

Center for **L**ightweighting **A**utomotive **M**aterials and **P**rocessing

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Purpose of Work

- ∞ To create a university/industry/government collaborative education/research/information center on automotive materials and processing for lightweight automobiles
- ∞ Emphasis is on graduate education, research and knowledge transfer to future engineers and researchers



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Barriers Addressed

- ❧ Improvement in energy efficiency and environmental impact will require significant mass reduction and much more efficient use of materials in future automobiles.
- ❧ Materials and processing development, and innovative adaptation of advanced technology are needed for mass reduction and lightweight structures.
- ❧ Many university curricula and research do not address the advanced materials and processing technology used and/or developed for the automotive industry.



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Approach

- ❧ Establish automotive materials concentration in the existing master's program on Automotive Systems Engineering
- ❧ Conduct research on automotive materials and processing
- ❧ Establish an automotive materials database
- ❧ Conduct seminars/colloquia/continuing education courses for practicing engineers on automotive materials

Ω Year 3 Objectives

- Develop a new course on Vehicle Crashworthiness
- Continue upgrading the materials laboratories
- Offer at least two research assistantships
- Collaborate with industry in research and design projects
- Organize seminars and symposium on lightweight automotive materials

- ∞ No. of students in materials classes offered in the ASE program: 65
- ∞ No. of graduate students in CLAMP research: 10
- ∞ No. of faculty: 6
- ∞ No. of research projects: 10
- ∞ No. of CLAMP supported research: 3
- ∞ No. of industry funded research: 5
- ∞ No. of refereed journal publications: 4
- ∞ No. of conference publications: 7

- ∞ Graduate Courses Taught/Developed in 2008-2009
- Materials Selection in Automotive Design (AE 581) (W, 09)
 - Mechanical Behavior of Polymers (F, 09)
 - Composite Materials (ME 589) (S, 08)
 - Design and Manufacturing for Environment (AE 588) (W, 08)
 - Designing and Manufacturing with Lightweight Automotive Materials (AE 586) (W,08)
 - Materials and Design for Crashworthiness of Automobiles (AE 599) (developed in S, 08)

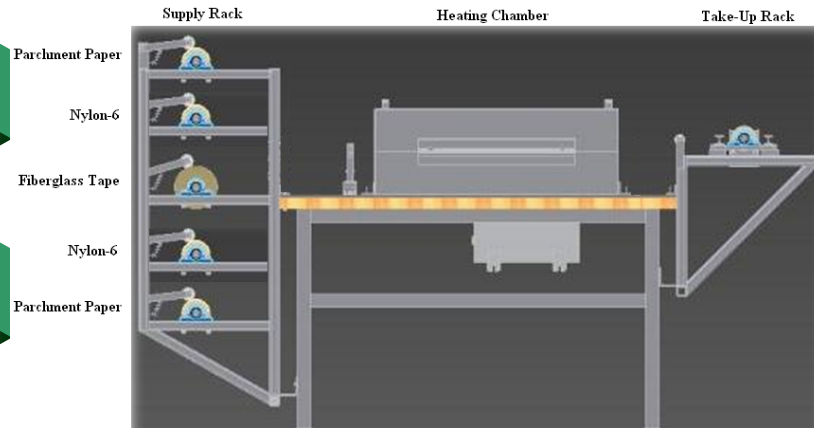
- ❧ Development of Coupled Thermo-Mechanical Finite Element Analysis Tools for Simulating Warm Forming Processes (Ford)
- ❧ Development of CAE Tools and Design Guidelines for Ford's Advanced Superplastic Technology (FAST) (Ford)
- ❧ Fatigue Performance of Fusion Welded Joints in High Strength Steels (Auto/Steel Partnership)
- ❧ Effect of Surface Treatment on Adhesive Joining of Magnesium Alloys (USAMP and Ford)

- ❧ Development of Thermoplastic Matrix Composite Prepregs using Continuous Resin Infusion (CLAMP)
- ❧ Study of Crush Characteristics of Composite and Metal Plates (CLAMP)
- ❧ Fatigue Performance of Injection Molded Short Fiber Reinforced Polyamide-6,6 (CLAMP)
- ❧ Development of Thermally Conductive Composites for Lightweight Heat Exchangers (UM-D Faculty Research Grant)

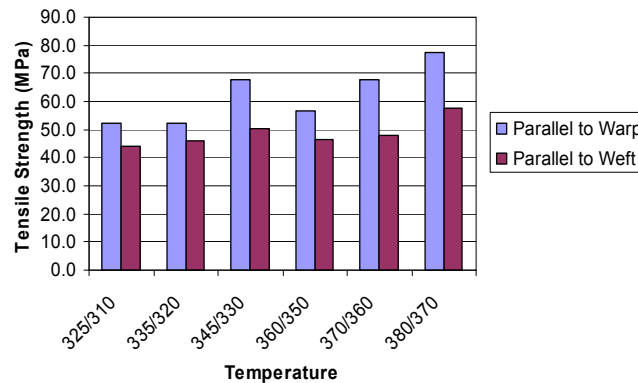
- ❧ Development of Aluminum Frame for Fuel Cell Scooter (Asian Pacific Fuel Cell Technologies)
- ❧ Determining Vehicle Interior Material Characteristics to Satisfy Needs for the Elderly (CEEP)

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Thermoplastic Prepreg Development using Continuous Resin Impregnation

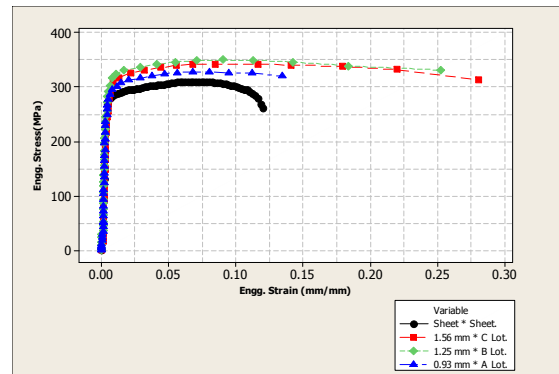
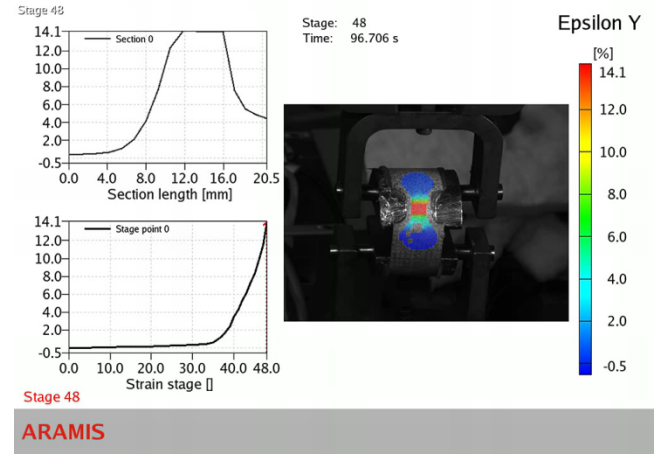
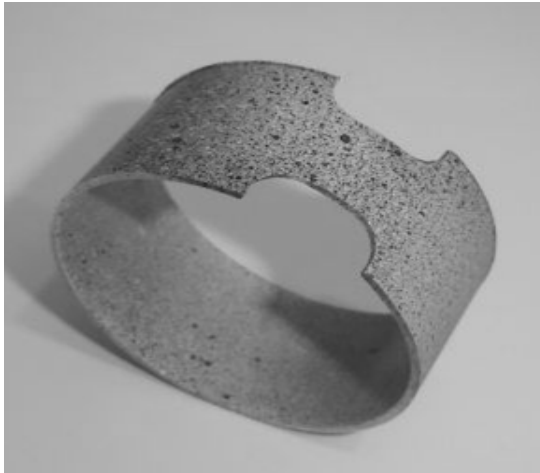


Average Tensile Strength vs Temperature



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Material Characterization using Non-Contact Strain Measurement: Aluminum Tubes



- ∞ Mechanical Behavior of Cast and Forged Magnesium Alloys and their Microstructure (Matls. Engg. and Sci., 2008)
- ∞ Influence of Geometric Parameters and their Variability on Fatigue Resistance of Spot Welded Joints (SAE, 2008)
- ∞ Fatigue of Spot Friction Welded Joints in Mg-Mg, AL-Al and Al-Mg (SAE, 2009)
- ∞ Development of Thermoplastic Prepreg Manufacturing Process by Continuous Resin Infusion (SAMPE, 2008)

- ∞ Information on structural automotive materials
- ∞ Gather, store and disseminate archival and encyclopedic information on structural automotive materials
- ∞ Database on properties, processing, test methods and application examples
- ∞ Internet access to industry, universities and individuals
- ∞ Working with National Center for Manufacturing Sciences (NCMS) to broaden the materials database

- ❧ Current industry collaboration: Ford, Auto/Steel Partnership, USAMP, Asian-Pacific Fuel Cell technologies
- ❧ Participating member in the Corrosion sub-group of the Magnesium Front End Research and Development
- ❧ Discussions held with Faurecia (for lightweight seat development) and International Manufacturing and Assembly (for extrusion process development for magnesium)

- ∞ Design, Materials and Processes Enhancing the Performance of the 2008 Corvette Z06 – D. Gerard (GM)
- ∞ Low Cost Ultrafine Grained Nano Materials for Structural Applications – V. Segal (Engineered Performance Materials)
- ∞ Laboratory Blast Simulation for Testing Composite Materials – D. Liu (Michigan State University)

- ∞ *Design a **mobility solution** in the spirit of the Model T while meeting the following requirements:*
 - Compete against non-consumption like the original Model T
 - Base list price : **\$7000**
 - Has a minimum range of **200 km (125 miles)**
 - Base model seats at least **2 passengers**
- ∞ Funded by Ford Motor Co.
- ∞ Collaboration with Institute of Advanced Vehicle Systems (IAVS) of UM-D
- ∞ Project Duration: May 2008-August 2008
- ∞ 6 graduate students and 3 undergraduate students participated in the project

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FINAL CONCEPT

3 BODY STYLES

**FUNCTIONAL SIDE SCOOPS
FOR INTAKE AND COOLING**

**FLAT SIDE WINDOWS HELP REDUCE
COST OF MANUFACTURING**

**RECONFIGURABLE BODY PANELS
ALLOW MULTIPLE BODY STYLES**





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UM-D Model T Concept: Some of the Design Features

- Snap-fitted molded-in color body panels made of polypropylene (easy to disassemble and no paint shop)
- High strength steel space frame chassis
- Use of composites in suspension
- Less energy consumption in manufacturing (no welding in assembly) and transportation (stackable chassis parts)
- Easy to recycle (use of only one type of plastic in both exterior and interior panels and interior components)
- Extensive use of recycled materials (e.g. used pop cans as energy absorber in the bumper)
- Use of natural materials (natural fibers, chicken feather, soy foam)



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UM-D Model T Concept: Overall Design

- **\$7000** list price
- **1600 lb** curb weight
- Fuel: Natural Gas
- **33 / 37 mpg** Gasoline Equivalent (EPA's new 5-cycle mpg-based approach)
- **65%** lower annual fuel cost compared to a mid-size sedan
42% lower HC, **80%** lower CO & **57%** lower NOx than EPA Tier 1 requirement
- **3** body styles with no structural changes
- **23** options for reconfigurable interior
- **20%** fewer parts in suspension system
- **2.25** times more eco-friendly body construction (vs. steel body)
- **Assembly at dealership** and local, distributed supply base

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UM-D Model T Concept



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- Ω Develop a new graduate course titled “Forming Process Modeling and Optimization”
- Ω Offer “Materials and Design for Crashworthiness of Automobiles” and “Fuel Cell Materials and Manufacturing”
- Ω Laboratory upgrading
 - Mechanical Testing Laboratory [on-going]
 - Metals Forming Laboratory
- Ω Offer two symposia: “Design and Manufacturing for Environment and Sustainability” and the 2nd Symposium on Lightweight Automotive Materials and Processing [the 1st Symposium was held in 2003]



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- ∞ Increase collaborative research with industry
- ∞ Recruit more full time graduate students
- ∞ Add more courses to our distance learning programs
- ∞ Explore collaboration with other universities



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∞ Acknowledgement

- Department of Energy
- College of Engineering and Computer Science
- Industry Collaborators
- Graduate Students in the Program

Thank You...