American Chemistry Council

Efficient Assembly And Joining: Reversible Bonded Joints Using Nano-ferromagnetic Particles

ACC Automotive Team

- Increase P&PC in automotive
- Provide transformative innovations
- www.Plastics-car.com

BASF The Chemical Company

Bayer MaterialScience

Braskem

DuPont The miracles of science

DOW Automotive Systems

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TOTAL

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MICHIGAN STATE UNIVERSITY | Composite Vehicle Research Center

CAR CENTER FOR AUTOMOTIVE RESEARCH

Research Project
Reversible Bonded Joints

Concept:

- Address need: fast, robust process for joining dissimilar materials
- Develop technology for joining composites and other lightweight materials
- ACC sponsored research project at MSU, assisted by CAR
- Multi-Phase project demonstrating reversible bonded joints
- Use thermoplastic polymer adhesive, modified with nano-ferro-magnetic particles
- Enable multi-material assemblies (repairable)

Example:
Vehicle Closure
- Composite inner assembly
- Aluminum outer skin

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Research Project
Reversible Bonded Joints

Objectives:

- Enable efficient multi-material joining and assembly
- Allow for easy and rapid assembly, disassembly, re-assembly and repair
- Capable of easy transition to current industry/assembly processes
- Enable efficient load transfer, eliminate stress-concentration and strength reduction at joints
- Allow for part consolidation and other benefits possible with composites
- Reduce vehicle weight and in-turn, improve fuel economy and reduce emissions

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Research Project
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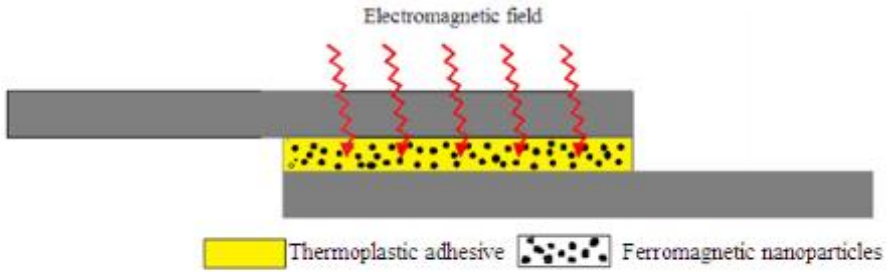
Approach:

REVERSIBLE BONDED ADHESIVES

- Thermoplastic adhesives reinforced with conductive nano-ferromagnetic particles
- Allow targeted heating of adhesive only using electromagnetic fields



METHODOLOGY

- Use integrated experimental and numerical approach that would eliminate costly trial-and-error, and would instead use a rational computational materials based approach
- Use of Non-Destructive Evaluation NDE) for joining efficiency, health monitoring
- Develop business case to assess practical feasibility, manufacturing investment model

DoE – Technical Gaps for Vehicle Applications

Table 14: Key Technical Gaps for Systems for Light-Duty Vehicles

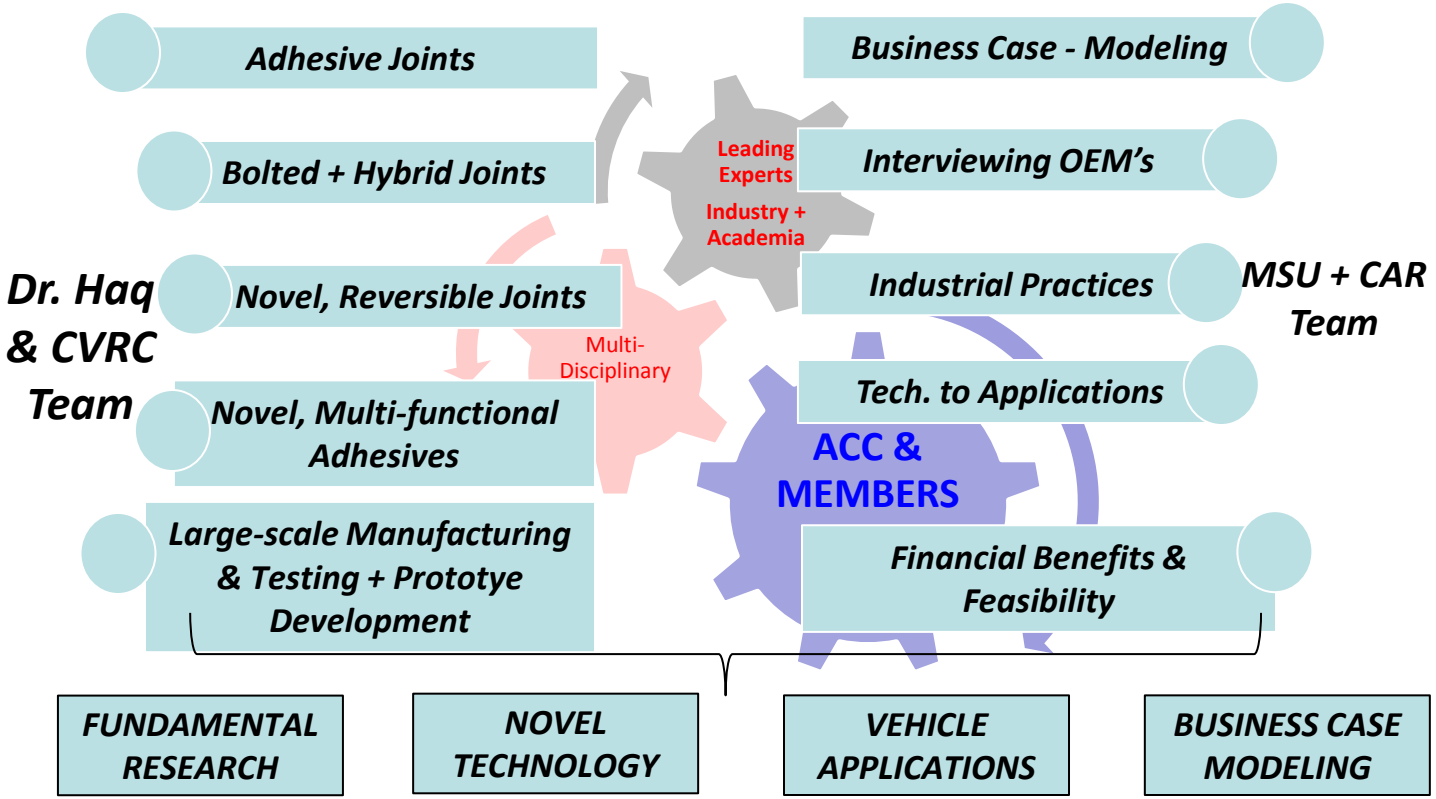
Source: http://www1.eere.energy.gov/vehiclesandfuels/pdfs/wr_ldvehicles.pdf

System	Three Most Significant Technical Gaps Impeding Widespread Implementation		
Body Structures (Composites)	Lack of understanding of properties with respect to fracture and energy absorption	Lack of predictive engineering and modeling tools	Lack of high-volume manufacturing capability
Body Structures (Metals)	Lack of technology for joining dissimilar materials	Properties of alternative lightweighting materials are inadequate for forming and energy absorption	Modeling, simulation, and design tools are inadequate for optimization
Chassis and Suspension	Inadequate properties (strength, ductility, corrosion resistance, etc.)	Manufacturing capacity to produce high- integrity components is inadequate	Robust joining processes, especially to other materials, are lacking
Closures, Fenders, and Bumpers	Fast and reliable processes for joining dissimilar materials are not available	Design knowledge and databases are inadequate	Cost/availability of most lightweight materials and current manufacturing processes are not competitive
Engines and Transmissions	Materials needed for advanced technology propulsion systems are not cost competitive	Properties of current materials are not adequate	Databases for modeling and design are inadequate

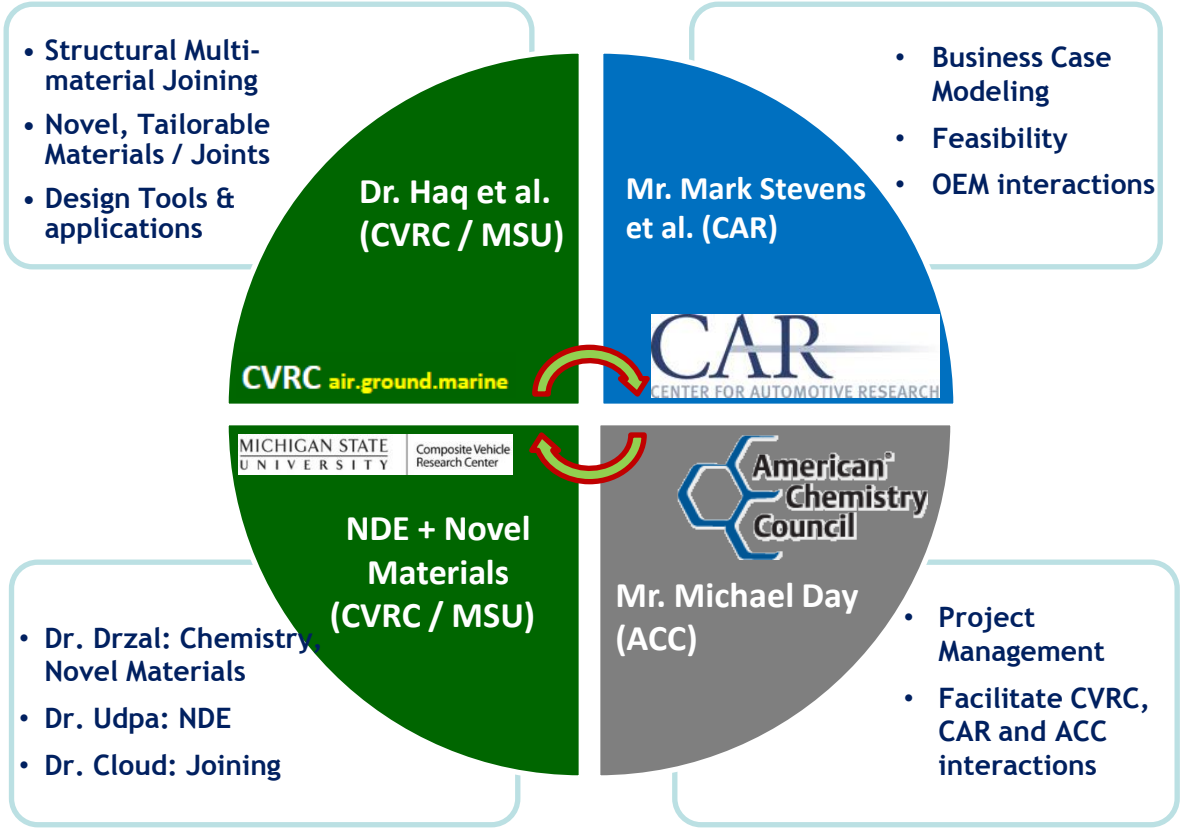
- **This project addresses all the "Critical Concerns": a) Dissimilar material Joining, b) Experimentally validate models/simulations / database creation, and c) efficient/rapid manufacturing and repair**

MULTI-MATERIAL JOINING

A COLLABORATIVE EFFORT FOR VEHICLE APPLICATION

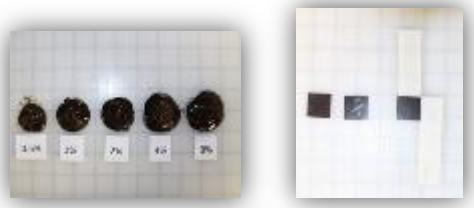


TEAM : Uniqueness & Pioneering the Effort on Combining Technology & Industrial Applications

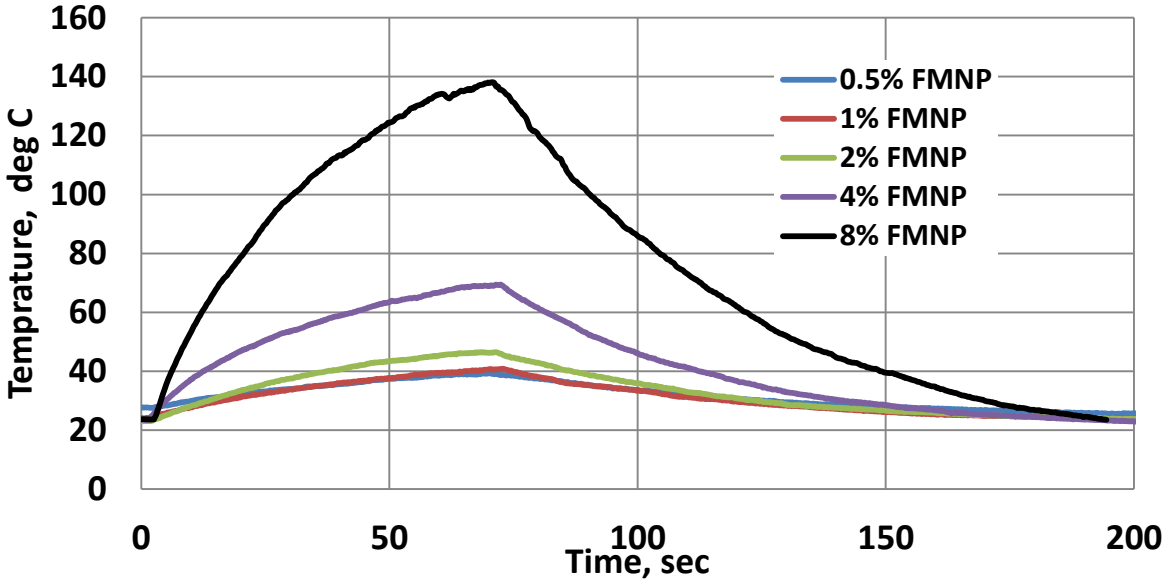


Progress to-date:

- Adhesive resin development - twin-screw micro-extruder compounding nano-ferromagnetic material, thermoplastic adhesive
- Adhesive films prepared - joining composite and aluminum samples.
- Lap shear joint samples – joint development, prelim. optimization
- Initial characterization adhesive - thermodynamic properties eval.
- Installation of Induction system - activation adhesively bonded joint
- Demonstrated reversible joint - lap shear specimens using inductive heating system
- Collecting input from key industry partners - joining concept for developing business case
- Developing prelim. industry model - vehicle closure applications

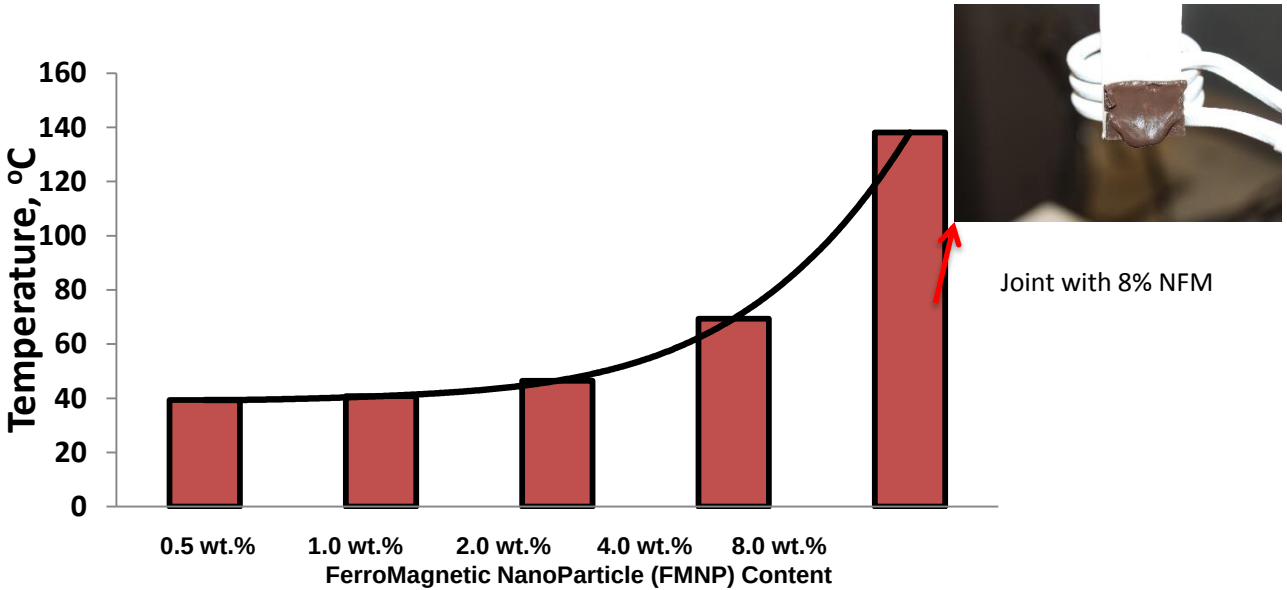


Thermophysical Characterization



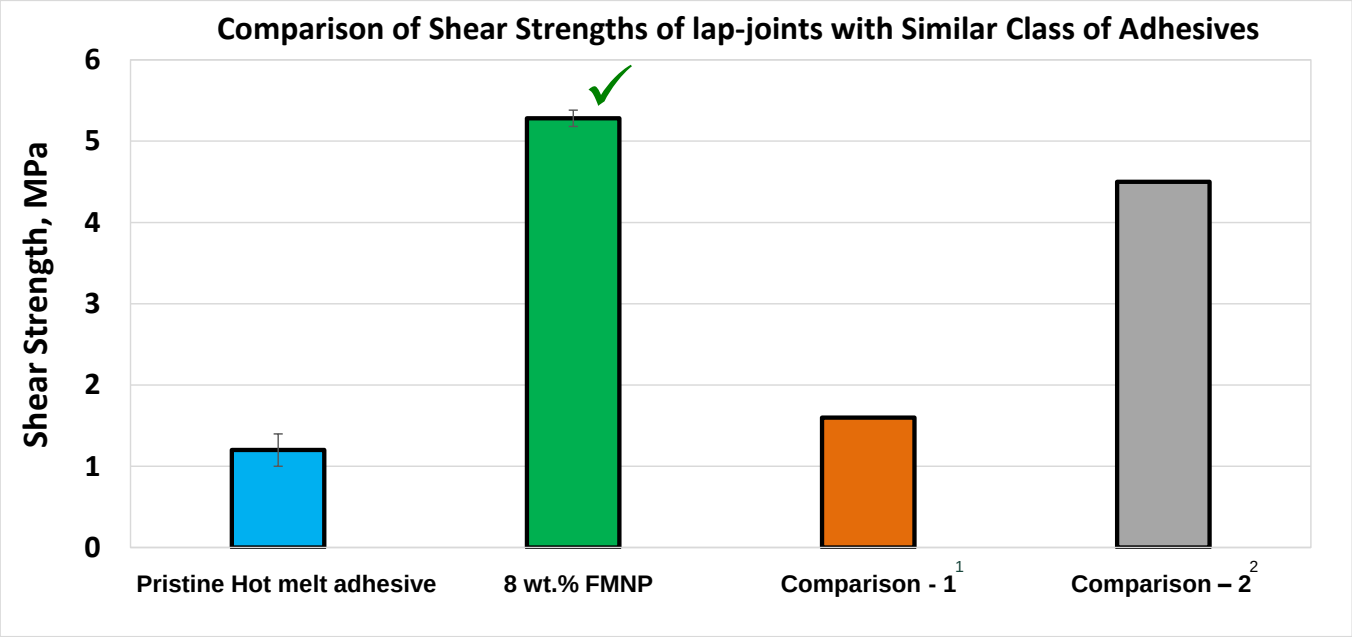
- Generally, presence of Ferromagnetic Nanoparticles (FMNP) was found to increase thermal response of thermoplastic adhesive while subjected to electromagnetic field
- It was evident that at lower concentration (0.5 – 2.0 wt.%) FMNP, the thermal response of the thermoplastic adhesive was insignificant; hence “threshold limit” is important to couple ‘thermal response’ with FMNP/induction heating

Thermophysical Characterization



- For the given Ferromagnetic Nanoparticles (FMNP) concentrations, the trend shows an exponential regression
- Again, it is evident that at lower concentration of (0.5-2.0 wt.%) FMNP, the thermal response is insignificant

Lap-Joint Shear Strengths: Similar Class of Adhesives



[1]Elena Verna, Ermias Gebrekidan Koricho, Irene Cannavaro, Valentina Brunella, Giovanni Belingardi, DavideRoncato, BrunettoMartorana, Vito Lambertini, Vasilica Alina Neamtu, Romeo Ciobanu, Adhesive joining technologies activated by electro-magnetic external trims, International Journal of Adhesion and Adhesives, 2013:46;21-25

[2]X.Yang, L. Yao, Yong Xia, Qing Zhou, Effect of base steels on mechanical behavior of adhesive joints with dissimilar steel substrates, International Journal of Adhesion and Adhesives, 2014;51:42-53

Accomplishment: Proof – of – Concept

Proof of Concept – Disbonding of Joint through Activation of Reversible Adhesive

Business Case

- Generic Business Case Target for bonded joint is being developed
- Historical Range shows dependence on OEM specs. + other factors

Next Steps:

- Review generic target with OEMs
- Program formula into the business case model
- Focus on dispensing methodology

- Collecting data to ensure compelling case for technology uptake

For More Information

Thank You

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This presentation was prepared by the ACC Plastics Division with input from experts from Michigan State University's CVRS and the Center for Automotive Research.

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