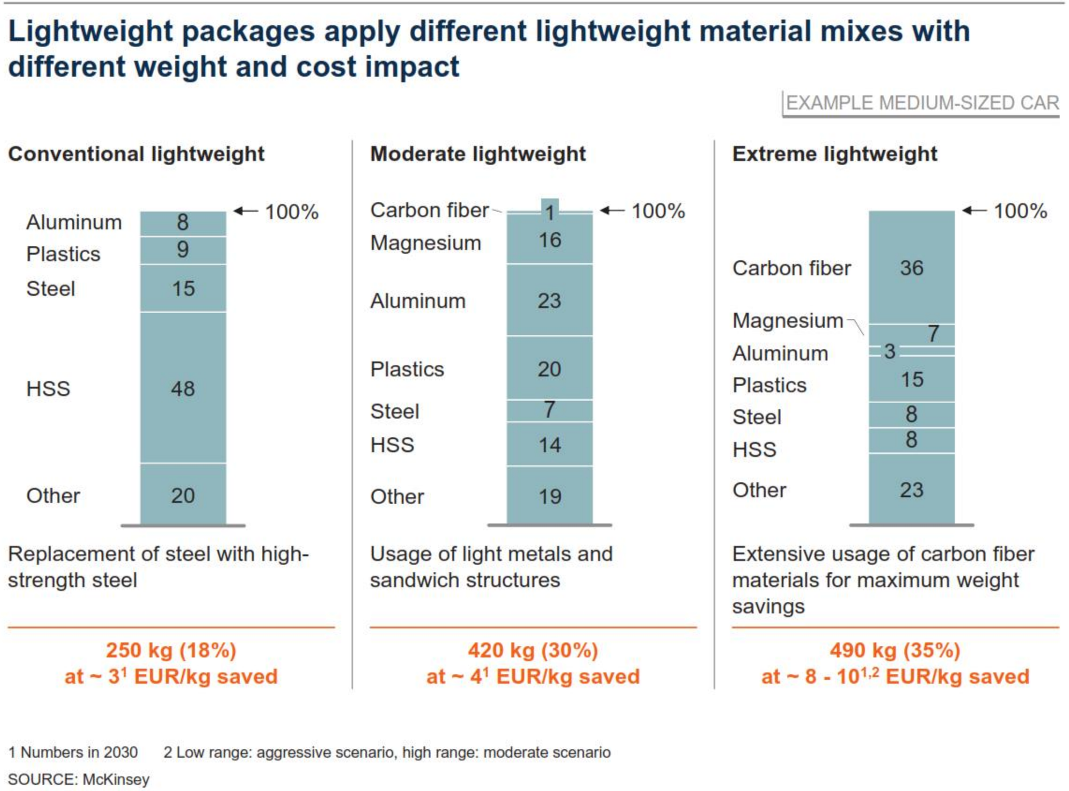
McKinsey&Company | Source: Expert interviews

Beiker,S., Hansson, F., Suneson, A., Uhl, M., “How the convergence of automotive and tech will create a new ecosystem”, McKinsey & Company, Automotive & Assembly, Nov 2016 [3]

Vehicle Design – MMLV Multi Material Lightweight Vehicle

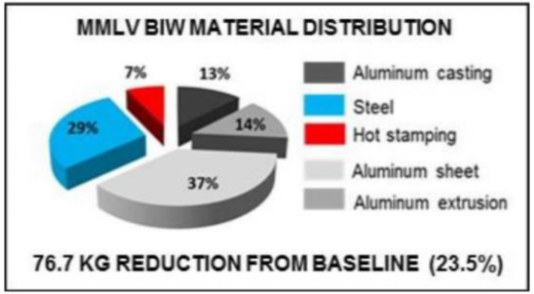
Fuel Economy improves 6-8%
by reducing **vehicle mass 10%**

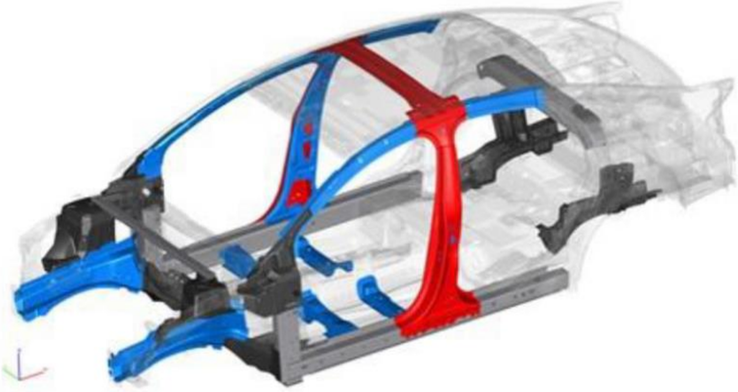
Lightweight Material	Mass Reduction
Magnesium	30-70%
Carbon fiber composites	50-70%
Aluminum and Al matrix composites	30-60%
Titanium	40-55%
Glass fiber composites	25-35%
Advanced high strength steel	15-25%
High strength steel	10-28%



Alternative Corrosion Methods

- Initiatives to Further Support *Lightweighting*
  - US Department of Energy/Ford /Magna International **MMLV Project** Ford Fusion vs. 2013 Baseline 23.5% weight reduction. **34 mpg** vs. 28 mpg
  - Two Corrosion Strategies
    - Conventional Paint Shop Process
    - **Alternative Corrosion Strategy**

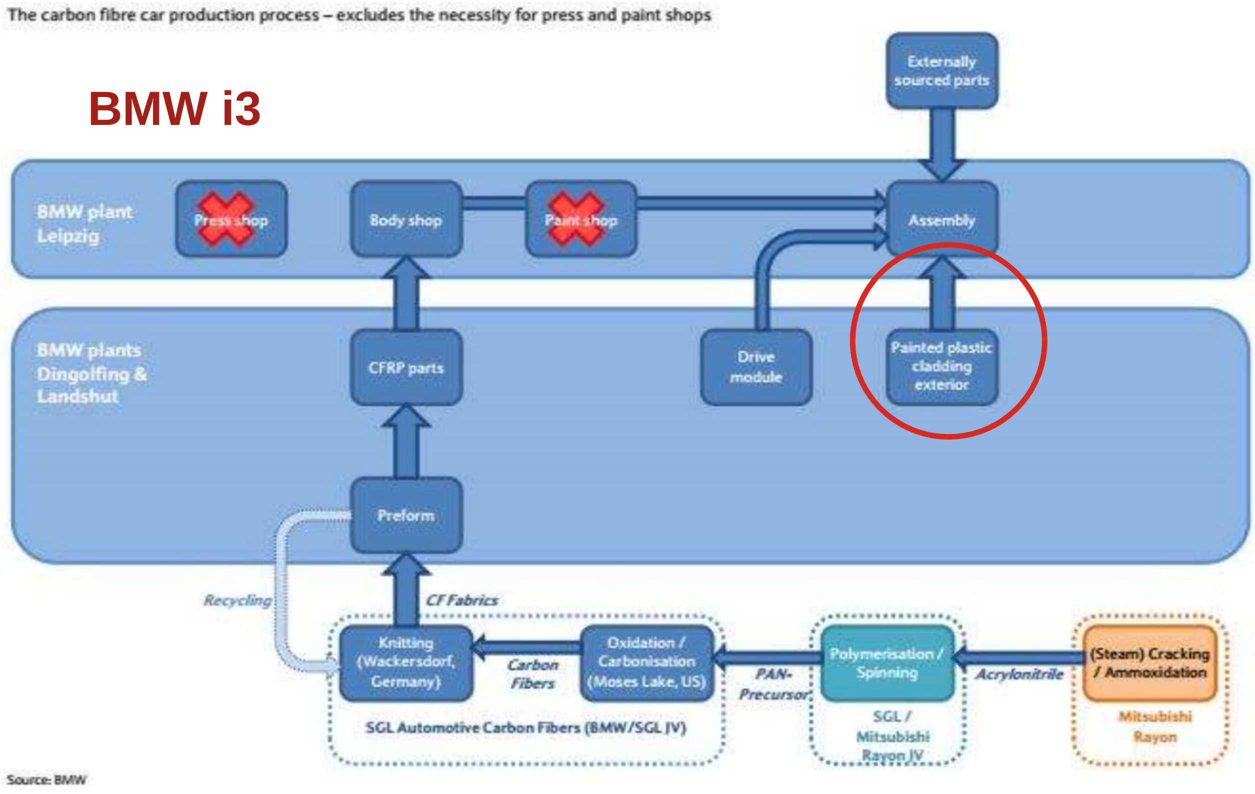




*Smith K., Zang Y. “MMLV: Corrosion Design and Testing”, Magna International, SAE Technical Paper 2015-01-0410,2015

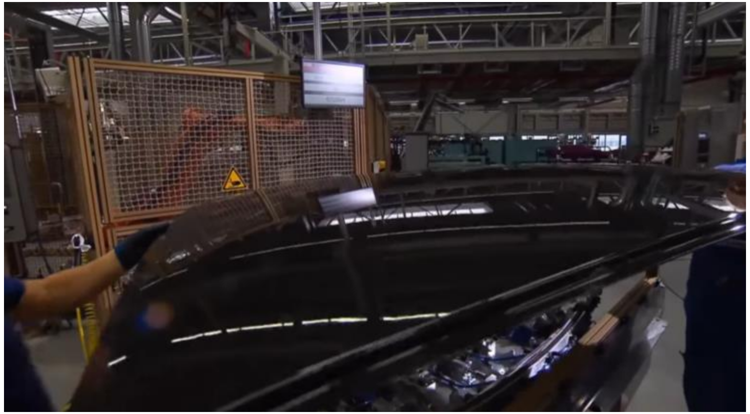
Light Weight Vehicle – Innovative Manufacturing Methods

Car production eliminates the need for stamping and paint shops



Paint Shop BMW i3 2016 – Exterior Class A Panels

2016 BMW i3 Production Final Assembly



2016 BMW i3 – Finish Vehicle Class A Panels

https://www.youtube.com/watch?v=HGi-KmYGuZE BMW i3 Production Car TV

How can UV EB Impact the Future of Automotive Manufacturing

Automotive Design Features

Lightweight Substrate

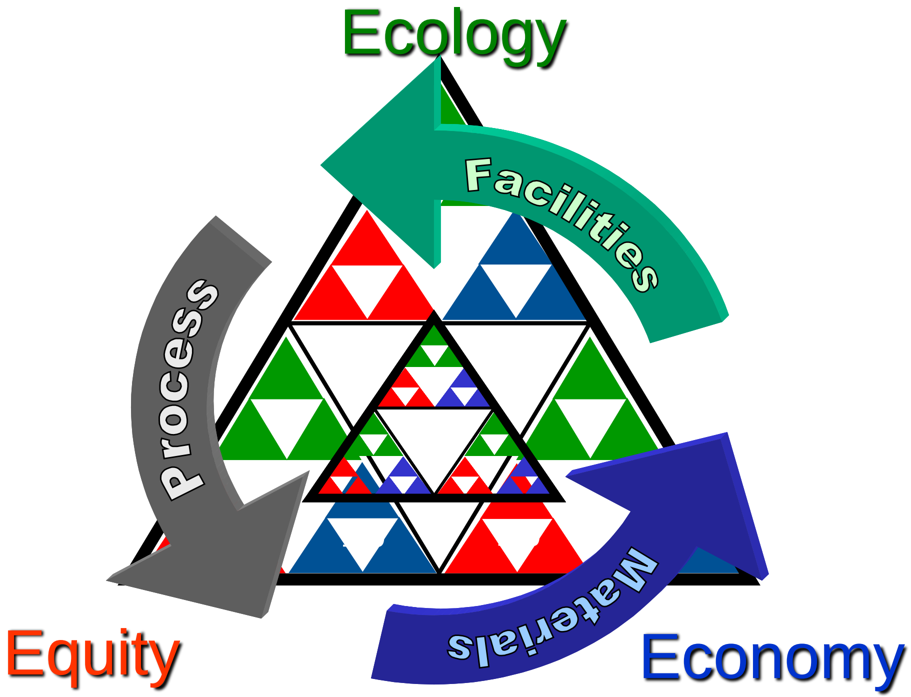
- Vehicle Design – Modular Body, Class A Panels

Advantages of UV EB Cure

- 3D for direct line of sight cure
- Cycle Time/ Energy (GHG) Savings/ Foot Print – Cost Savings
- Film Performance Advantages – Appearance / Film Hardness
- Multiple Substrate Compatibility

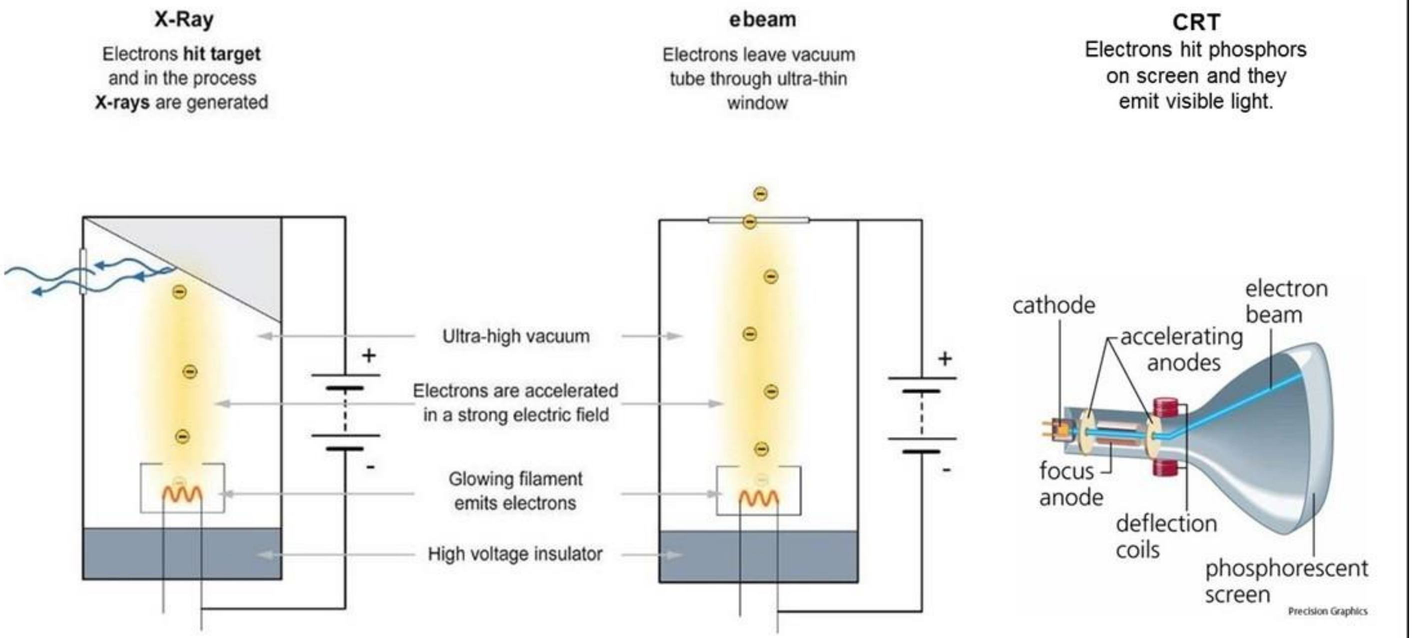
Opportunities

- Material Development
- Long Term Exterior Durability Studies



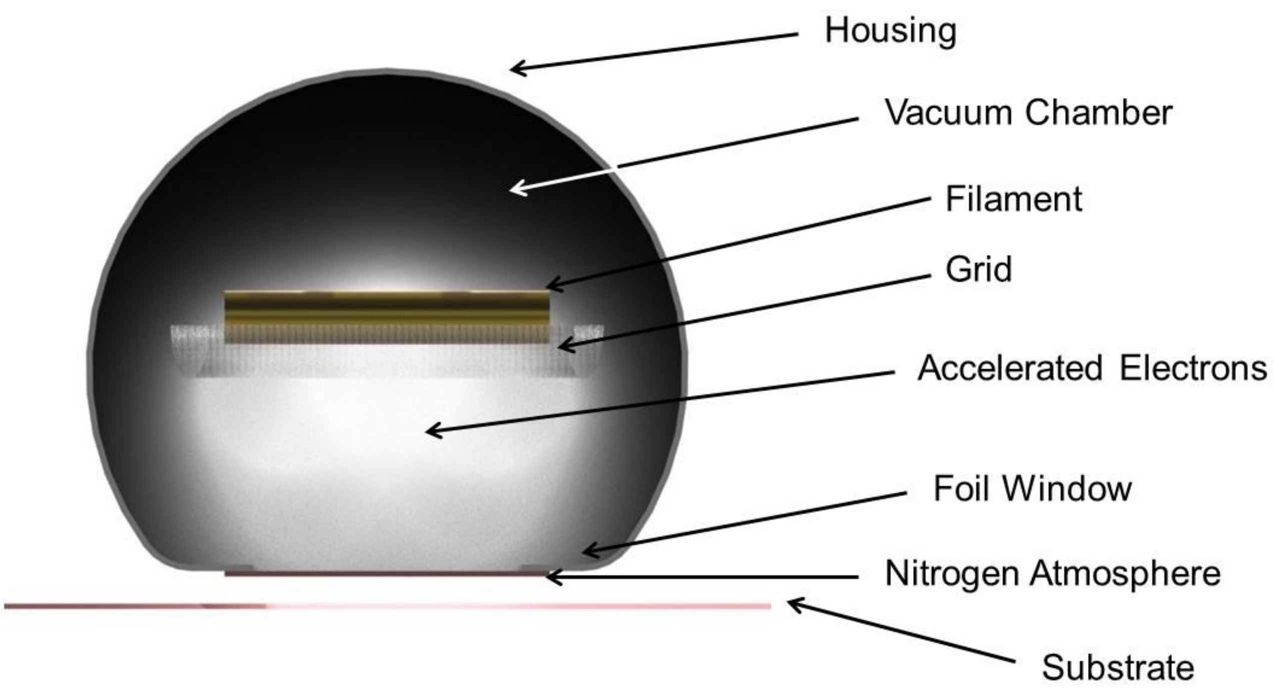
HOW EBEAM WORKS

- X-Ray Tube, EBEAM Lamp and CRT



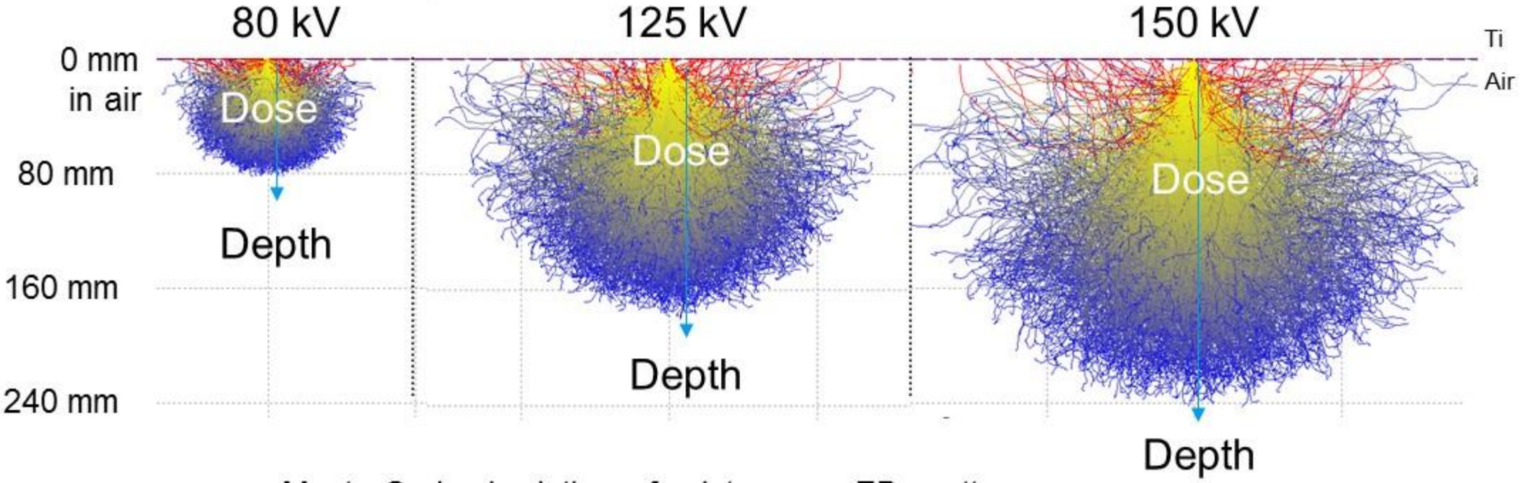
HOW EBEAM WORKS

- The anatomy of a low energy electron beam



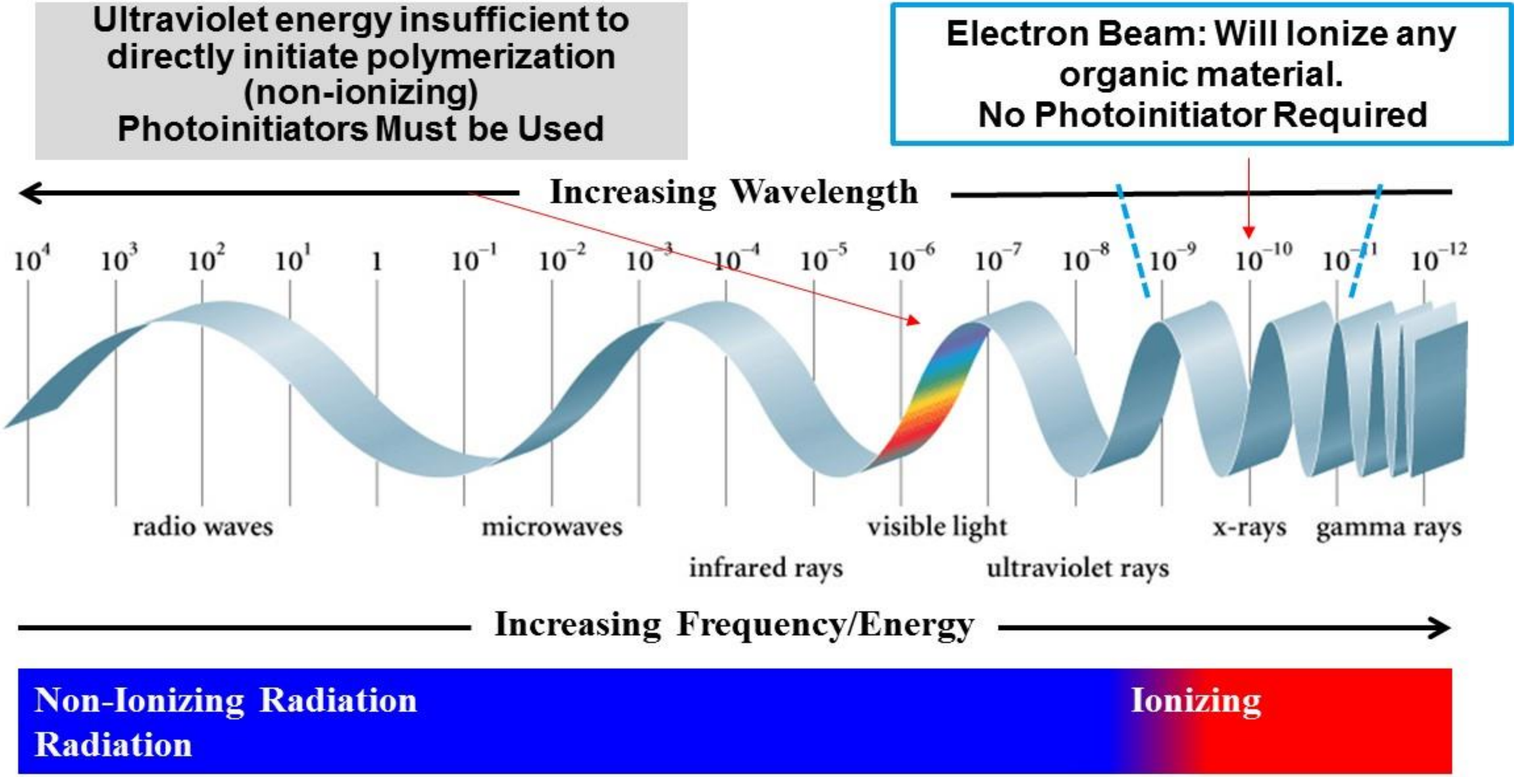
HOW EBEAM WORKS

- Electron Scattering



Monte Carlo simulation of point source EB scatter

Ebeam for Automotive Manufacturing: UV vs. Ebeam Technology



Ebeam for Automotive Manufacturing: UV vs. Ebeam Technology

Ultraviolet	Electron Beam
Photons	Accelerated Electrons
Wavelength determines energy; typically 250-450 nanometers	Accelerating voltage determines energy; typically 80-180 kV
Energy unit conversion; 350 nm Photon – 3.5eV	Typical electron energy at substrate; 70,000 eV
Total applied energy typically 0.1 to 0.5 J/cm^2	Total applied energy typically 20 to 40 kilo gray (kGy) 1 kGy = 1 J/gm for 50 g/m^2 layer = 0.1 to 0.2 J/cm^2

Ebeam for Automotive Manufacturing: UV vs. Ebeam Technology

Ultraviolet	Electron Beam
Optical Density of Material	Mass Density of Material
Peak Irradiance (power of focus) of UV Source	Controlled by Acceleration Potential (Voltage) of beam
Clearcoats, limited pigmented, opaque materials	Easily penetrates clearcoats, highly pigmented and opaque materials
Cures high film thickness with low pigment load. Lamination of clear materials	Cures high film thickness, heavily pigmented coatings. Enables lamination of opaque materials

Ebeam Cure of highly pigmented profiled automotive plastic part.

Measure	**Current Thermal Drying Line**	**200 kV EB Curing Line**
Parts/kWh	28	415
Plant Floor Space (sq..)	2400	1200
Yield (FTT - First Time Through)	60%	90%
Productivity (parts/hour)	1080	3240
VOC_2 Emissions	0.98 lbs./gal	0.047 lbs. /gal

Source – 2011 Akzo Nobel Department of Energy Proposal Ref. 2

EB Cured Interior Automotive Part

Technology	% Solids	Energy (J/g)	Cure Time	Cure Temp
Waterborne	40%	3390	20-30 min.	80 C
Solventborne	40%	555	20-30 min.	80 C
EB Cure	100%	30	< 1 sec.	Room Temp.

Interior automotive ABS/PC plastic trim plate support structure coated with Akzo Nobel high-gloss black mono coat. Cured with COMET EBLab Unit. *Ref. 2*

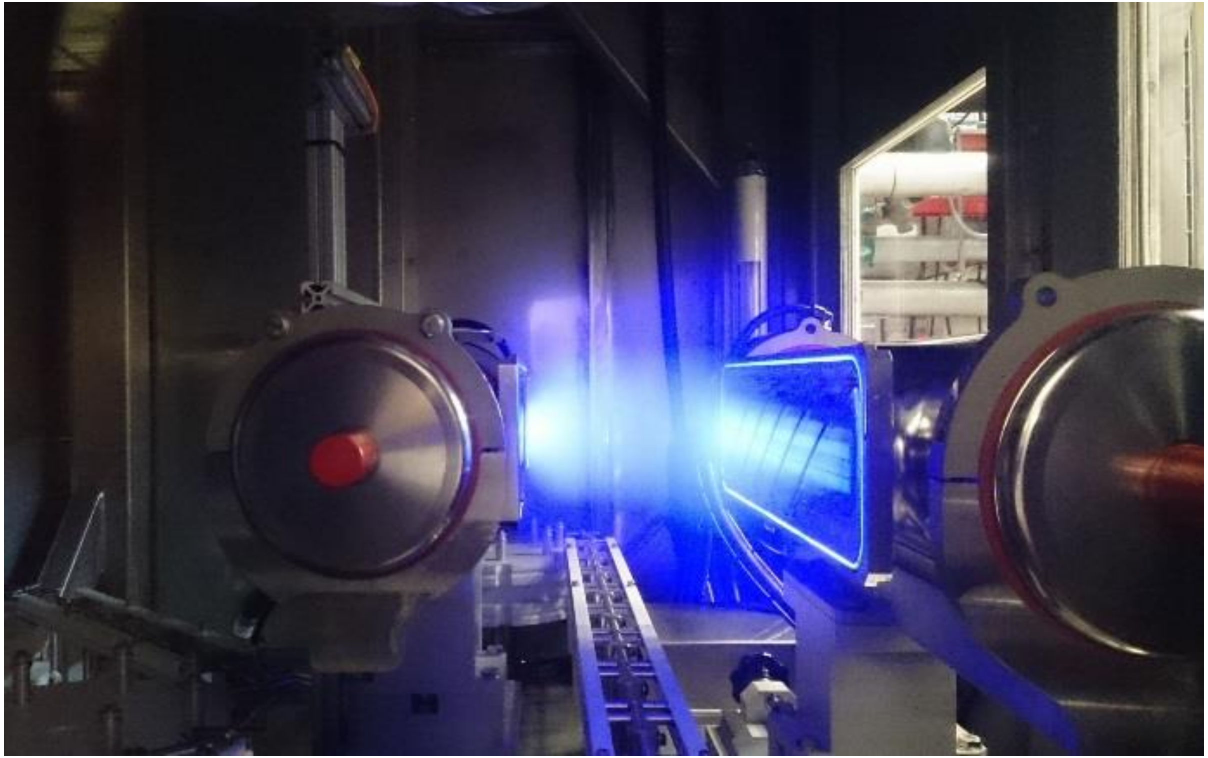
“Prospects and Challenges for the Industrial Use of Electron Beam Accelerators” Berejka, A. 2009 IAEA Conference

- Energy to dry/cure one gram of dried coating
- Water-borne coating (at 40 percent solids), the energy required to dry and cure the coating (independent of other energy required to heat the substrate) is **3390J/g**.
- On the same basis, the equivalent energy required for a solvent-borne coating (40 percent solids in toluene) is **555J/g**.
- Compared to an electron beam-cured coating (100 percent solids, solvent-free) using a dose of **30kGy (30J/g)**.
- **Converting Joules to kWh, the total kWh cost to dry 1 Mil (25.4 microns) of dry applied coating is almost twenty times higher for solvent-based versus electron beam-cured 100 percent solid formulations.**

Ebeam Cure of highly pigmented profiled automotive plastic part.

Advantages:

- Excellent high gloss/ matte appearance of dark pigmented/ high P/B
- Compared to UV cure, similar thermal shock, chemical and scratch resistance.



Ebeam Cure of highly pigmented profiled automotive plastic part.

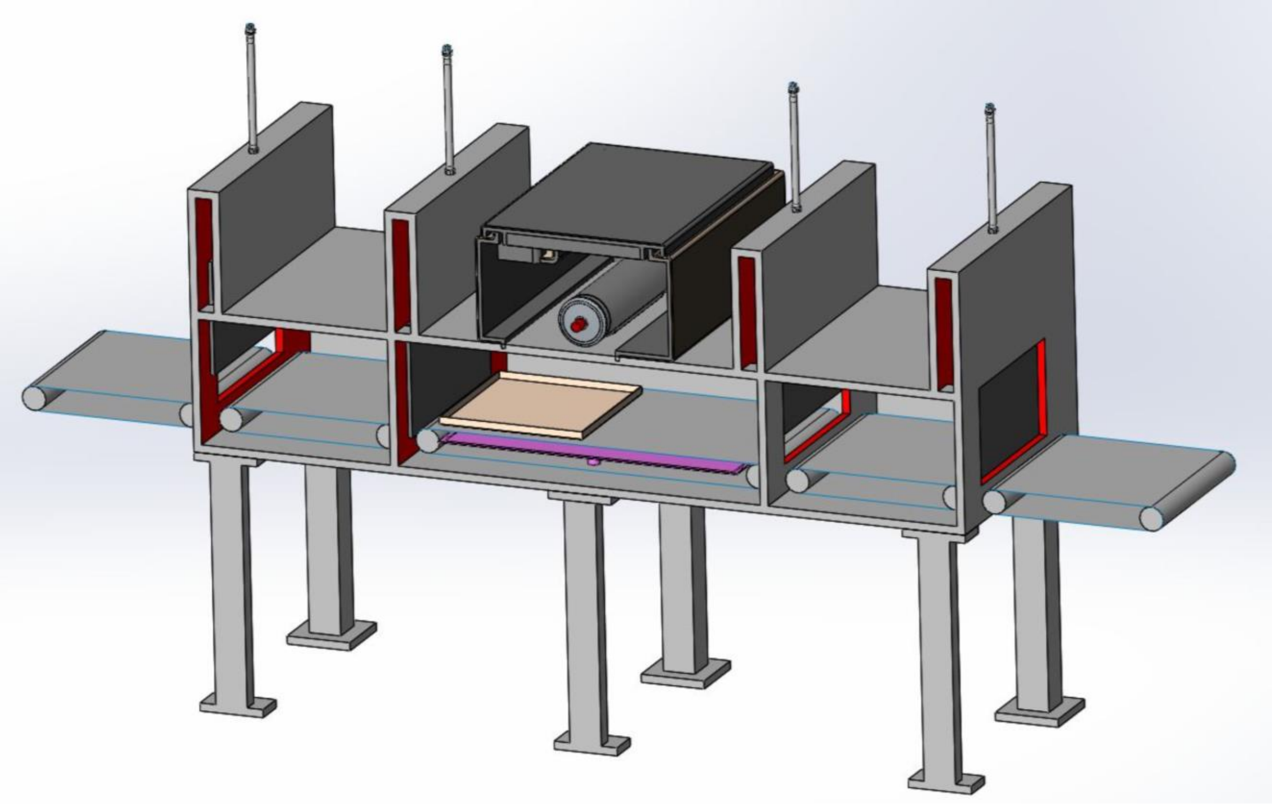
Automotive Plastic Part

- Flat Stock / Side Panels, down-fire process which uses a 200kV electronbeam.

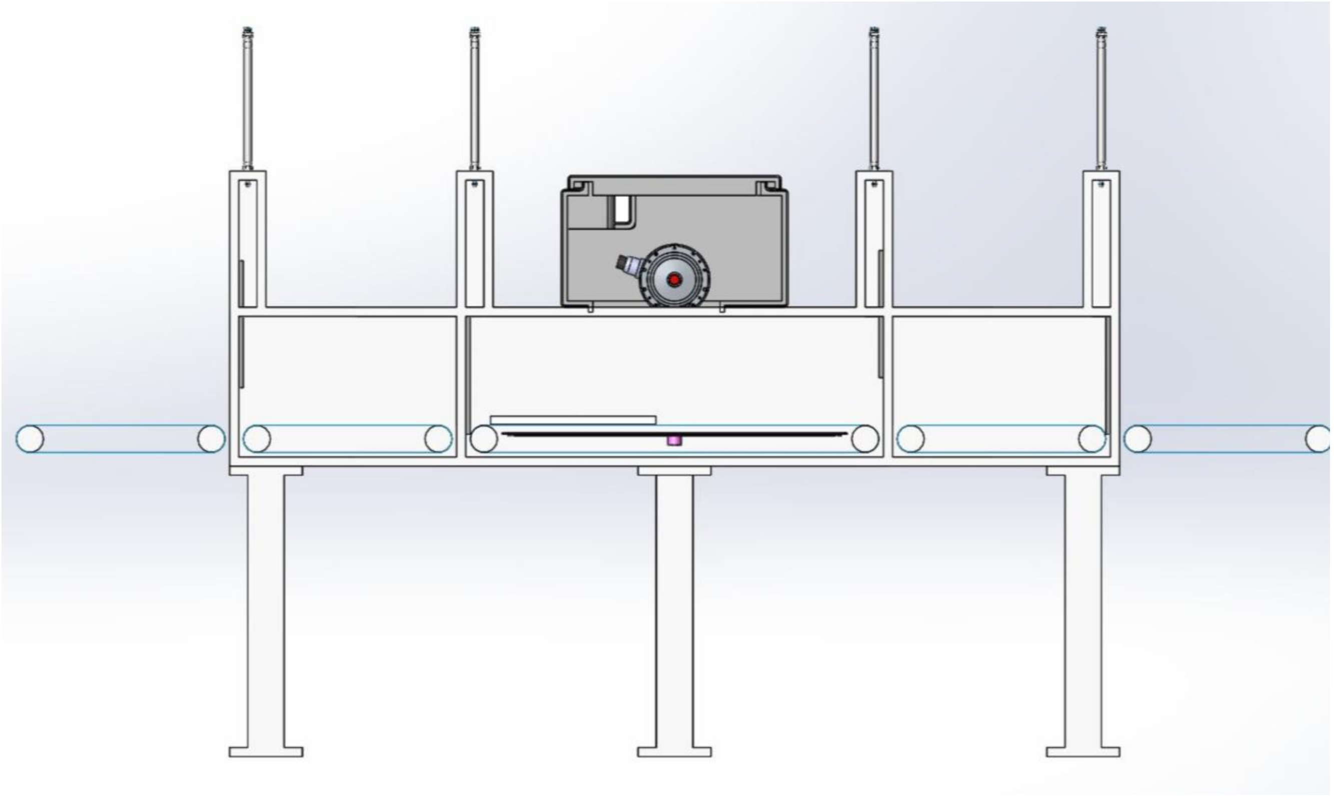
- The parts enter an inner chamber where inerting and then irradiation would occur.

- 60 second process

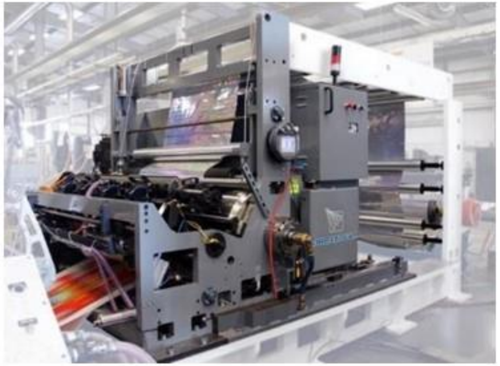
- The inner chamber would be shielded and have a shifting table. Parts would exit fully cured.



Ebeam Cure of highly pigmented profiled automotive plastic part.



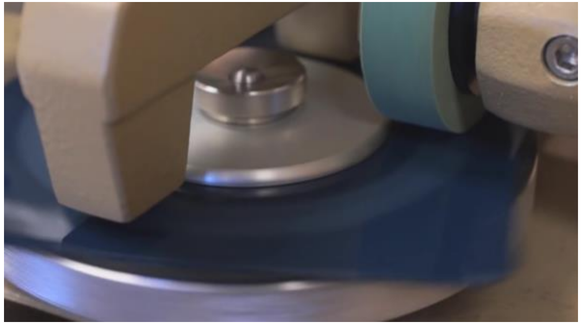
Ebeam for Automotive Applications. Equipment Configurations



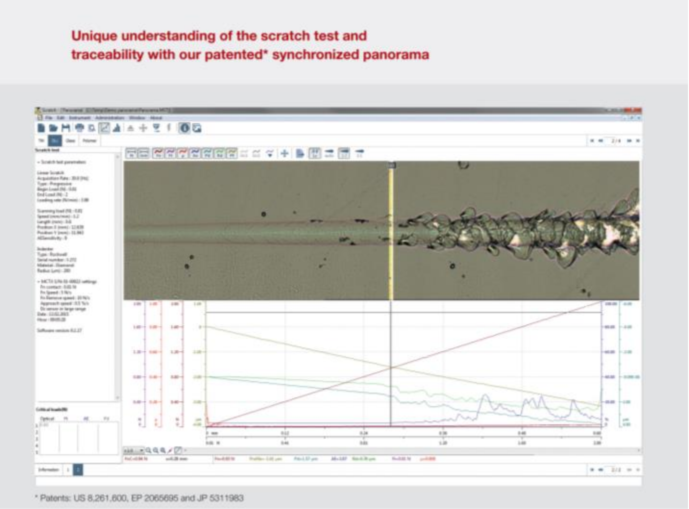
Coating Development & Automotive Test Methods

Opportunities

- Material Development – Test Methods
- Long Term Exterior Durability Studies
- WOM - SAE J2527 – ASTM D7869
- Nano Scratch – ASTM D7187
- Taber Abrasion – ASTM D4060-10



Q-SUN Xe-3 Xenon Test Chamber



Anton-Paar Nano-Scratch Tester

“Innovating better paint isn't always about the wet stuff” – Automotive News”

Parting Words & Comments:

- Christopher Toomey, BASF senior vice president, coatings solutions North America envisions future innovations allowing paint to dry faster.
- "**How do we reduce the temperatures in the ovens, or even go to ambient dry?" he asks.**
- **"That's the Holy Grail -- if you could take out an oven.“**
- Innovating in the paint business is sometimes as **much about the process** as the product.
- The segment's big players are spending R&D dollars to **take time and cost out of the process** of painting new vehicles.

Thank You!

References:

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2. Carignano, A – "The Development of Low-Energy Electron Beam Technology for Automotive Interior Plastic Coating Application" UV EB Technology, RadTech International, 2017, Q1
3. Heuss, R., Muller, N, van Sintern, W, Starke, A, Tschiesner, A., McKinsey & Company, Advanced Industries, "Light Weight, Heavy Impact - How carbon fiber and other lightweight materials will develop across industries and specifically in automotive", February 2012
4. Beiker,S., Hansson, F., Suneson, A., Uhl, M., "How the convergence of automotive and tech will create a new ecosystem". McKinsey & Company, Automotive & Assembly, November 2016
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7. Wernle, B, "Innovating better paint isn't always about the wet stuff", Automotive News, April 18, 2016

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