U.S.–China Clean Energy Research Center
中美清洁能源研究中心
Clean Vehicles Consortium

中美清洁能源研究中心
清洁汽车联盟

欧阳明高　　彭晖

中方主席　　美方主席

2013年1月10日

University of Michigan

提 纲

- 目标和达成指标
- 中心项目和协作活动
- 重要研究成果
- 知识产权
- 行业参与
- 五年末预期成果

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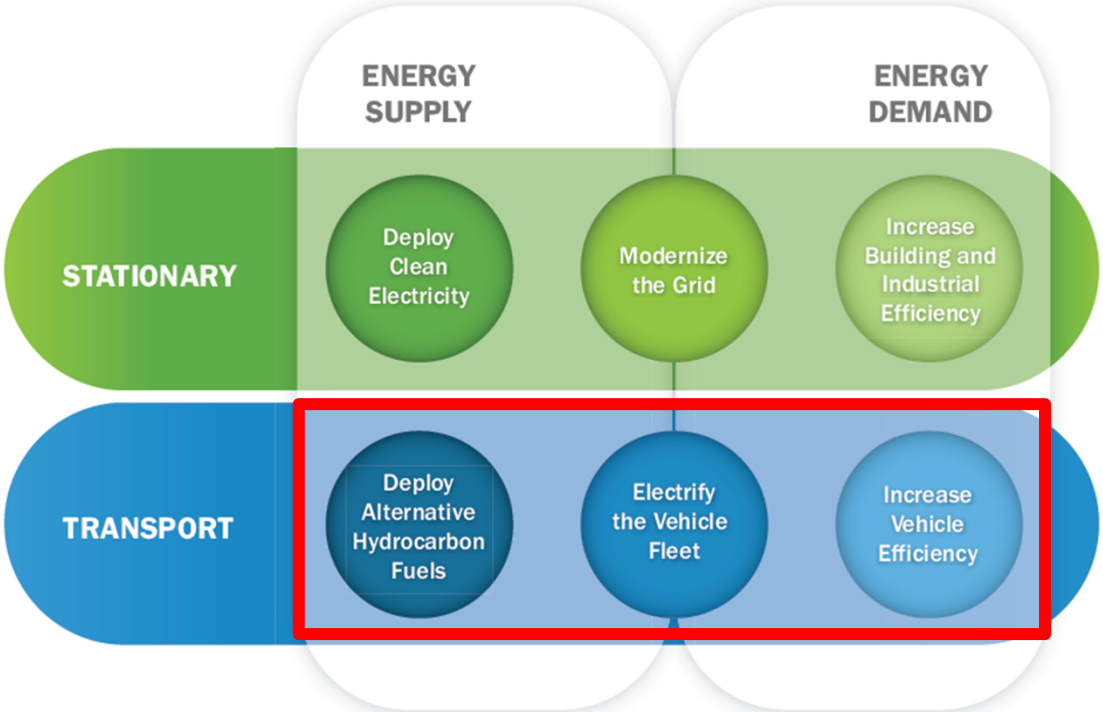
清洁汽车联盟：目标

“研究可以大幅减少车辆燃油依赖和/或提高汽车燃油效率的潜在技术”

Figure ES-1. The QTR has framed six strategies to address national energy challenges.



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清洁汽车联盟预期指标(2011)

- 组织双边工作会议、技术研讨会、专题讨论会
- 发表期刊及会议论文
- 达成知识产权协议；申请美国、中国和国际专利
- 组织人员交流
- 联合培养学生，向CERC-CVC成员单位推荐优秀毕业生
- 博士后交流
- 争取获得科技奖励（个人，团体）
- 在国际学术会议上做主题发言或讲座
- 促进知识产权在CERC-CVC内转移

最近指标完成情况

- 组织双边工作会议、研讨会、专题讨论会
  - 3 次联盟内会议，6次电动汽车与电池研讨会
  - 51 次技术交流会议（多数由独立TA完成）
- 发表期刊及会议论文
  - 152 篇发表或接收 (22篇联合发表)
- 知识产权公开入档；美国，中国和国际专利
  - 中国专利12项，美国专利20项（中方申请11项）
- 人员交流情况
  - 完成 80 人次短期访问，21 次长期访问（>30天）

提　纲

- 目标和达成指标
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Clean Vehicles Consortium

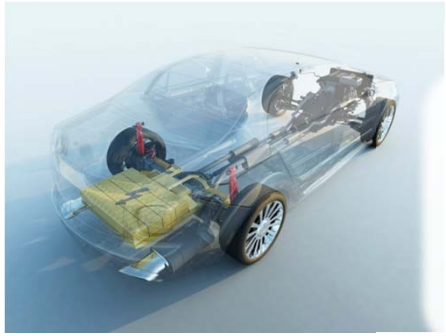
CERC-CVC 研究方向

先进的电池和能量转换

轻量化

先进生物燃料，清洁燃烧和APU

车与电网集成



车辆电动化

能源系统分析，技术路线图和政策

项目变更

- 美国方面：
  - 密歇根大学终止1项(项目负责人工作调动)
  - 2012年新增4个项目、2013年增加3个项目（由企业合作伙伴提供经费，研究课题由工业咨询委员会确认）
- 中国方面：
  - 在清华大学新增一个项目（千人计划引进人才）

提　纲

- 目标和达成指标
- 中心项目和协作活动
- 重要研究成果
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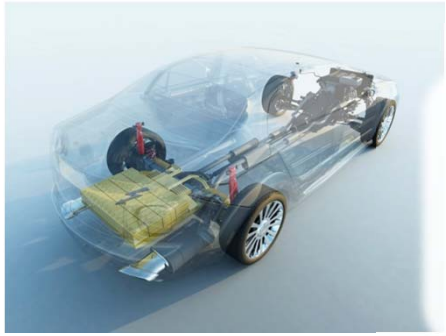
主要汇报方向

先进电池和能量转换

轻量化

先进生物燃料，清洁燃烧和APU

车与电网集成



车辆电动化

能源系统分析

U.S.–China Clean Energy Research Center
中美清洁能源研究中心
Clean Vehicles Consortium

先进电池和能量转换

邱新平[1]，Don Siegel[2]

Battery & Energy Conversion Thrust Co-Leaders

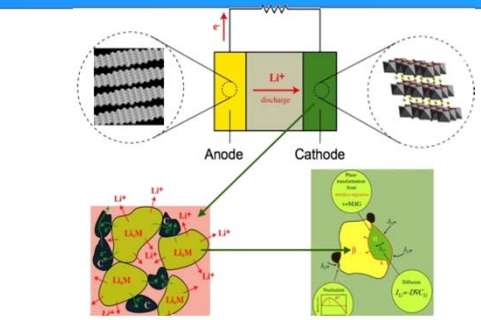
[1]清华大学化学系

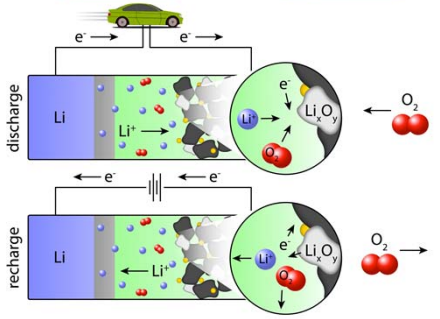
[2] 密西根大学机械工程系

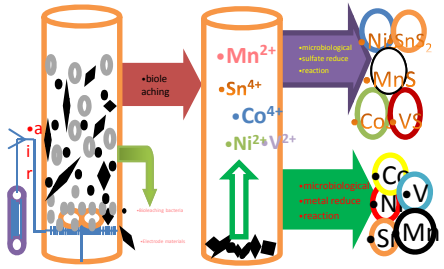
CERC Steering Committee, January 10, 2013
Washington, DC

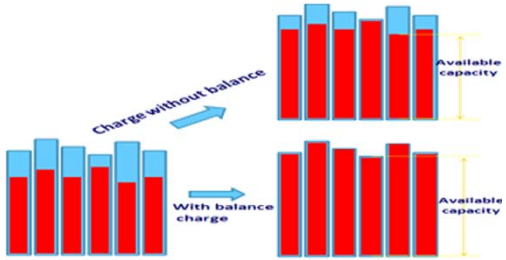
研究目标

- 电池性能衰变机理:结合模型与先进的表征手段研究锂离子电池性能衰变的机理。
- 电池模型与智能管理：发展基于能量平衡的电池管理系统；对比两国电池性能与安全性测试标准与方法；发展电池梯级利用及电池回收的可能途径。
- 新型电池体系：探索电极反应新机理、开发新型电极材料与电极结构，推动锂硫电池与锂空气电池的产业化。









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研究内容与参加人员

性能衰变机理
Babu (OSU)
Bhushan (OSU)
Conlisk (OSU)
Cao & Canova (OSU)
Daniel (ORNL)
Leung (Sandia)
Amine (ANL)

↔

衰变机理
邱新平，清华大学

新型电池体系
Siegel (UM)
Van der Ven (UM)
Shao-Horn (MIT)
Ceder (MIT)

↔

新型 电池体系
吴锋，北京理工 大学
康飞宇，清华大学
邱新平，清华大学
何向明，清华大学

电池模型及电池管理系统
Bernstein & Stein (UM)

↔

电池模型与电池管理
卢兰光，清华大学

测试方法与电池回收
Bloom, Gaines, Sullivan (ANL)

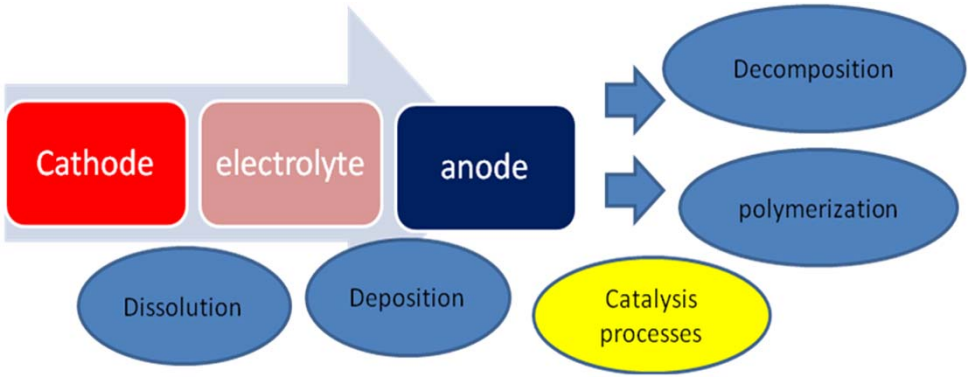
↔

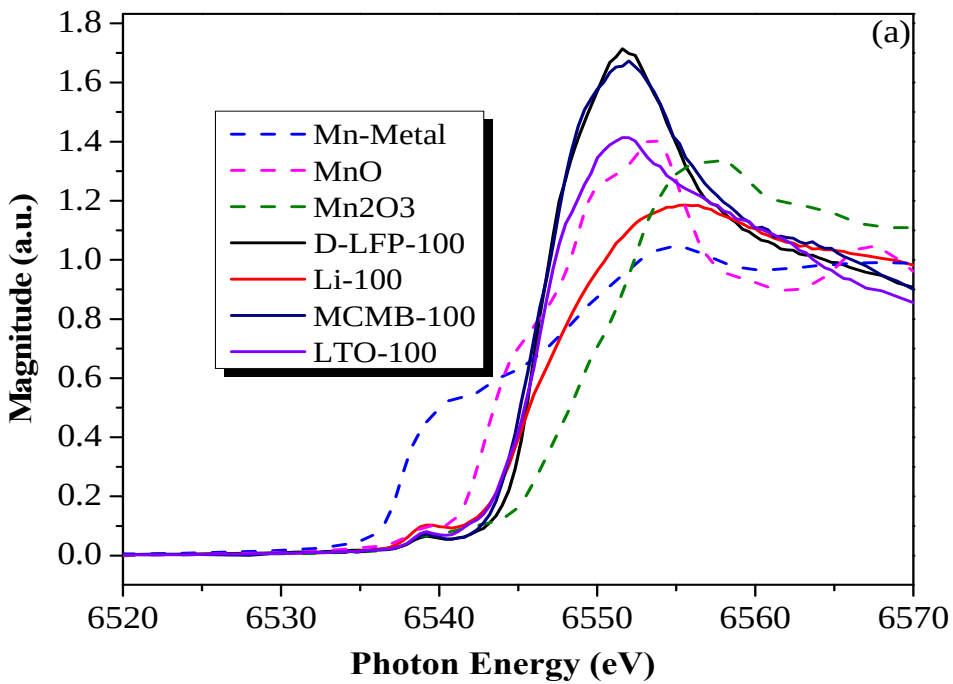
测试方法与电池回收
王芳，汽车研究中心
李丽，北京理工 大学

U.S.–China Clean Energy Research Center
中美清洁能源研究中心
Clean Vehicles Consortium

锂离子电池正极溶解过程

邱新平, 詹纯(清华大学)， Jun Lu and K. Amine(ANL)





- 锰离子在负极表面沉积并积累，随着循环次数的增加而增加
- 在负极表面的锰以离子形式存在，而不是通常人们所说的0价的锰金属

为深入理解锂离子电池循环过程的电池容量衰减以及内阻增加提供重要证据。

中美电池标准与测试方法对比

I Bloom(ANL), D. Robertson(ANL) J. Christophersen(INL)
Wang Fang(CATARC)and Fan Bin (CATARC)

- 采用测试标准
  - -美国ABC EV DST
  - -中国 QC/T 743 and 846
- 两标准的相似点
  - 参照测试及电池容量衰减终点采用的DOD窗口、温度、容量
- 两标准的不同点

—循环性：恒电流（中）、动态功率（美）

—功率密度：50% DOD (10-s 脉冲）（中)、80% DOD时的功率峰值 (30-s 脉冲)（美）

—参照测试频率：24 次循环(6 天）（中) 、50 次循环 (10.5 天）（美)

—参照测试时长: 18 h vs. 35 h

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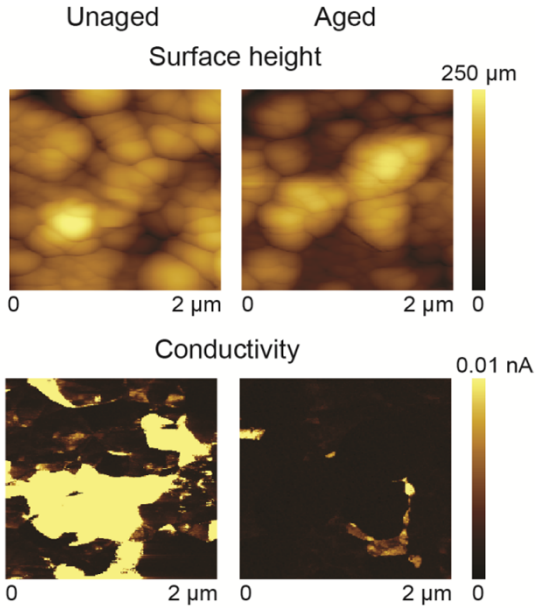
电极结构表征方法

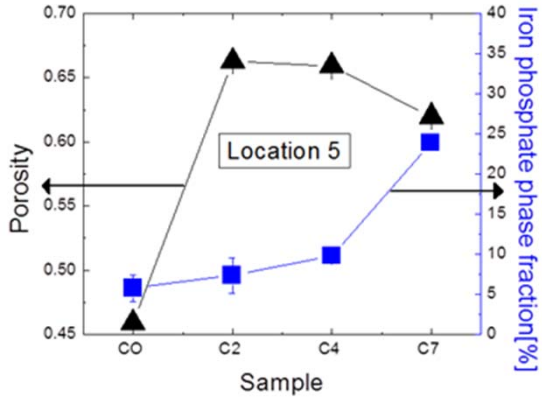
B. BHUSHAN (PI), S. C. NAGPURE (PDR), S. RAMDON (GRA) The Ohio State University

团聚 → 孔隙率增加 → Li 迁移

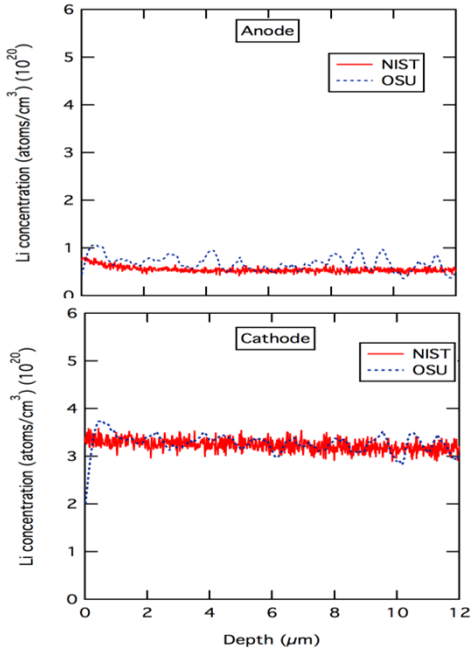


采用高分辨AFM观察电极材料颗粒的团聚

团聚后，电极电子导电性下降

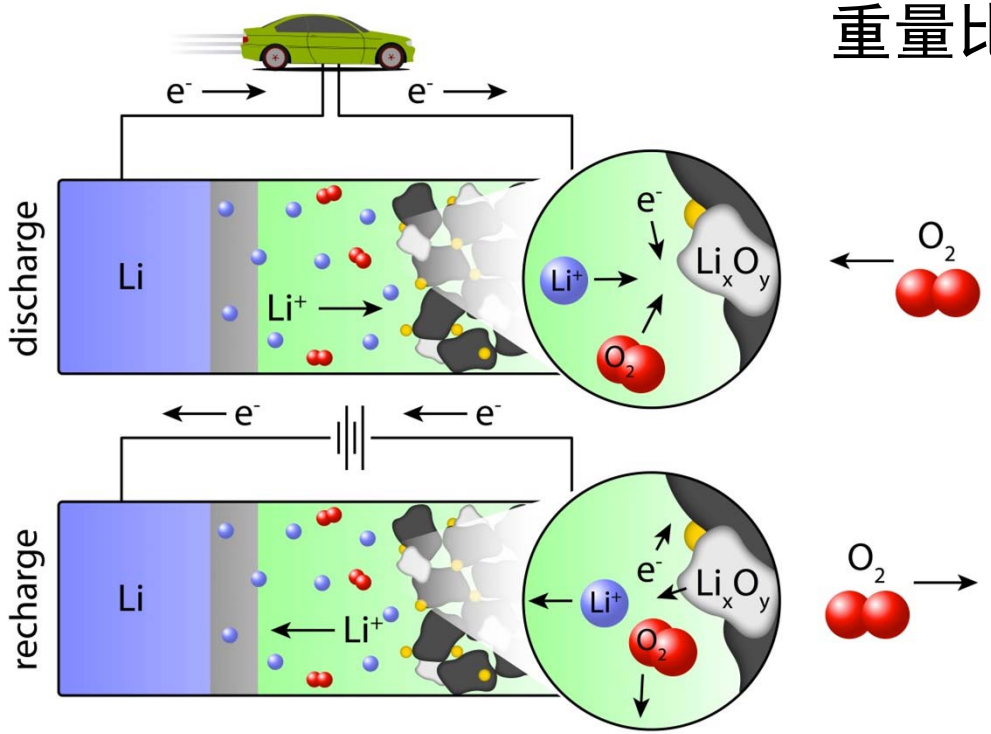


孔隙率增加引起了活性材料的损失，即活性材料破裂引起容量损失



在电池老化过程中，负极增加，正极中锂含量下降。

新电池体系



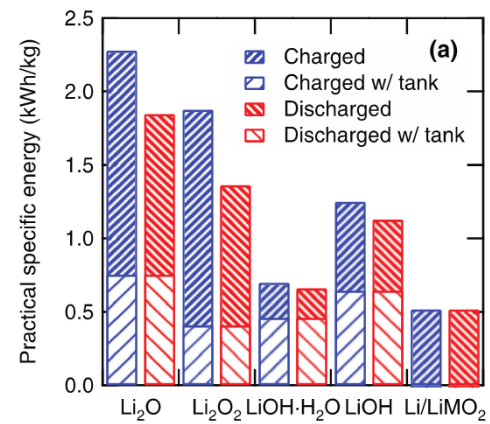
$2Li^+ + O_{2(g)} + 2e^- \rightarrow Li_2O_{2(s)}$ $U^0 = 2.96$ V

$2Li^+ + ½ O_{2(g)} + 2e^- \rightarrow Li_2O_{(s)}$ $U^0 = 2.92$ V

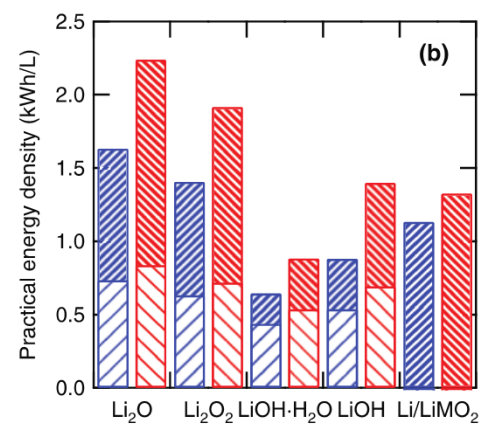
Li-air projected cost:
$100/kWh[1],
$238/kWh[2]

[1]Johnson Controls, 2011 Battery Congress
[2]J. Power Sources 199 (2012) 247– 255

重量比能与体积比能量的估计值



300-400% vs. Li-ion



30-60% vs. Li-ion

JES **159**, 2193, R1 (2012).

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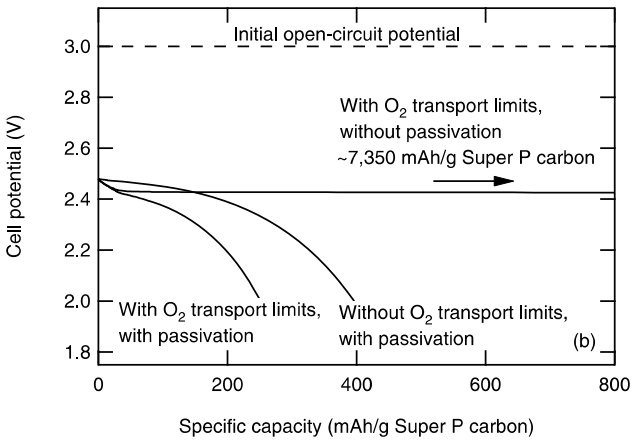
锂空电池正极

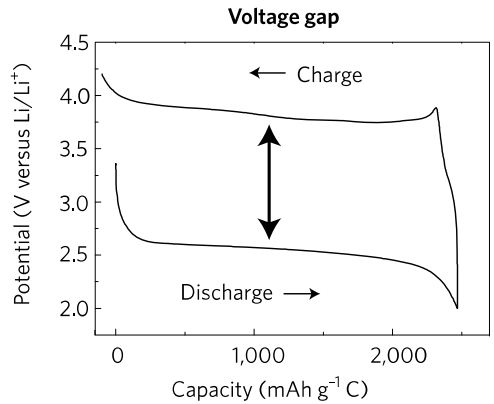
•Continuum-scale models and flat-electrode experiments suggest that electrical passivation can limit capacity

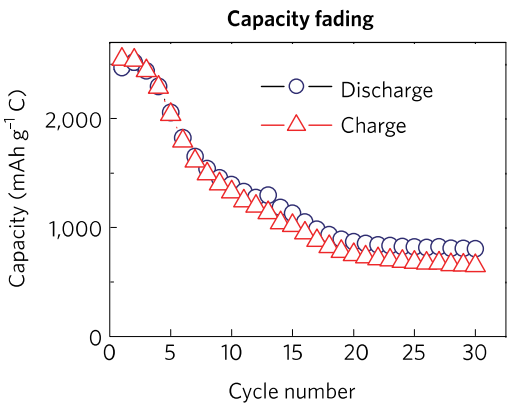


•Simulated discharge curves illustrating the effects of O_2 transport or electrical passivation.

•J. Electrochem. Soc. 158, A343 (2011)

•High efficiency and long cycle-life are also challenges

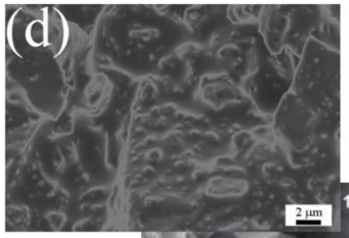




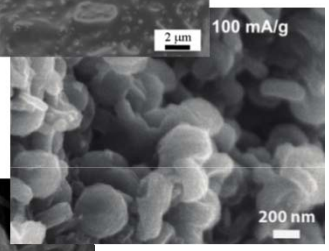
•Nature Mat. 11, 19 (2012)

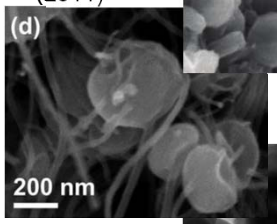
•Morphology of discharge phase can vary dramatically

•Energy Environ. Sci. 5, 8927 (2012)

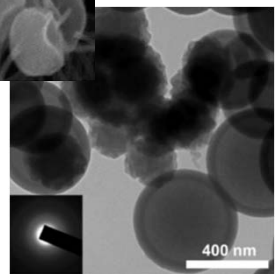


•Energy Environ. Sci. 4, 2999 (2011)





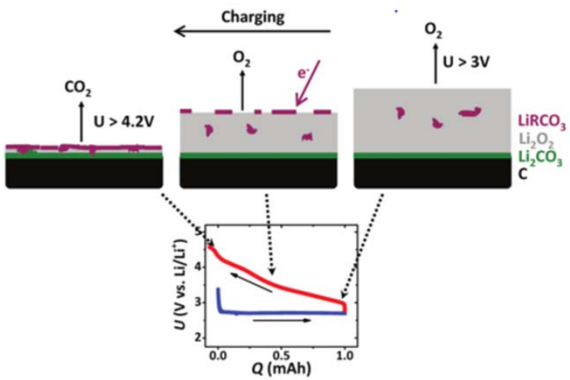
•Energy Environ. Sci. 4, 2952 (2011)

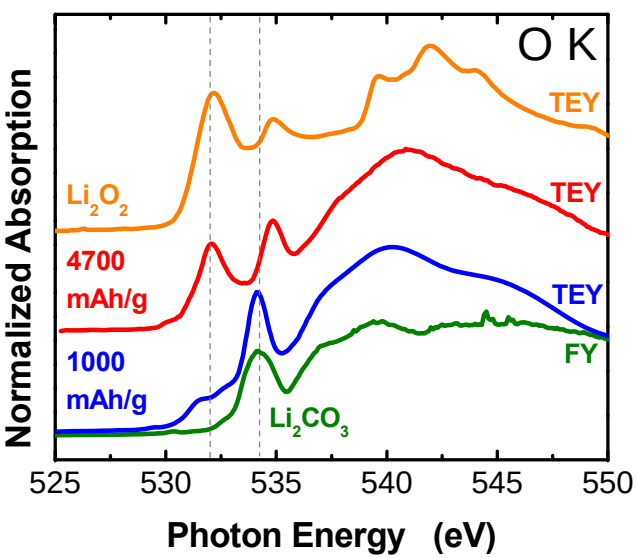


•Nano Lett. 12, 4333 (2012)

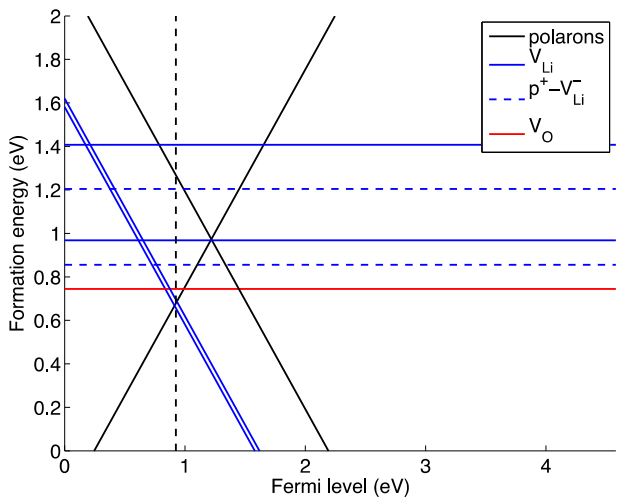
放电产物的结构与性质

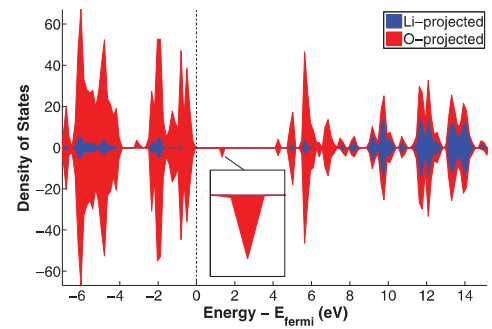
•XANES 光谱



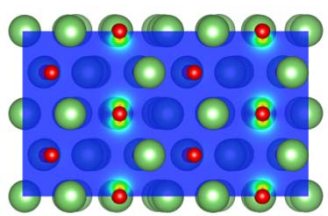


•第一性原理计算

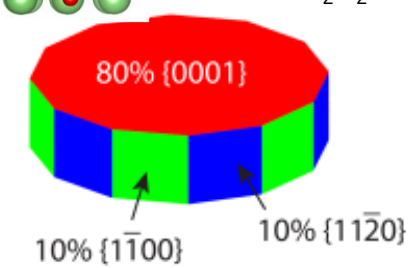


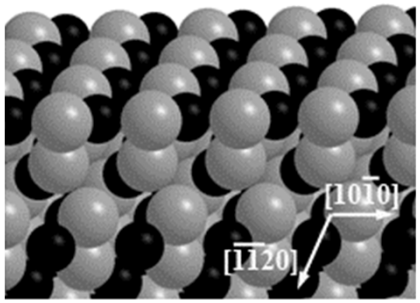


Material	σ (S/cm)
Stainless Steel 304	1.4×10^4
Vulcan carbon	4×10^{-1}
Bulk Li_2O_2	**$2 \times 10^{-7}/3 \times 10^{-8}$**
Glass	10^{-12}-10^{-16}



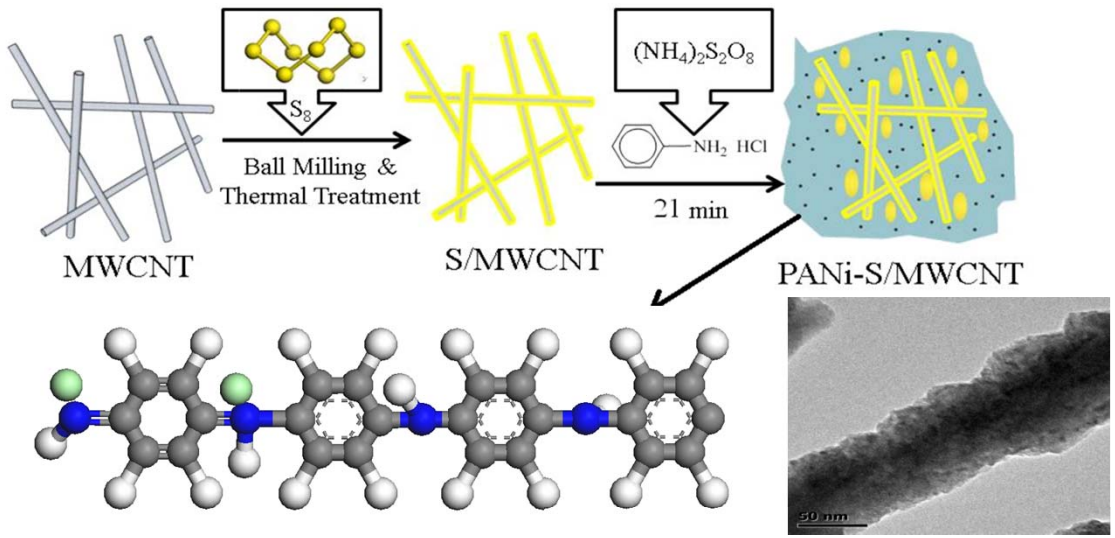
•Li_2O_2

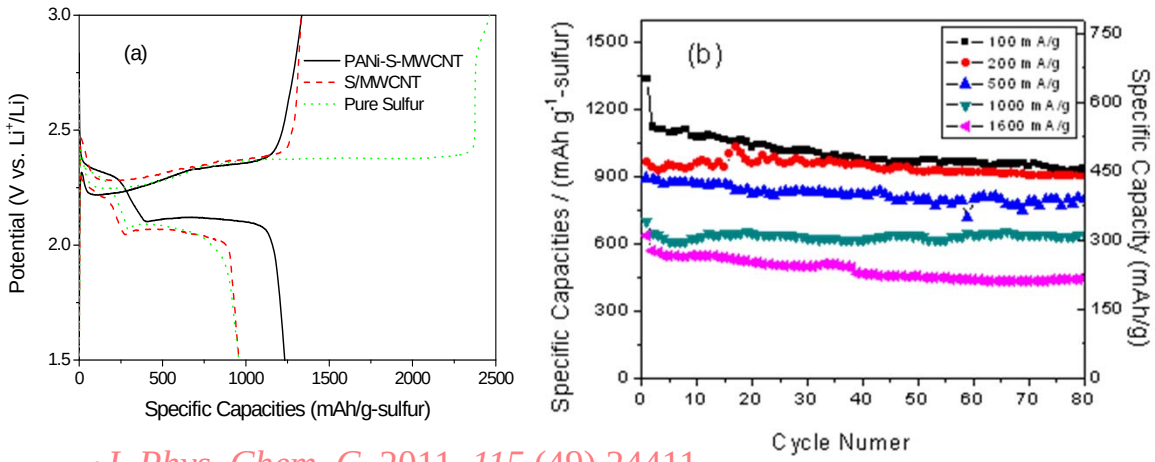




硫碳复合电极

吴锋，北京理工大学





•*J. Phys. Chem. C*, 2011, *115* (49),24411

在S/MCNT聚合高分子材料

益处：提高了材料充放的库仑效率和可逆性

（容量 1334.4 mAh g^{-1}，库仑效率高于90% ）.

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Clean Vehicles Consortium

方向6：能源系统分析、技术路线图和政策

中方研究人员 Chinese Participants

1.清华大学 (THU)
欧阳明高,王贺武杜玖玉(汽车系)
张希良(车用能源中心)
王赞基(电机系)
欧巡民(车用能源中心)
朱桂平(电机系)
霍红(环境学院)

2.北京航空航天大学(BHU)
宋凌珺

3 华北电力大学(NCEPU)
杨勇平

美方合作伙伴 US Participants

1. 密西根大学(UM)
Huei Peng、John DeCicco、Jarod Kelly
Greg Keoleian、Ming Xu
2 阿贡国家实验室: ANL
Michael Wang
3. 橡树岭国家实验室:ORNL
Lin Zhenghong
4 圣地亚哥国家实验室(SNL)
Dawn Manley
5.麻省理工学院(MIT)
John Heywood
6. 美国环保署(EPA)
Jeff Alson

U.S.–China Clean Energy Research Center
中美清洁能源研究中心
Clean Vehicles Consortium

研究内容和合作单位

University of Michigan
Argonne National Laboratory

- 设定清洁汽车的节能减排目标
  评价生命周期能耗及排放

University of Michigan
Sandia National Laboratories

- 车用能源策略与环境约束

University of Michigan

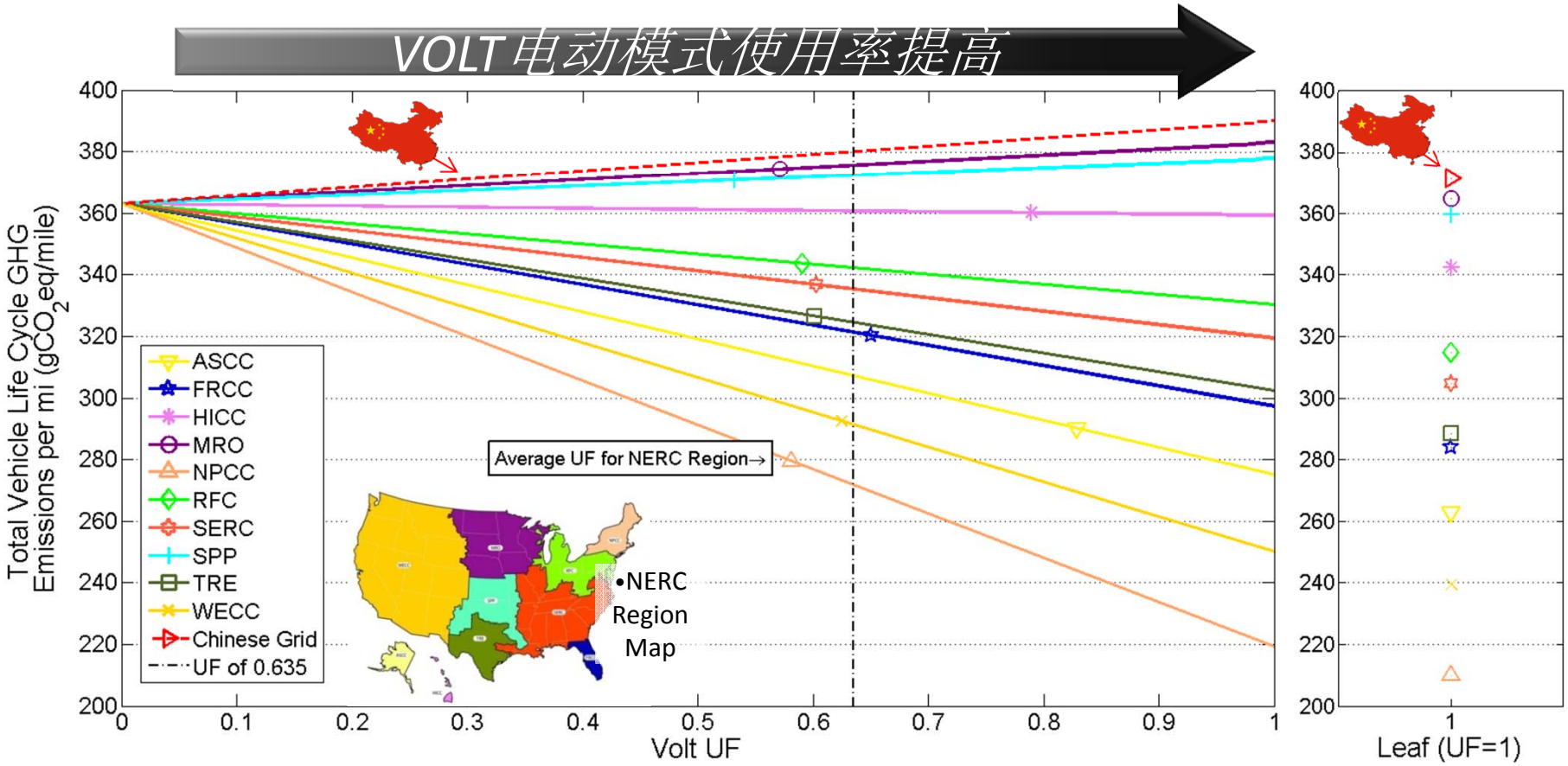
- 电动汽车全生命周期燃油经济性
  与碳排放标准与标签

University of Michigan
Massachusetts Institute of Technology
Argonne National Laboratory

- 清洁汽车技术路线图及政策建议

U.S.–China Clean Energy Research Center
中美清洁能源研究中心
Clean Vehicles Consortium

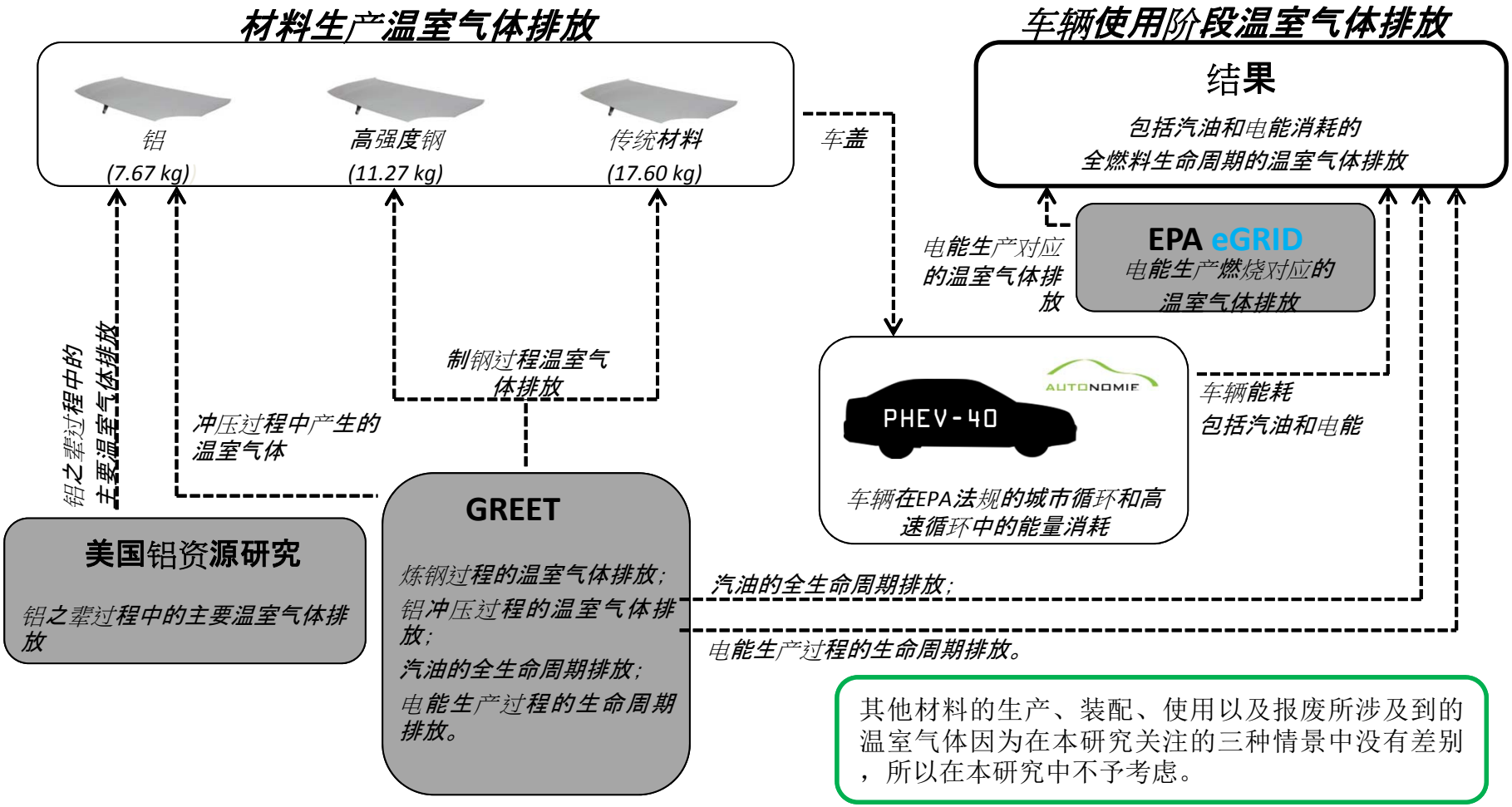
电动汽车全生命周期燃油经济性与温室气体排放标识及标准



利用EPA's National Vehicle & Fuel Emissions实验室的政策分析数据开展了电动汽车排放及标识分析

U.S.–China Clean Energy Research Center
中美清洁能源研究中心
Clean Vehicles Consortium

基于汽车技术战略的电力和车辆材料情景分析



其他材料的生产、装配、使用以及报废所涉及到的温室气体因为在本研究关注的三种情景中没有差别，所以在本研究中不予考虑。

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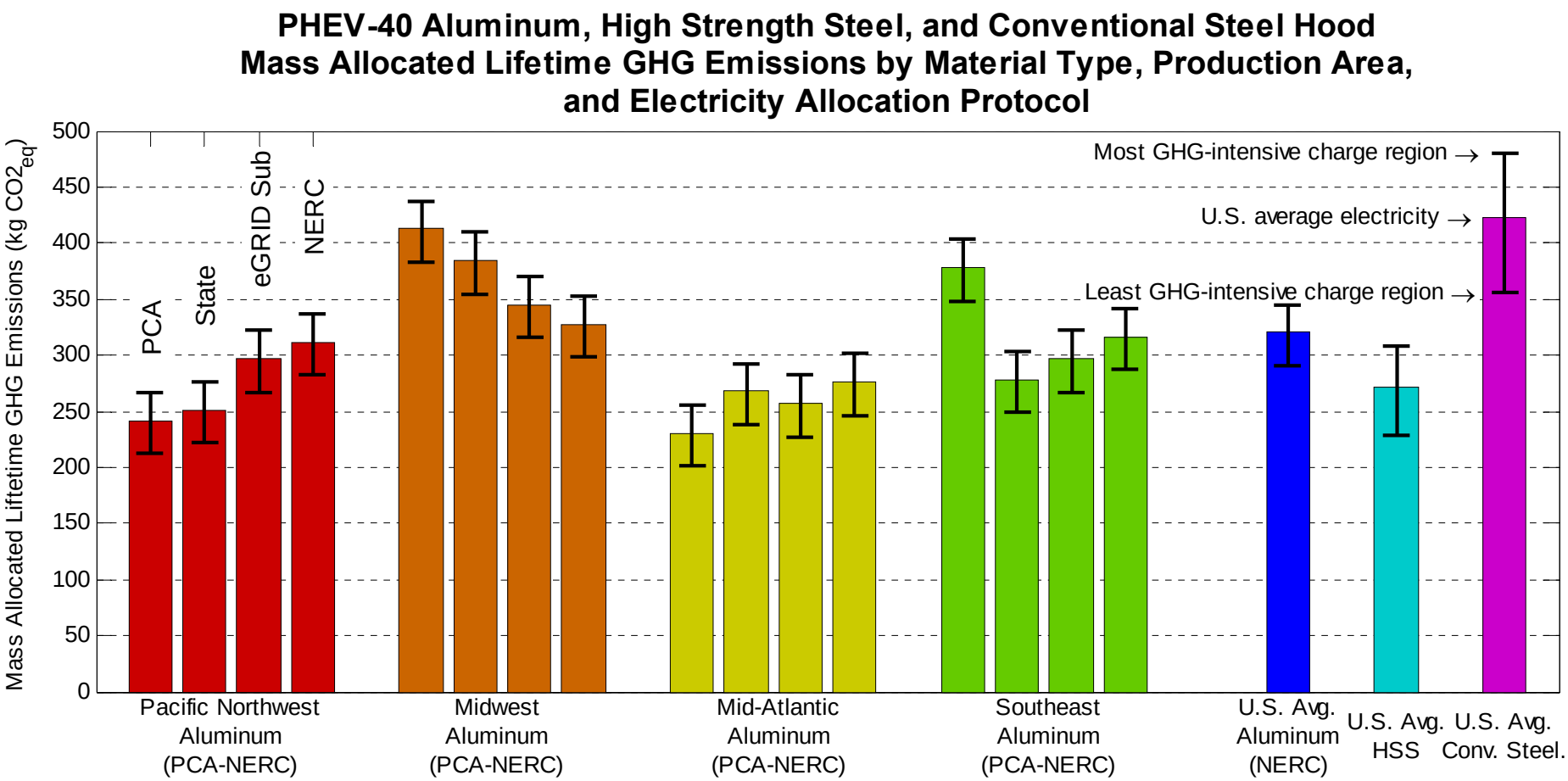
中美清洁能源研究中心
Clean Vehicles Consortium

PHEV轻量化：PHEV40汽车案例分析



主要的铝生产所排放的温室气体，会因生产地点和电能构成的不同而产生很大的变化。

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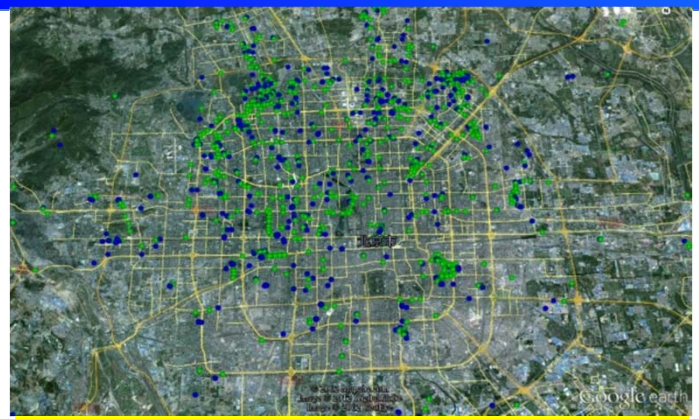
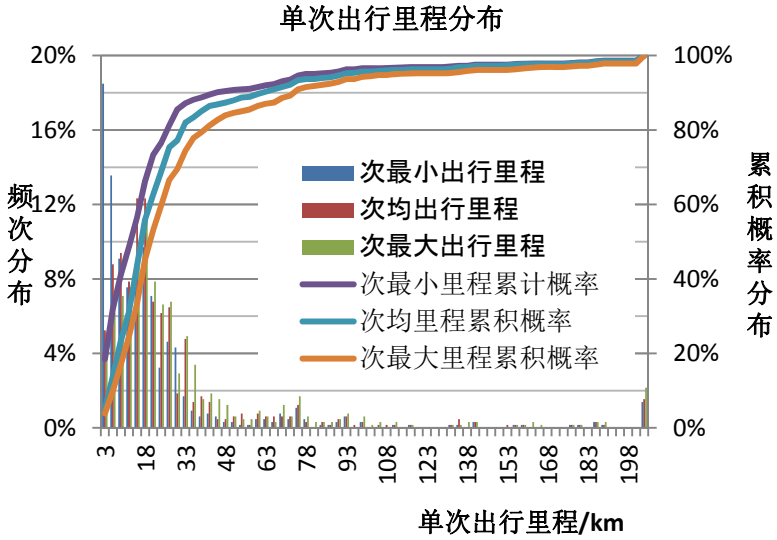
Clean Vehicles Consortium

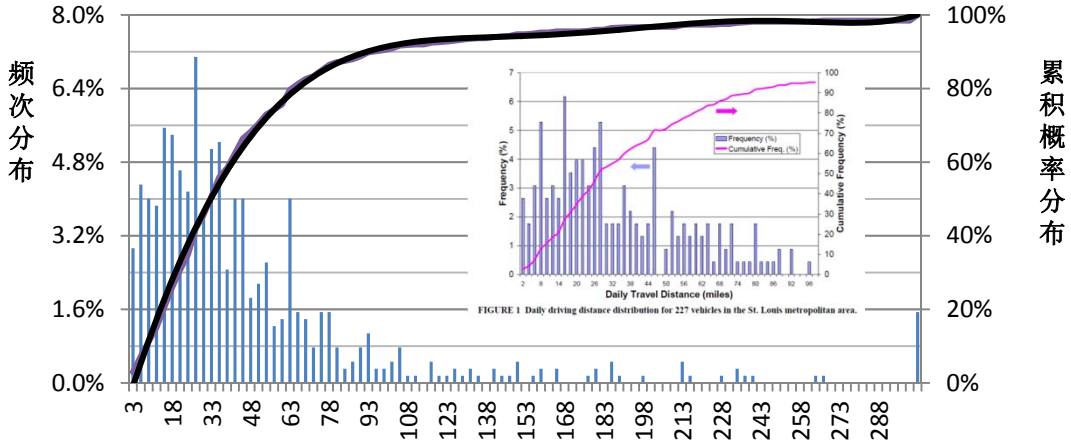
基于电动汽车参数设计的北京私人乘用车出行特征调研



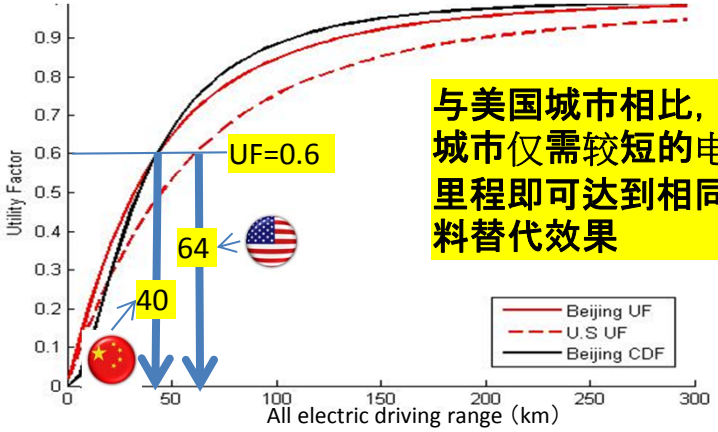
98家庭，987车天，4-41天记录，超过2000次出行

	三环以内	四环以内	五环以内
起点(Origin)	26.2%	43.0%	72.8%
终点(Destination)	24.6%	43.6%	75.9%





	日均出行里程(km)	50% (Km)	80% (km)
基于GPS的北京市（2012）	**43.1**	33	60
NHTS（300万以上人口城市，2009）	**46.8**	-	-



与美国城市相比，中国城市仅需较短的电驱动里程即可达到相同的燃料替代效果

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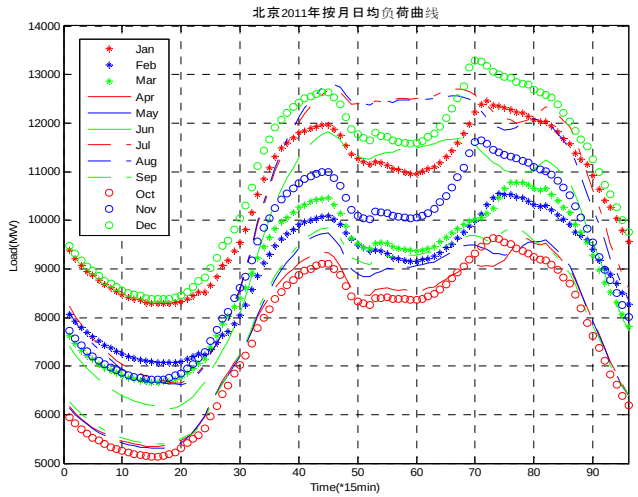
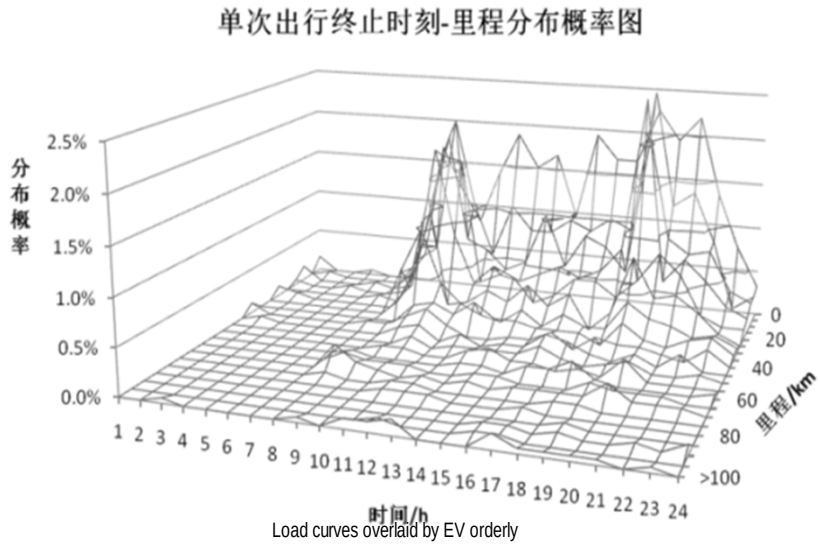
Clean Vehicles Consortium

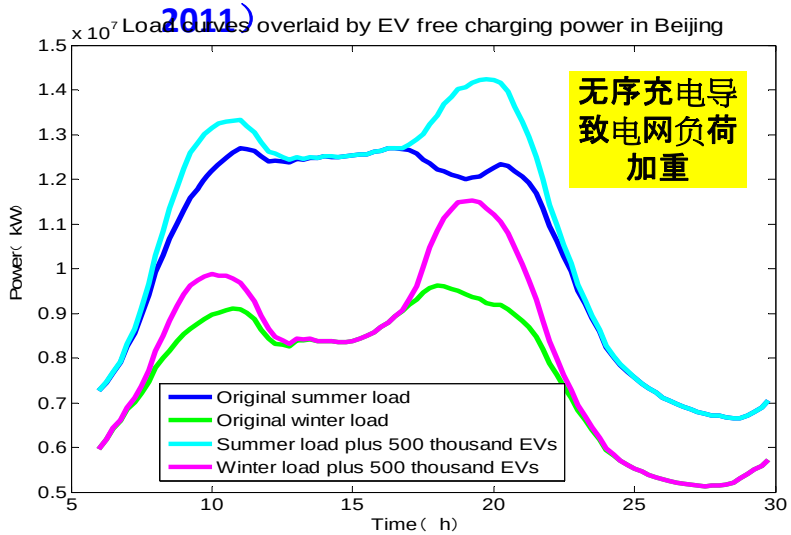
充电模式对电网负荷的影响

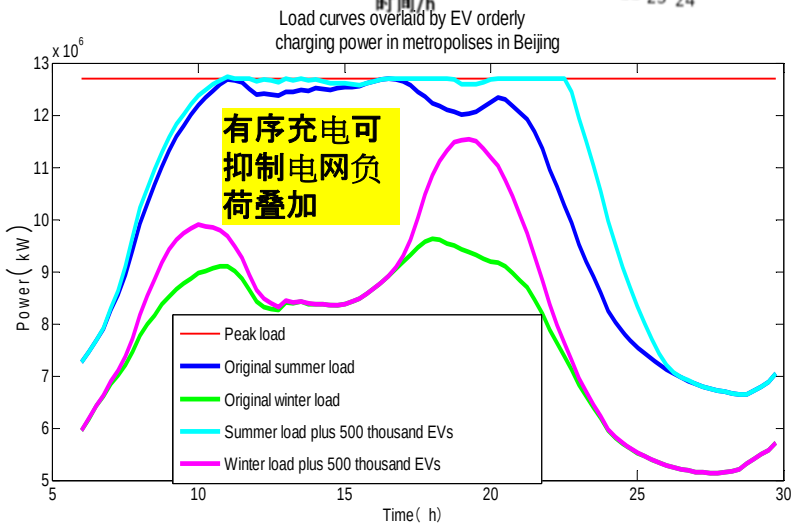
私人汽车出行特征和充电行为（有序或自由充电）对电网负荷曲线的影响





- **Electricity load curves in Beijing（2011）**





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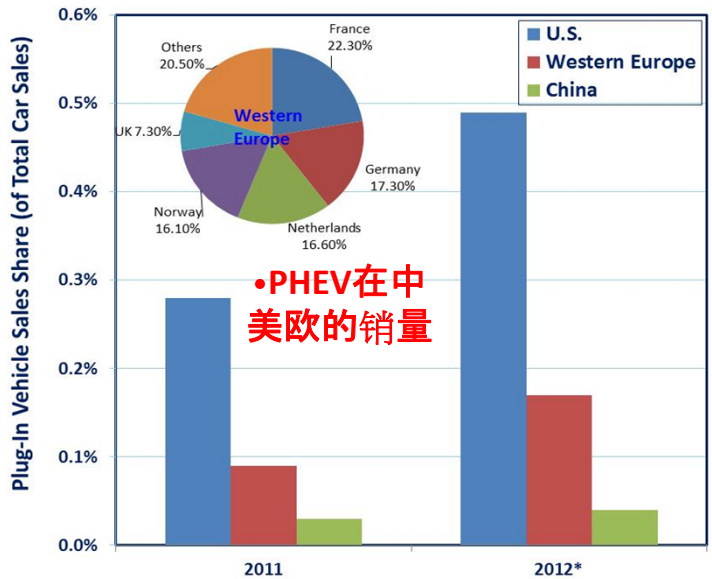
Clean Vehicles Consortium

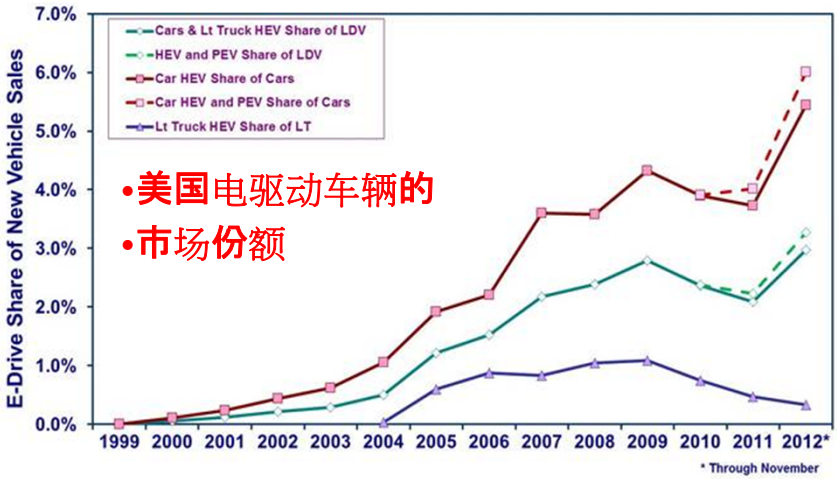
建立了数据共享机制和途径，实现了新能源汽车信息的有效利用

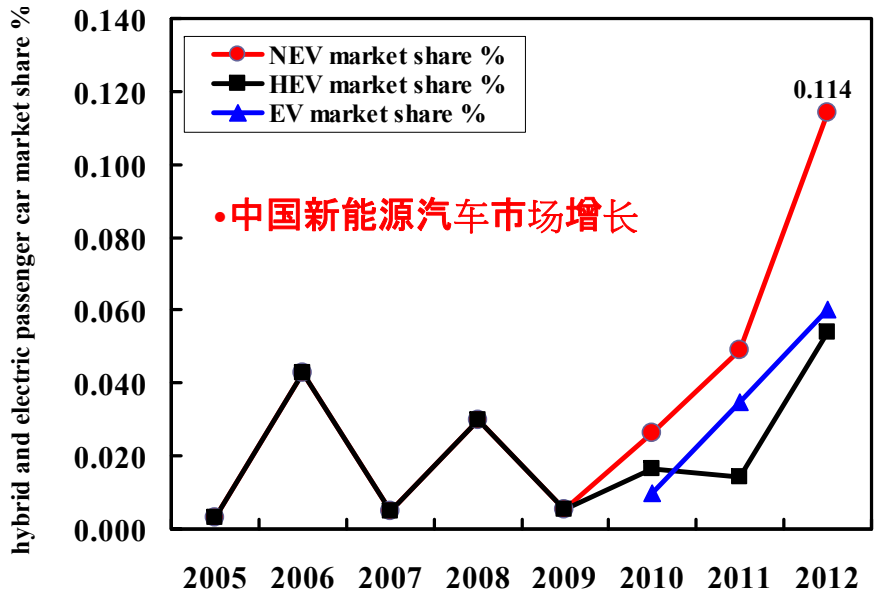


分析并分享中美两国的新能源汽车数据，并且每月上报至DOE和MOST（总体情况数据对外开放，CERC成员可浏览具体数据）

http://www.transportation.anl.gov

http://www.car.tsinghua.edu.cn





Data source: collected and analyzed by CERC-CVC(Tsinghua)

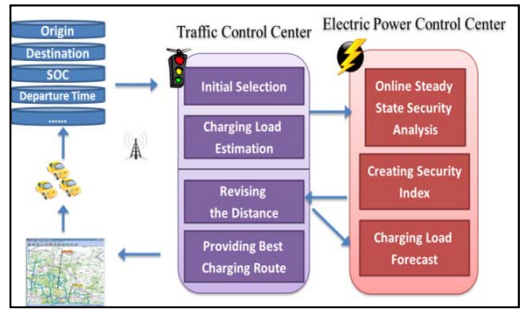
Copyright: State Key Laboratory of Automotiv e Safety and Energy, Tsinghua University

U.S.–China Clean Energy Research Center
中美清洁能源研究中心
Clean Vehicles Consortium

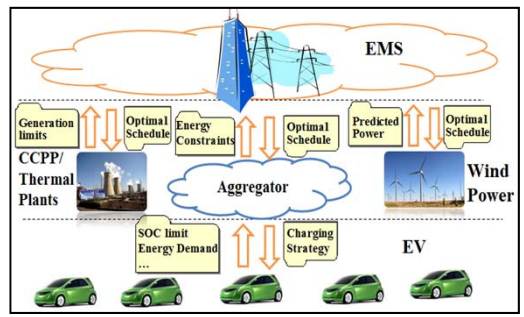
TA 5 - Vehicle-Grid Interactions, Goals

Establish framework and key technologies to implement vehicle-grid systems:

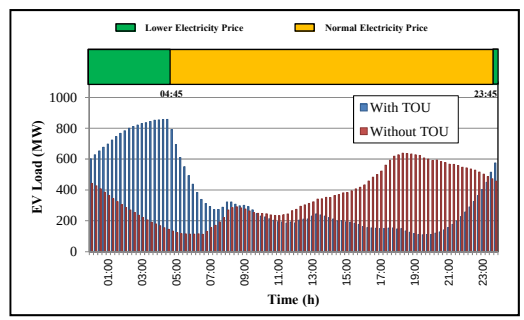
- Use of Intelligent Transportation Systems technology to optimize vehicle charging and energy use.
- Development of adaptive battery management systems, on and off the grid
- Assess the impact of large-scale deployment of PEVs on the grid and develop technology and policy recommendations to accelerate EV deployment in the U.S. and China
- Develop control strategies and protocols for vehicle-grid interactions



Smart Charging Guiding System (SCGS)



EV-RES Coordination



Charging load model based on transportation information

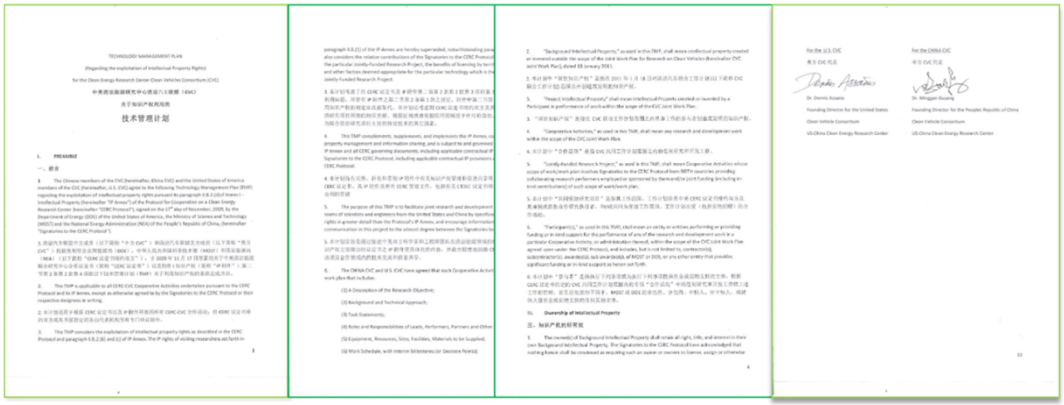
提　纲

- 目标和达成指标
- 中心项目和协作活动
- 重要研究成果
- 知识产权
- 行业参与
- 五年末预期成果

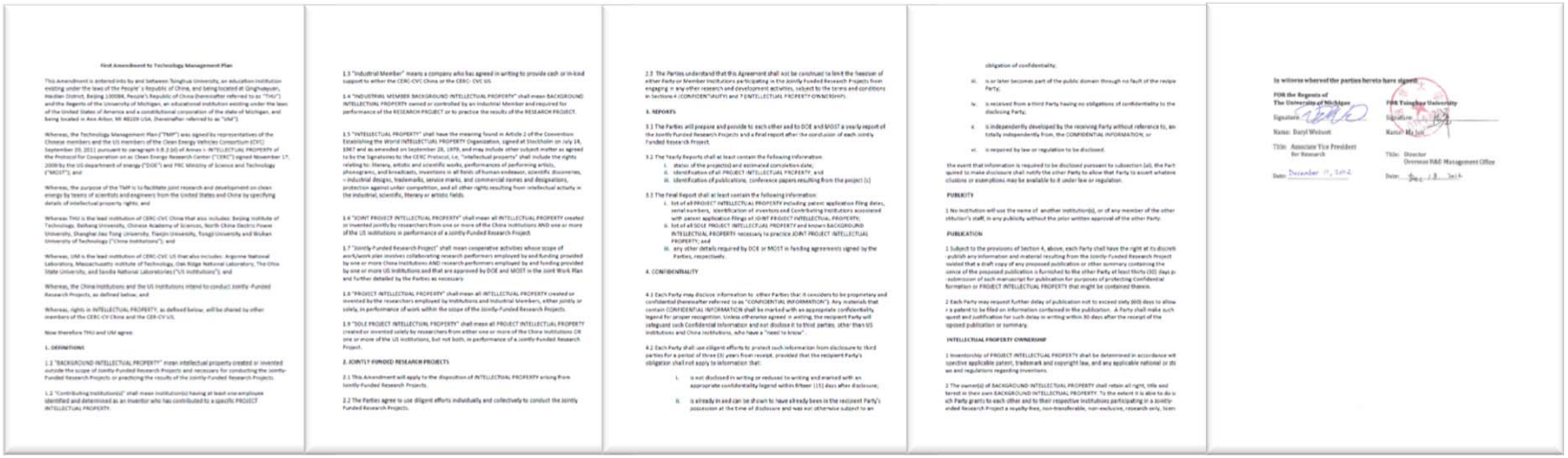
U.S.–China Clean Energy Research Center
中美清洁能源研究中心
Clean Vehicles Consortium

发明专利协议时间表

- 2011年9月签订的技术管理计划



- 2012年12月的第一次修订版本



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- 行业参与
- 五年末预期成果

企业伙伴

美国方面

Ford
DELPHI
DENSO
EATON
TOYOTA
HONDA
pjm
TE connectivity

中国方面

SAIC
GEELY
JAC
CAERI
CATARC
GM
LISHEN
Potevio
JJE

U.S.–China Clean Energy Research Center
中美清洁能源研究中心
Clean Vehicles Consortium

相关企业界专家

Christian Fau	Honda
Toshiaki Shimizu	Honda
Wu Bi	Honda
Andy Drews	Ford
Alvaro (Al) Masias	Ford
Ted Miller	Ford
Heri Rakouth	Delphi
Gregory Simopoulos	Delphi
Brian Denta	Delphi
John Absmeier	Delphi
Bruce Moor	Delphi
Bradley Brodie	Denso
Masaki Uchiyama	Denso
Masafumi Kurata	Denso
Mike Safoutin	EPA

Clay Maranville	Ford
Tony Phillips	Ford
Ming Kuang	Ford
John Viera	Ford
John Absmeier	Delphi
Bruce Moor	Delphi
Heri Rakouth	Delphi
Gregory Simopoulos	Delphi
Rajesh Malhan	Denso
Zhe Huang	Denso
Mike Safoutin	EPA
Clay Maranville	Ford
Tony Phillips	Ford
Ming Kuang	Ford
John Viera	Ford

Ken Labertaux	Toyota
Heri Rakouth	Delphi
Steve Briggs	First Energy
John Absmeier	Delphi
Bruce Moor	Delphi
Gregory Simopoulos	Delphi
Rajesh Malhan	Denso
Zhe Huang	Denso

Heri Rakouth	Delphi
Mike Tamor	Ford
Tim Wallington	Ford
Sandy Winkler	Ford
Heiko Maas	Ford
Mark Mehall	Ford
Danil Prokhorov	Toyota
Gregory Simopoulos	Delphi
John Kirwan	Delphi
John Absmeier	Delphi
Bruce Moor	Delphi
Bruce Myers	Delphi
Manabu Miyata	Denso
Tomoya Tohnai	Denso
Patrick Powell	Denso
Ken Labertaux	Toyota
Jeff Alson	EPA

James Anderson	Ford
Tim Wallington	Ford
John Kirwan	Delphi
Heri Rakouth	Delphi
Jeff White	Denso
Yujui Tomiita	Denso
Dan Sweeney	Denso
Rob Cardno	Denso
Mike Safoutin	EPA

Heri Rakouth	Delphi
Joe Weishaar	Ford
Matt Zaluzec	Ford
Umesh Gandhi	Toyota
Tomonori Ishikawa	Denso
John Baciak	Denso
Javed Mapkar	Eaton
Alaa Elmoursi	Eaton

CERC-CVC合作拓展

- 密歇根大学正在与政府机构和CERC的企业伙伴合作，致力于建立一个5年预算770万美元的联合电池实验室

- 伊顿公司正在与CERC的研究专家合作，计划在EVTown项目的充电机上安装数据采集系统(Mercy Davison, Normal, IL). 采集的数据将用于改进CERC电网项目中插电式汽车的使用与充电模型.

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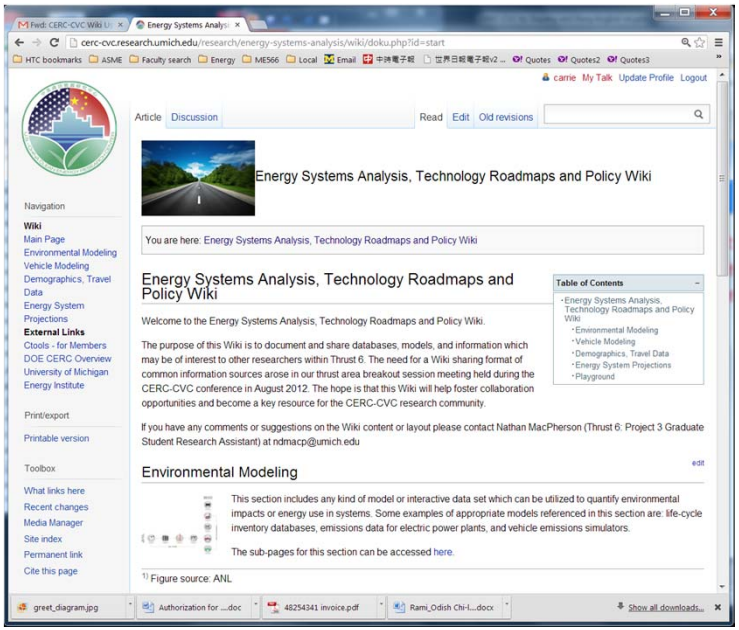
Clean Vehicles Consortium

CERC-CVC合作拓展（续）

- 创建了中国城市车辆出行数据、全球新能源汽车数据库，和中国电网运行数据库，部分内容对CERC研究人员和工业界成员开放。
- 中方CERC成员与电池企业建立了广泛合作。



提　纲

- 目标和达成指标
- 中心项目和协作活动
- 重要研究成果
- 知识产权
- 行业参与
- 五年末预期成果

下一阶段预期成果

- 高质量的研究
  - >100篇期刊论文,>200篇会议论文，60位博士生，>50 IP
- 更加紧密的合作
  - >40篇合作发表论文，>10合作IP
- 紧密的学术界工业界合作
  - 向工业界提供车辆分析与设计工具库、电池测试标准咨询、、LCA工具等服务
- 技术转化
  - 促进若干项CERC-CVC知识产权的转移

第三届CERC-CVC年度技术交流会议将于2013年8月在中国重庆市召开

附录

U.S.–China Clean Energy Research Center
中美清洁能源研究中心
Clean Vehicles Consortium

CERC-CVC启动会议

安娜堡市, 密歇根, 1月20-21, 2011, 120 人参会

确定了CERC-CVC 的6大合作领域最初的框架。

U.S.–China Clean Energy Research Center
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Clean Vehicles Consortium

第一届CERC-CVC年度技术论坛

北京，中国，10月17-18,2011,200人参会

20个中美高水平清洁汽车项目，以及具体的研究项目报告

讨论并拟定了2012合作工作计划

U.S.–China Clean Energy Research Center
中美清洁能源研究中心
Clean Vehicles Consortium

第二届CERC-CVC年度技术论坛

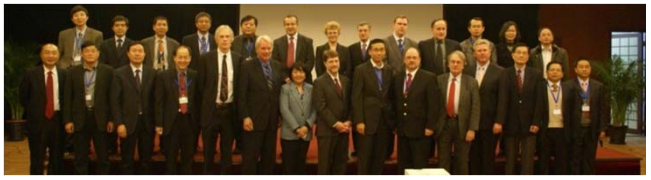
安娜堡市, 密歇根, 8月27-28, 2012

- 项目汇报, 成果展览
- 2013合作计划
- 集中讨论工业界成员参与
- 2013年学生交换计划

U.S.–China Clean Energy Research Center
中美清洁能源研究中心
Clean Vehicles Consortium

举行了6次EVI座谈会

- 2009年9月，中国北京。
- 2010年9月，美国芝加哥。
- 2011年3月，中国北京。
- 2011年8月，美国芝加哥
- 2012年4月，中国杭州
- 2012年8月，美国波士顿



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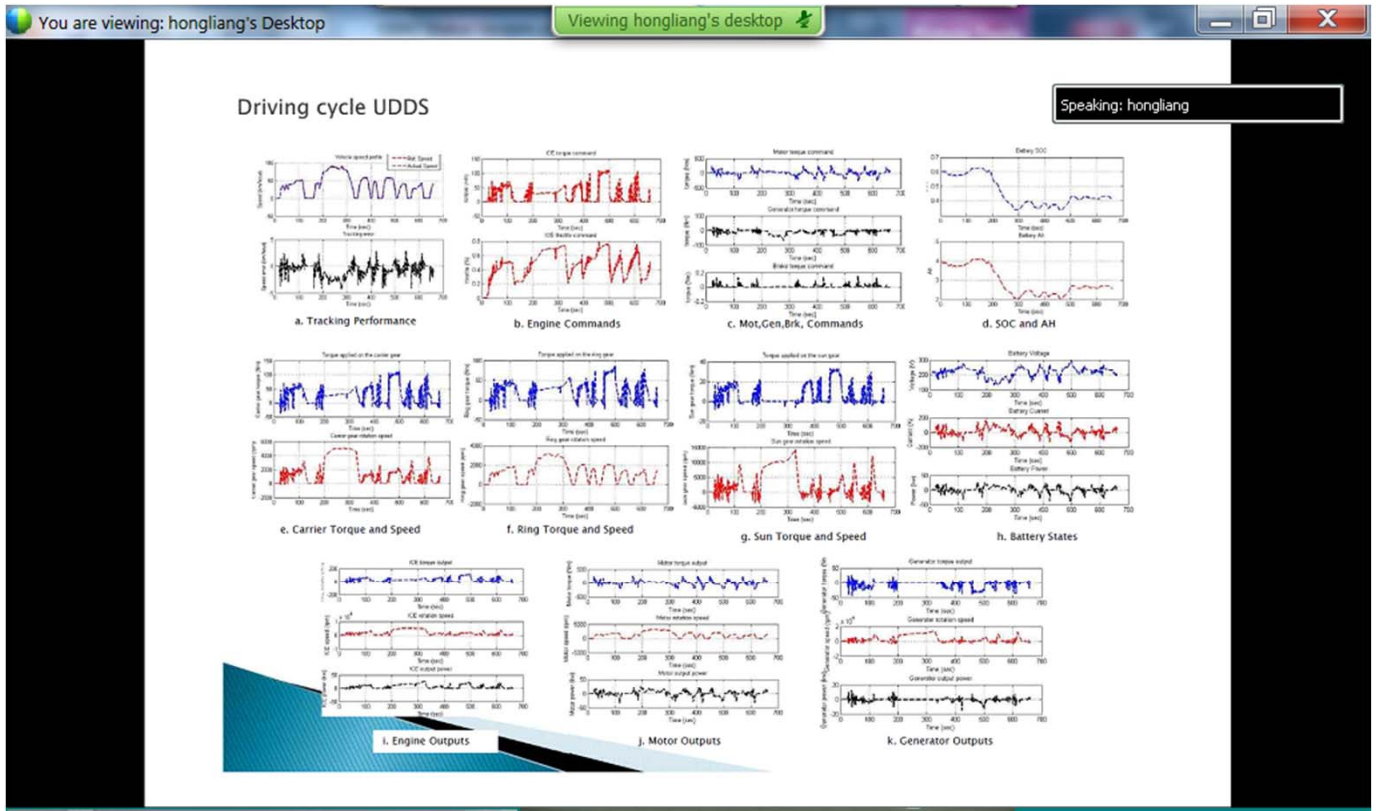
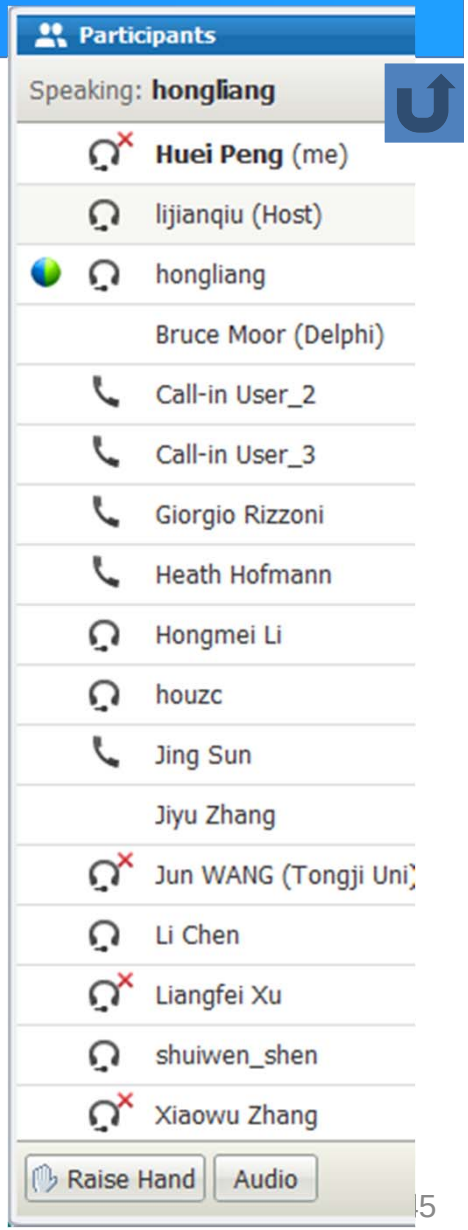
中美清洁能源研究中心
Clean Vehicles Consortium

使用WebEx的每月一次合作领域技术交流会议





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中美清洁能源研究中心
Clean Vehicles Consortium

2012 TA 会议

TA1 TA2 TA3 TA4 TA5 TA6 CVC

2012

January

Mo	Tu	We	Th	Fr	Sa	Su
30	31					1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29

February

Mo	Tu	We	Th	Fr	Sa	Su
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29				

March

Mo	Tu	We	Th	Fr	Sa	Su
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

April

Mo	Tu	We	Th	Fr	Sa	Su
30						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29

May

Mo	Tu	We	Th	Fr	Sa	Su
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

June

Mo	Tu	We	Th	Fr	Sa	Su
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	

July

Mo	Tu	We	Th	Fr	Sa	Su
30	31					1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29

August

Mo	Tu	We	Th	Fr	Sa	Su
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

September

Mo	Tu	We	Th	Fr	Sa	Su
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

October

Mo	Tu	We	Th	Fr	Sa	Su
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

November

Mo	Tu	We	Th	Fr	Sa	Su
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

December

Mo	Tu	We	Th	Fr	Sa	Su
31					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

2012年的一些TA3展示

No.	Date	Topic	Presenter	Affl.
1	2012-03-21	Computationally -Efficient Steady -State Solvers for Synchronous Machines.	Heath Hofmann	UM
2	2012-04-18	Electrical Variable Traction Transmission (EVTT) System Based on DMP Machine.	Longya Xu and Jin Wang	OSU
3	2012-04-18	Model-based State Estimation for Networked Systems	Xiao He	THU
4	2012-04-18	Research on a Battery Test Profile Based on Road Test Data from Hybrid Fuel Cell Buses	Xuning Fend Yang Minggao	THU
5	2012-05-16	Electric Drive Hazard Analysis	Simona Onori, Giorgio Rizzoni	OSU
6	2012-06-20	Development of a Novel Multi-mode Transmission for a HEV using a Single EM	Zhu Futang, Yin Chengliang	SJTU

- TA3, 2012 (续)

No.	Date	Topic	Presenter	Affl.
7	2012-06-20	Design Methodology for Single Planetary Gear Power Split Hybrid Vehicles	Zhangxiao Wu Peng Huei Jing Sun	UM
8	2012-09-19	Modeling, Control, and Simulations for A Power-split Hybrid Electric Vehicle	Hongliang Yuan Jun Wang	TJU
9	2012-10-17	Full-automatic Code Generation Platform in VCU Development	Geng Peng, Li Jianqiu	THU
10	2012-11-21	Torque Coordination Control During Mode Transition for a Series Parallel Hybrid Electric Vehicle	Li Chen, Chengliang Yin	SJTU
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2012年度会议展出 67幅海报

公开发明和专利 (中方)

- 1. 20120059129, METHOD FOR MAKING SULFURIZED POLYACRYLONITRILE
- 2. 20120059128, SULFURIZED POLYACRYLONITRILE AND LITHIUM-ION BATTERY CATHODE ACTIVE MATERIAL USING THE SAME
- 3. 20120059085, METHOD FOR MAKING CONJUGATED POLYMER
- 4. 20120052390, ELECTRODE COMPOSITE MATERIAL OF LITHIUM ION BATTERY, METHOD FOR MAKING THE SAME, AND LITHIUM ION BATTERY USING THE SAME
- 5. 20120052389, ELECTRODE OF LITHIUM ION BATTERY, METHOD FOR MAKING THE SAME, AND LITHIUM ION BATTERY USING THE SAME
- 6. 20120052368 MODIFIED CURRENT COLLECTOR OF LITHIUM ION BATTERY, METHOD FOR MAKING THE SAME, AND LITHIUM ION BATTERY USING THE SAME
- 7. 20120028120, ELECTRODE COMPOSITE MATERIAL, METHOD FOR MAKING THE SAME, AND LITHIUM ION BATTERY USING THE SAME
- 8. 20120028118, ELECTRODE COMPOSITE MATERIAL, METHOD FOR MAKING THE SAME, AND LITHIUM ION BATTERY USING THE SAME
- 9. 20120028114, ELECTRODE COMPOSITE MATERIAL, METHOD FOR MAKING THE SAME, AND LITHIUM ION BATTERY USING THE SAME
- 10. 20110300446, LITHIUM BATTERY CATHODE COMPOSITE MATERIAL
- 11. 20110236299, METHOD FOR MAKING LITHIUM-ION BATTERY ELECTRODE MATERIAL

公开发明和专利 (中方)

- 12. 许敏,张玉银,袁志远,陈晓济,王森,王振侃. 发动机组合框架式气缸体及曲轴箱结构. 中国发明专利申请号：201110110013.0
- 13. 许敏,张玉银,袁志远,陈晓济,王森,王振侃. 两缸水平对置发动机组合框架式气缸盖. 中国发明专利申请号：200910311673.8
- 14. 张科勋;杨福源;欧阳明高等. 一种发动机EGR与VGT控制方法及系统. 中国发明专利申请号：201110094588.8
- 15. 张科勋;杨福源;欧阳明高等. 电控柴油机EGR系统NOx排放水平监控方法及装置. 中国发明专利申请号：201110112638.0
- 16. 欧阳明高;杨福源;卢兰光等. 一种串联混合动力客车的辅助功率单元及控制方法. 中国发明专利申请号：201110130472.5
- 17. 一种基于多信息融合的整车控制方法. 中国，发明专利. 201210229109.3
- 18. 一种车用高效复合储能系统，中国，发明专利，201210066119.X
- 19. 一种永磁电机装配机. 中国，发明专利，201210074743.4
- 20. 一种超声波端子焊接机.中国，发明专利发明，201210109402.6
- 21. 磁钢装配机. 中国，发明201210074921.3
- 22. 一种非晶态合金径向磁场电机，李琦，范涛，温旭辉；
- 23. 基于DC-DC变换器的直流有源滤波器，申请号201210461604.7

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公开发明和专利 (美方)

TA	Project	Inventor	Org	Disclosure Number	Title
3	1	Hofmann	UM	5115	A voltage-driven, two-dimensional steady-state finite-element solver for the analysis of synchronous machines.
1	2	Siegel	UM	5597	Improved Performance in Rechargeable Metal-air Batteries via Fermi-Level Tuning
3	3	Peng/Sun	UM	5521	New configurations of power split hybrid vehicles using a single planetary gear
5	6	Sun/Peng	UM	5519	On-board State of Health Monitoring of Lithium-ion Batteries Using Incremental Capacity Analysis with Support Vector Regression
4	4	Saitou	UM	5536	A Tool to Assist in the Manipulation of a Vehicle FE model without Editable CAD Models
2	4	Wang	OSU	2013-098	Engine onboard fuel property identification method using common rail pressure signal
2	8	Heremans	OSU	2013-086	Aluminum as a resonant level in p-type CoSb3
1	2	Van der Ven	UM	-	New concept for a rechargeable metal air battery
4	2	Ni	UM	-	Hybrid Friction Stir Welding for dissimilar materials through Electro-Plastic Effect

人才交流

- 2011年约40次短期访问
- 2012年约40次短期访问
- 2011年开始进行长期交流活动

	姓名	职称	研究领域	日期
1	Caihao Wang	在读博士生(UM)	电池管理系统	05/11-06/11
2	Xiankun Huang	在读博士生(THU)	电池化学组成	07/11-08/12
3	Hongmei Li	教授(Hefei)	诊断和预测	05/12-11/12
4	Xiaowu Zhang	在读博士生(UM)	功率型混合动力汽车	06/12-06/12
5	Xianli Su	在读博士生(WUT)	热电材料	09/10-07/12
6	Lily Zhang	助理教授(WUT)	热电材料	02/11-01/12
7	Xuerei Ma	在读博士生(SJTU)	功率型混合动力汽车的构形	12/12-12/13
8	张明轩	预录取 (THU)	动力总成控制	01/13-02/13
9	侯聪	在读博士生(THU)	并联插电式混合动力汽车的部件尺寸优化	06/13-08/13
10	罗禹贡	副教授(THU)	汽车网络集成	08/13-08/14
11	冯旭宁	在读博士生(THU)	电池安全	12/13-12/14
12	宋子由	在读博士生(THU)	辅助储能装置	12/13-12/14

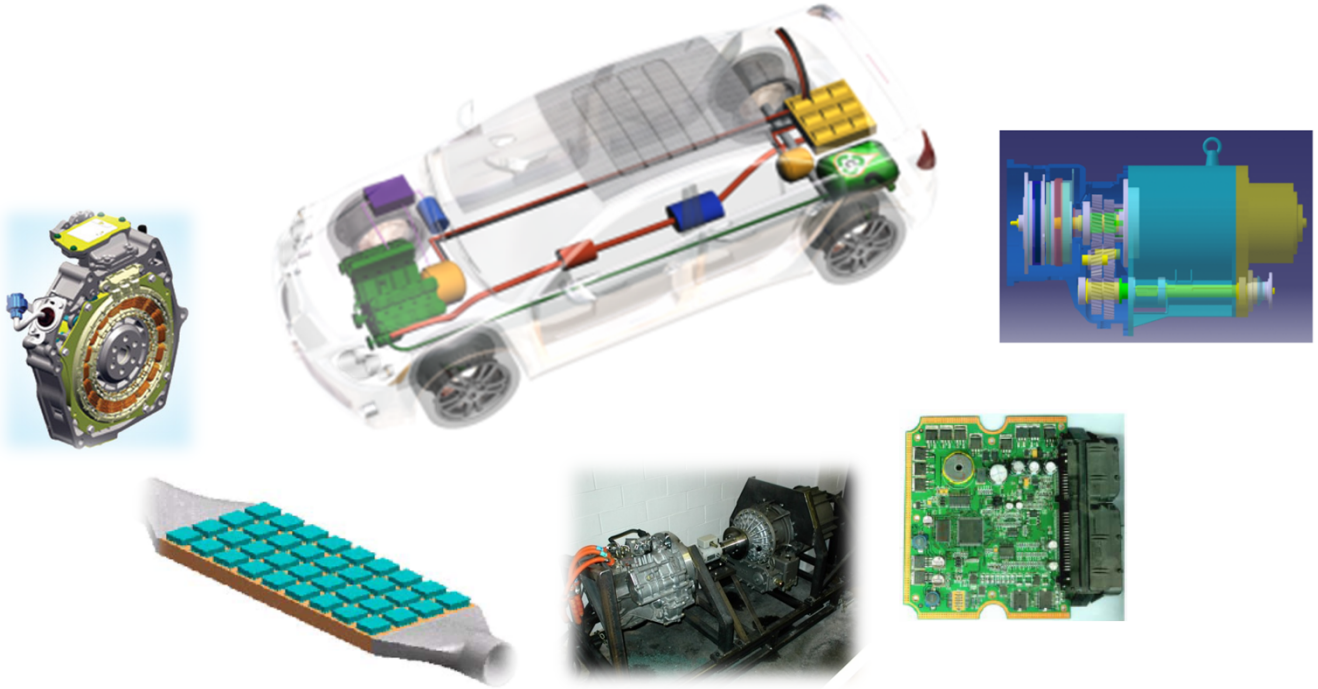
人才交流

	姓名	职称	研究领域	日期
13	王贺武	副教授(THU)	能源政策, 在阿岗国家实验室访问1年	2011.9-2012.9
14	Ingrid Bonde Akerlind	硕士生(MIT)	中国汽车市场政策	在清华访问1个月
15	Valerie Karplus	研究员(MIT)	能源和气候项目, 2/3时间在清华大学访问	
16	欧训民	助理教授(THU)	能源政策, 访问麻省理工学院	
17	Dawn Manley	研究人员(SNL)	访问清华大学	
18	Hong Huo	副教授(THU)	能源政策, 在阿岗国家实验室访问4个月	
19	Lei Zhu	博士生(CAS)	EV/HEV motor drive, visited OSU	2011.12-2012.5
20	Li Chen	副教授(SJTU)	电池, visited OSU	2012.04-2012.11
21	Jianqiang Kang	助理教授(WUT)	电池, visited OSU	2012.09-

Research Highlights—TA3

Vehicle Electrification Goal

- To develop new concepts, models, methodologies, and tools to construct, analyze, design and simulate key components of electrified vehicles, and to study their controls and integrations.



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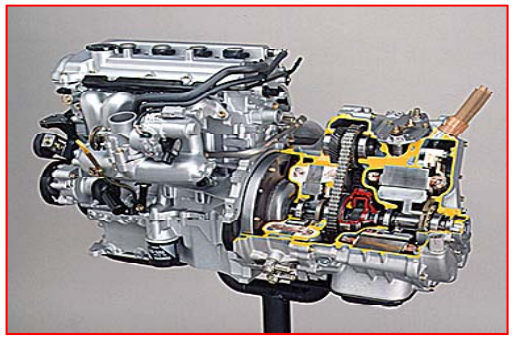
Projects and Participations

US	
Jing Sun	UM
Heath Hofmann	UM
Huei Peng	UM
Giorgio Rizzoni	OSU
Jin Wang	OSU
Longya Xu	OSU
Simona Onori	OSU

China	
Jianqiu Li	THU
Minggao Ouyang	THU
Zhichao Hou	THU
Jun Wang	TJU
Liangfei Xu	THU
Geng Yang	THU
Chengliang Yin	SJTU
Zaimin Zhong	TJU
Xuhui Wen	CAS-IEE
William CAI	JJE

- Components Design and Optimization

- Powertrain Control and Distributed Vehicle Control Networks



- System Integration Technologies

Collaborations and Interactions

- Collaboration/Exchange activities:
  - Visits/seminars
  - Student exchanges
- Industrial collaborations
  - Monthly WebEx meeting participation
  - Exchange/training of design tools
  - Annual conference presentations:
    - Presentations from Ford and Delphi

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TA#3 Project 1: Efficient and high-power density electric powertrain

•Collaborators: Xu, Wan (OSU), Hofmann (UM), Wen, Fan (CAS)

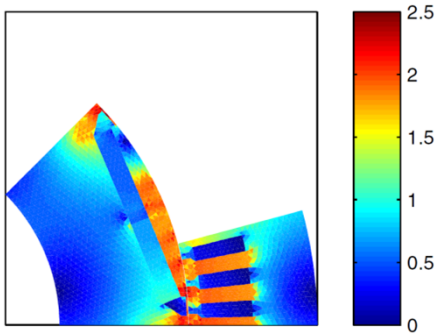
•Research Objectives

- Develop innovative and optimized electric machines and drives to achieve electrified powertrain with significantly higher power density and efficiency.

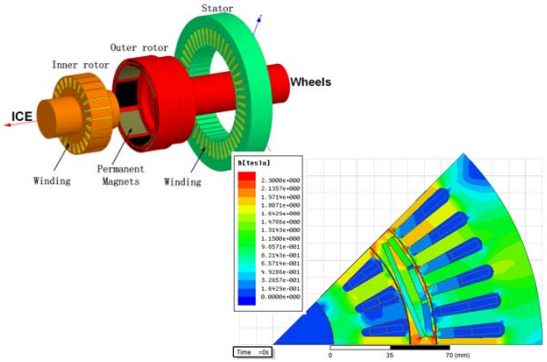
•Technical Approach

- Development of computationally-efficient finite element tools for the steady-state analysis of electric machines (UM)
- Development of EVTT dual-mechanical port electric machine concept for electric vehicle and hybrid electric vehicle applications. (OSU)
- Model the unique features in amorphous alloy such as saturation, non-sinusoidal excitation and high-frequency eddy current effect (CAS)
- Design optimal permanent magnet machine using the above magnetics models (CAS)

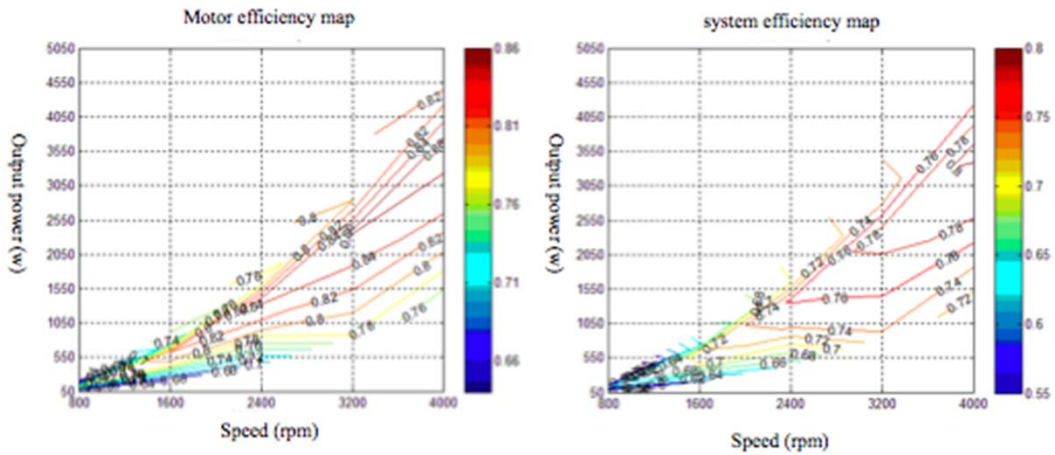
Initial Results



Computationally-efficient 2-D FEA steady-state solver



Simulation of EVTT machine and drive.



Permanent magnet motor with amorphous alloy laminations has been built and tested.

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TA#3 Project 2: Control and optimization of distributed vehicle network

•Collaborators: Li, Xu (Tsinghua), Wang, Zhong (Tongji), Yin (SJTU), Peng (UM)

•Research Objectives

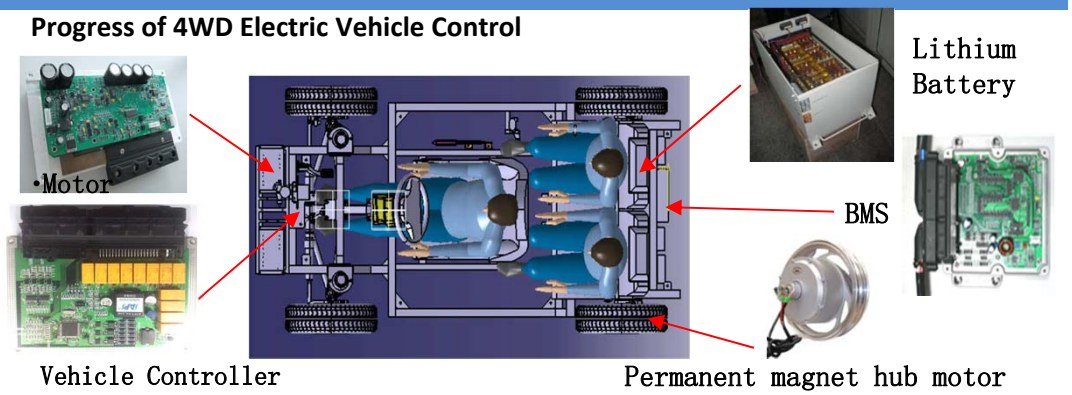
•Develop hardware solutions, design tools, and control strategies to optimize distributed vehicle network architecture and information management system for electrified vehicles.

•Technical Approach

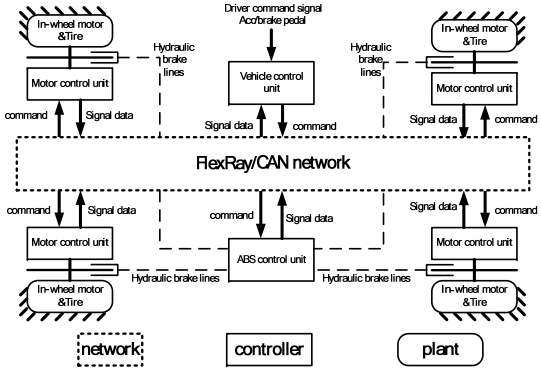
- Develop advanced hardware/software platforms, in-vehicle network control systems, and inter-vehicle communication and monitoring systems.
- Develop optimal cooperative control among multiple power sources for the driving and braking processes
- Develop optimal power management for power-train systems with global positioning systems (GPS) and inertial navigator systems (INS), targeting 10% fuel economy improvements.
- This project will be led by Chinese partners, in collaboration with U.S. CERC members.

Initial Results

Progress of 4WD Electric Vehicle Control



Initial development completed for :four-wheel independent driving control, vehicle control system evaluation, hub motor drive control, and battery management system development



- FlexRay communication system design completed and prototype built
- Software architecture for automatic code generation from Matlab/Simulink model completed
- Initial design of a new generation vehicle controller unit based on MPC5644

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TA#3 Project 3: System integration technologies for improved efficiency, safety, reliability and NVH performance

•Collaborators: UM (Peng, Sun); OSU (Rizzoni, Onori); Tsinghua (Li, Xu ,Yang, Hou); SJTU (Yin, Zhu, Chen)

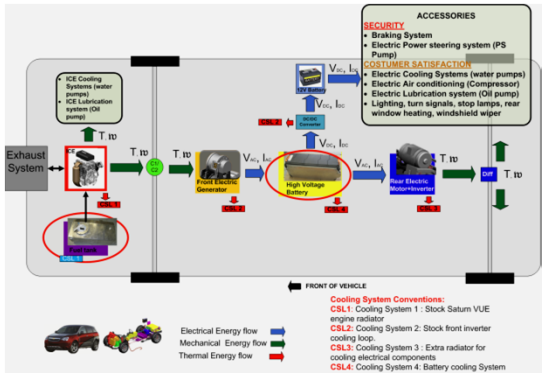
•Research Objectives

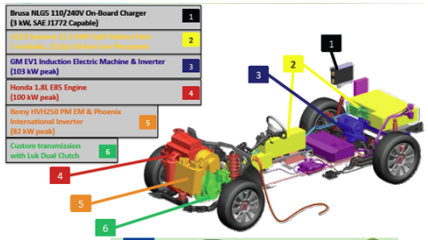
•Develop new concepts and tools for modeling, design and analysis for control and diagnosis of electric power-trains to enable rapid integration and optimization.

•Technical Approach

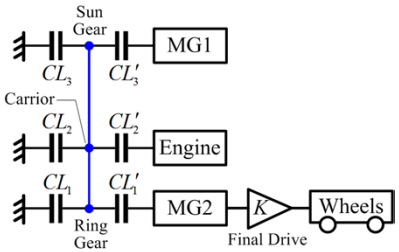
- Develop a systematic, top-down design and analysis framework for conceptual design, analysis, and evaluation.
- Development of a modular and hierarchical model structure to facilitate configuration optimization and trade-off analysis.
- Combined model-based investigation and experimental verification for intelligent diagnosis and prognosis.
- NVH and safety analysis for components and subsystems.
- Identify key vehicle operating modes
- Development of a state machine diagram
- Case study on the control and diagnosis of vehicles

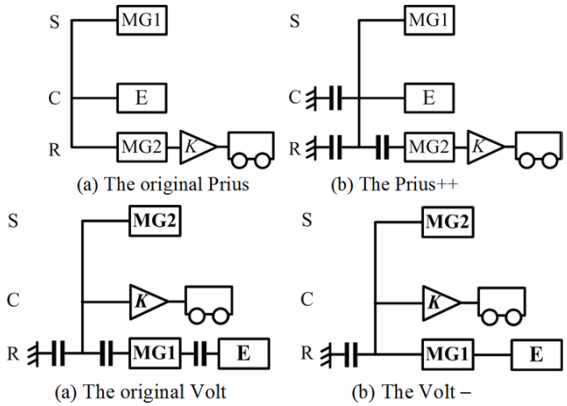
Initial Results





A complete Hazard Analysis along with Failure Mode and Effects Analysis (FMEA) and Failure Tree Analysis (FTA) for clean vehicles powertrains



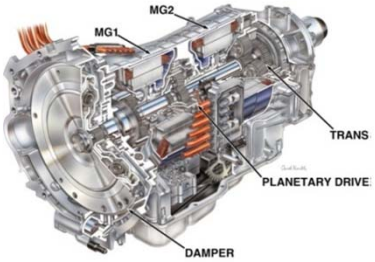


Thorough analysis of all possible configurations of power-split hybrid powertrain that use a single planetary gear. Dynamic Programming to identify best execution

Deep Dive: Configuration optimization and component sizing

Methodology Development

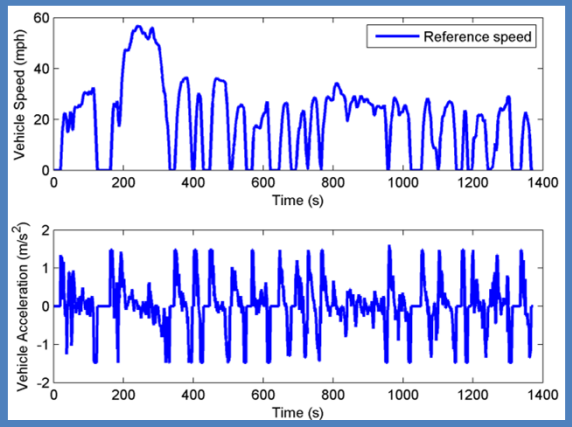
- Needs: Multiple design decisions on component sizes and subsystem selections
- State-of-the-art: DP (Dynamic Programming) used for hybrid vehicle sizing, but it is computationally expensive and subject to "curse of dimensionality"
- PEARS (Power-weighted Efficiency Analysis for Rapid Sizing):
  - Combines statistical information in optimization and efficiency analysis
  - Highlights sensitivities of overall cycle efficiencies to size parameters
  - Provides a much faster method for sizing: over **5000** times faster without compromising optimality!
  - Deals with several design variables such as MG sizes, Final drive and R:S



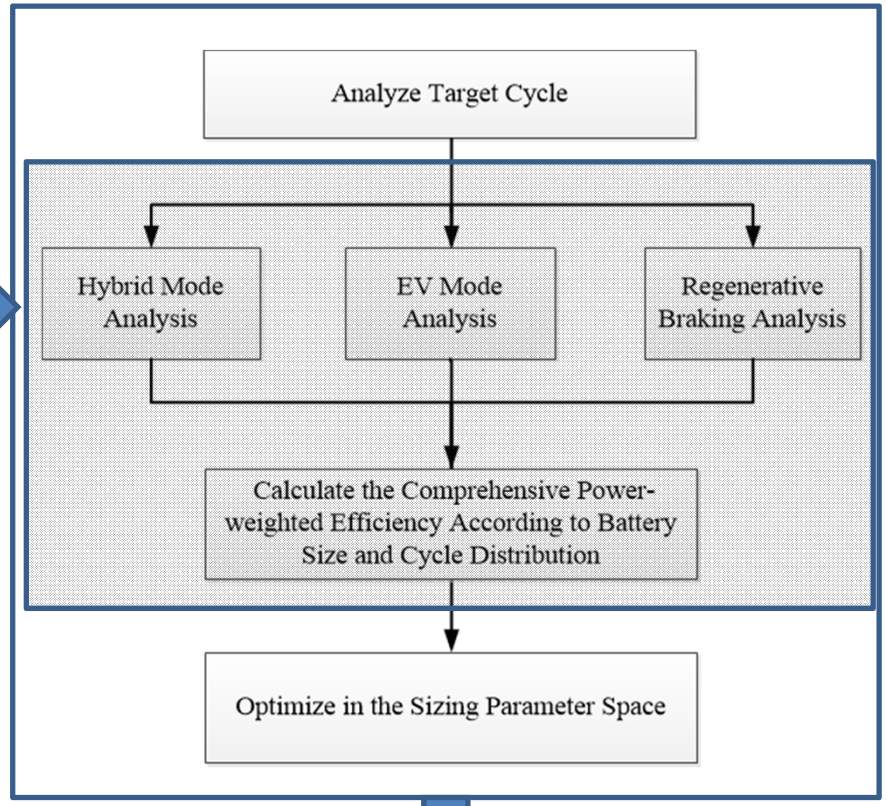
Deep Dive: Configuration optimization and component sizing

- Procedure

- Vehicle Parameters

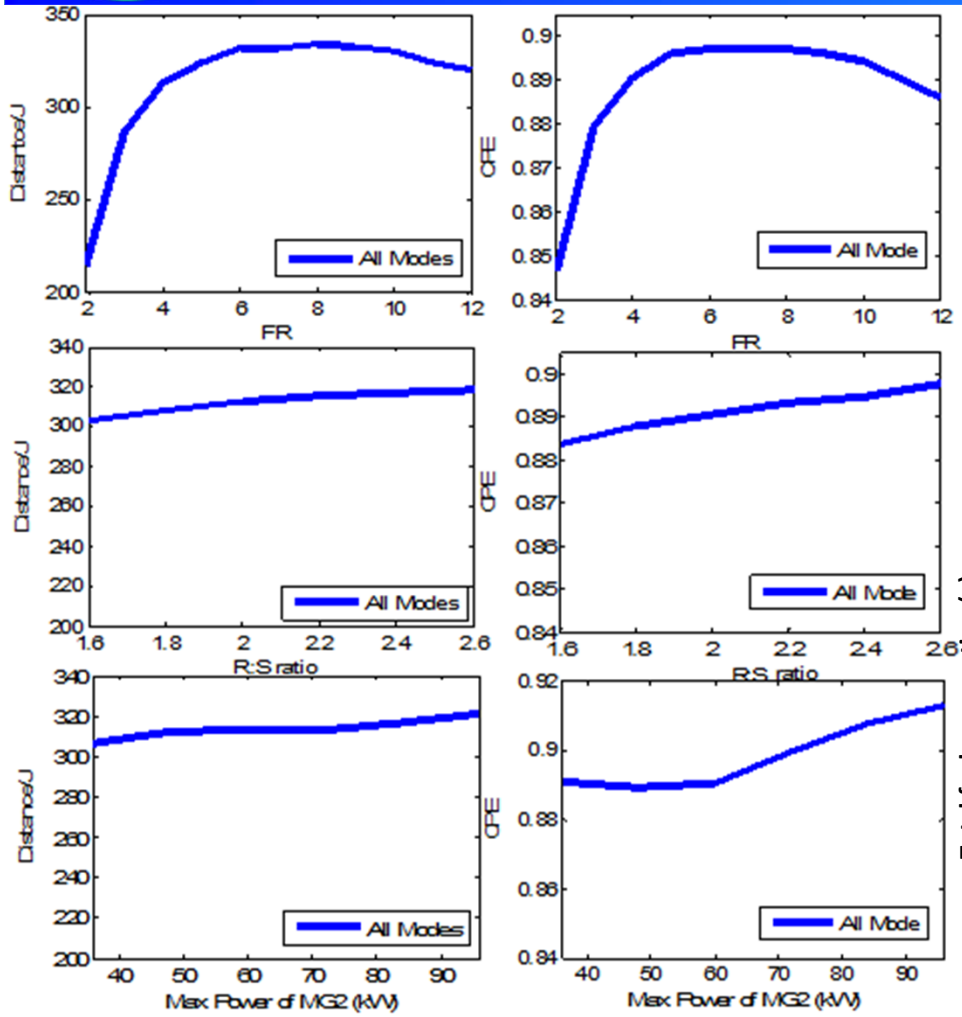


- Cycle Information



- Optimized Sizing Parameters

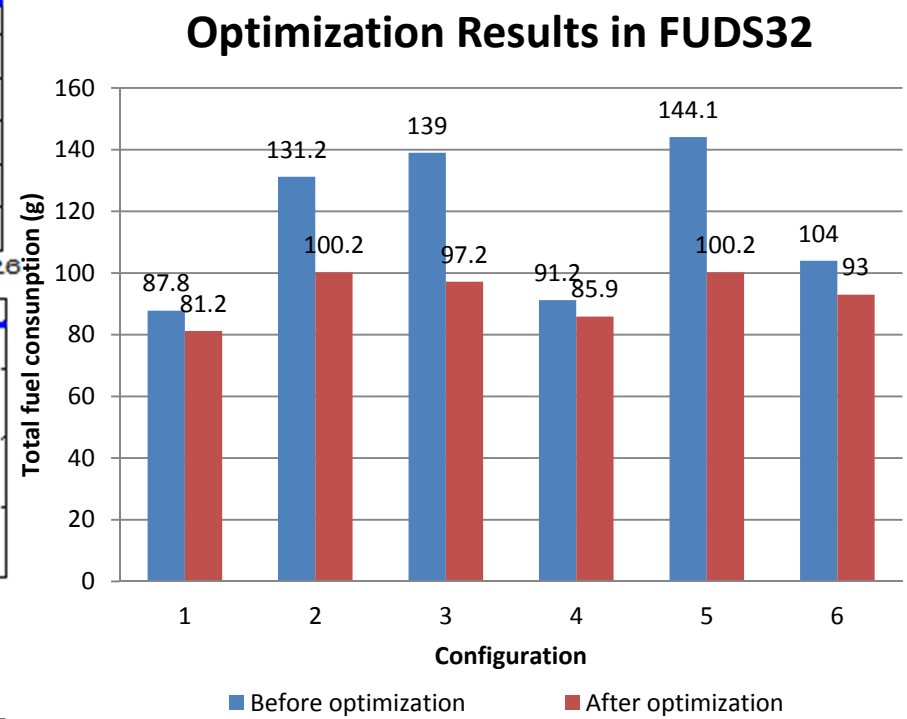
Deep Dive: Configuration optimization and component sizing



DP PEARS

DP v.s. PEARS verification is performed along 3 design dimensions

The Prius parameter is used as the baseline for each configuration study. After executing PEARS, best designs are identified and the corresponding fuel consumptions are calculated by DP.



Research Highlights—TA4

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TA#4 LIGHTWEIGHT STRUCTURES

MULTI-MATERIAL LIGHTWEIGHT BODY SUBSYSTEM OPTIMIZATION

Karim Hamza (UM); Kazuhiro Saitou (UM)

•Research Objectives

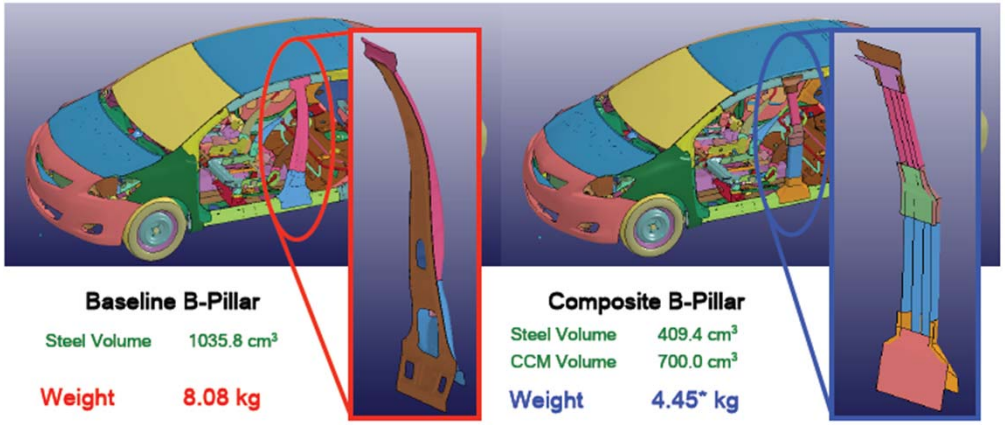
- Develop a methodology for economically integrating components made of lightweight materials in vehicle structure with maximum weight reduction benefit

•Technical Approach

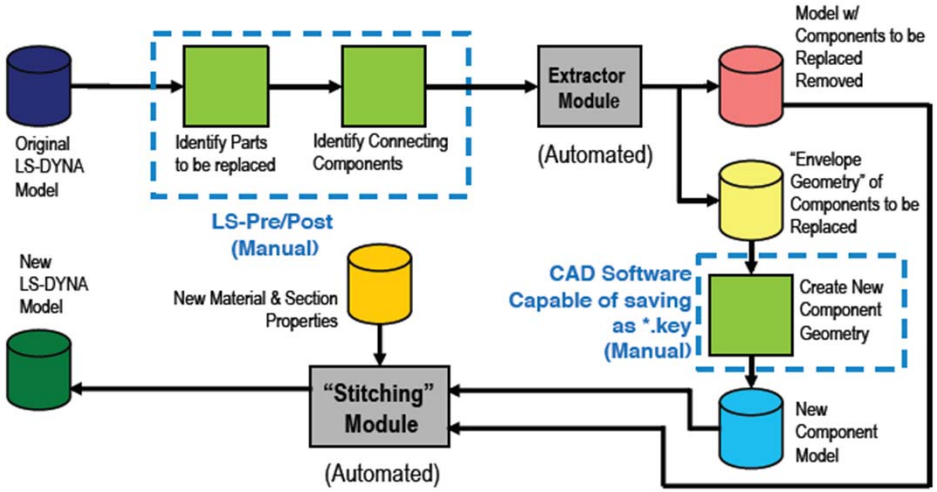
- Applying lightweight materials in key structural subsystems while maintaining crash performance.
- Optimize under constraints imposed by manufacturing and joining processes
- Benchmark with a public-domain Finite Element model of 2010 Toyota Yaris
- Initial focus: carbon fiber-reinforced composite B-pillar

Achievements

Design Modifications



Semi-Automated Design Assisting Tools



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TA#4 LIGHTWEIGHT STRUCTURES
JOINING MULTI-MATERIAL VEHICLE STRUCTURES WITH HYBRID FRICTION STIR WELDING PROCESS

Jun Ni (UM); LAI Xinmin (SJTU)

Research Objectives

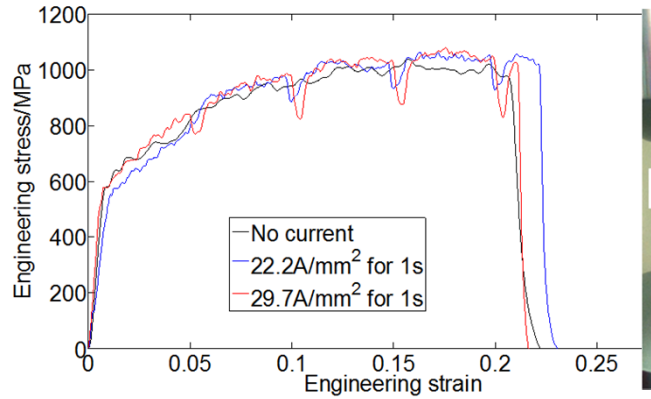
- Development of a hybrid Friction Stir Welding process to enhance joint quality for dissimilar materials, enlarge processing window and increase tool life

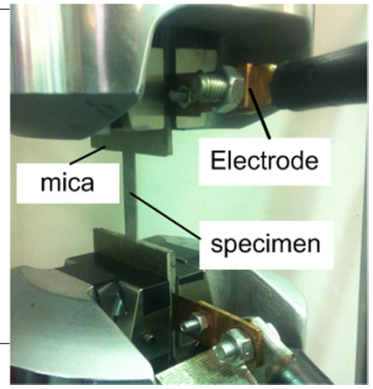
Technical Approach

- Investigate the effectiveness of Electro-Plastic Effect on various types of light weight materials
- Develop constitutive material model for Electro-Plastic Effect
- Integrate Electro-Plastic Effect into Friction Stir Welding process
- Develop Finite Element Model considering the electrical energy based on the material model developed before
- Optimize process parameters

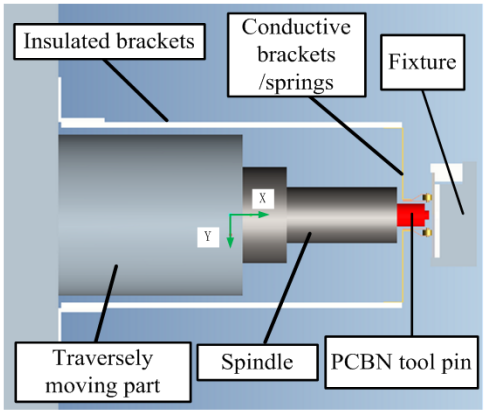
Achievements

Material behavior test on Electro-Plastic Effect

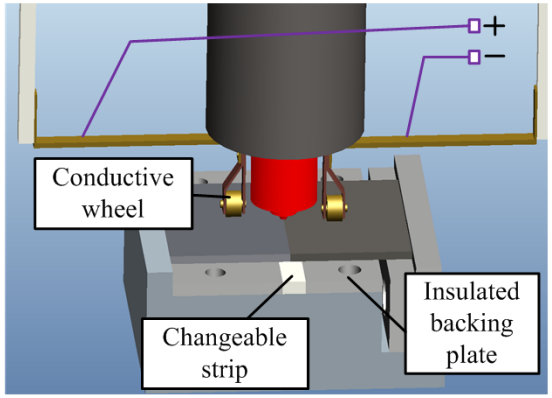




Hybrid Friction Stir Welding based on Electro-Plastic Effect



Overview of the CAD model



Partially magnified view

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TA#4 LIGHTWEIGHT STRUCTURES
STRUCTURAL CONFORMAL INTERFERENCE JOINING FOR MULTI-MATERIAL VEHICLE STRUCTURES

Nolan Windholtz (OSU), Geoff Taber (OSU), Andrew Sattler (OSU), Anthony Luscher (OSU), Glenn Daehn (OS

•Research Objectives

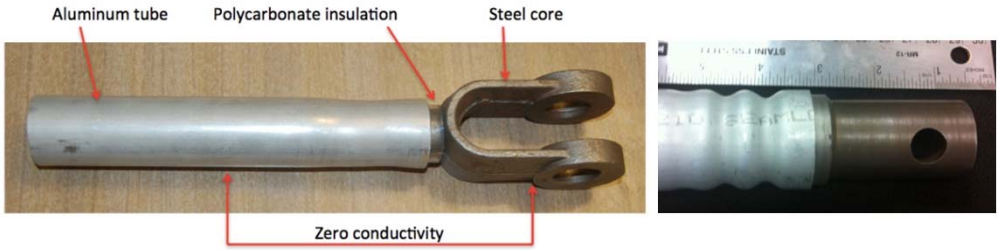
- Use high-speed conformal interference joining to assemble dissimilar metals
- Develop the engineering science both behind the manufacturing process and the assembly performance

•Technical Approach

- Use insulating layer between dissimilar metals.
- Explore axial and torsional strength in static loading and fatigue for round geometries with insulation.
- Explore development of non-axis symmetric shapes.
- Develop clear design methodology

Achievements

Introduced galvanically isolating polycarbonate layer between dissimilar metals. Maintains insulating properties without cutting. Layers can be as little as 0.005” thick and appear to give great mechanical properties.



Strength in varied joint designs demonstrated

Design of joints with torsional and axial strength properties

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TA#4 LIGHTWEIGHT STRUCTURES

AERODYNAMIC STYLING DESIGN FOR ELECTRIC-VEHICLE

YANG Zhigang (TJU), ZHU Hui (TJU), WANG Yigang (TJU), LI Qiliang(TJU)

•Research Objectives

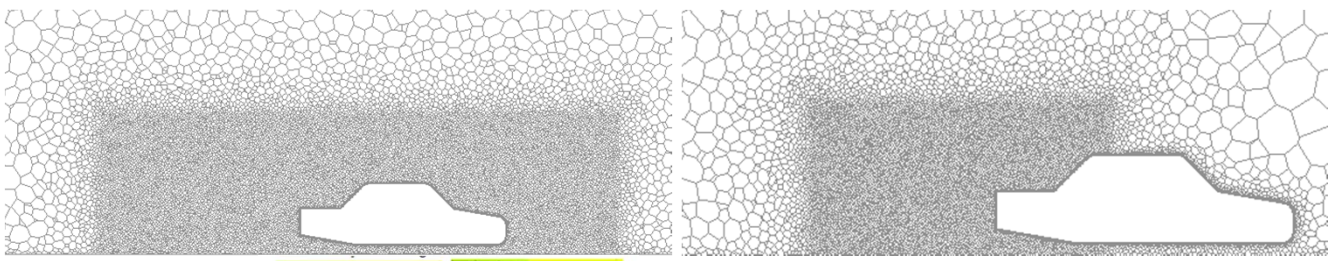
- Significant reductions in aerodynamic drag of EV
- Aesthetic design of EV
- A new style with low CD and fine appearance

Technical Approach

- CFD
- Drawing
- CAD

•Achievements

Grid independence and scheme research for simulating aerodynamic drag of notchback MIRA model



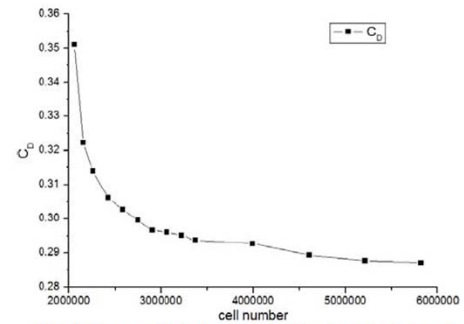


Fig. 9 Drag coefficient curve of refined polyhedral mesh around the model

Numerical Analysis on Effect of Vehicle Length on Automotive Aerodynamic Drag

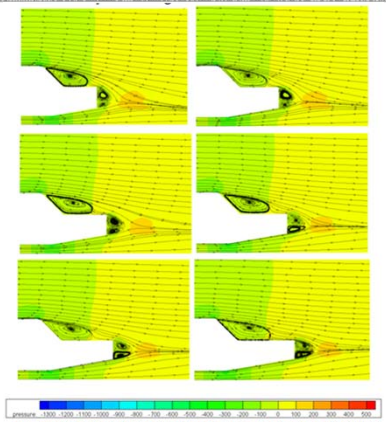


Fig. 8 Contors and streamlines of six models at y=0 plane

Numerical Analysis on Effect of Back/Front Windshield and Hood angle on Automotive Aerodynamic Drag

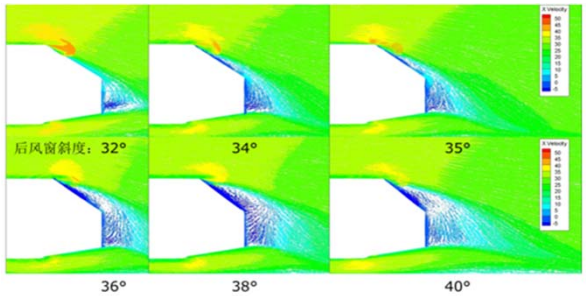


Fig. 6 .middle section velocity vector contour

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TA#4 LIGHTWEIGHT STRUCTURES
STUDY OF CRASH SAFETY OF SMALL LIGHTWEIGHT EV

ZHOU Qing (THU), XIA Yong (THU), TANG Liang (THU)

•Research Objectives

•Study of influence of structural design parameters and applications of lightweight materials for crash safety of small lightweight EV

•Technical Approach

•Define parameters of a study vehicle

•Build parameterized finite element model for crash analysis

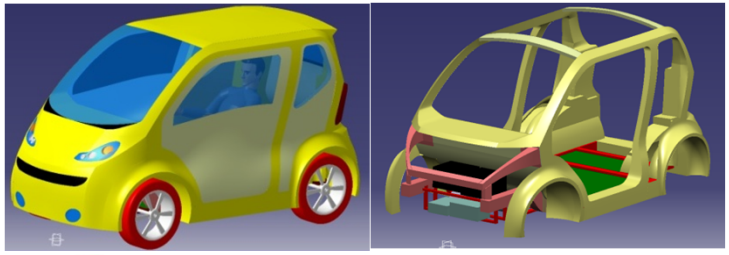
•Crash simulations and analyses

•Material selection for small lightweight EV body

•Deformation and failure modeling methods for lightweight materials and structures and design countermeasures

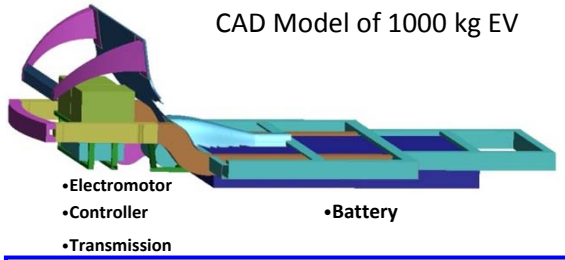
•Preliminary study of crashworthiness of EV battery

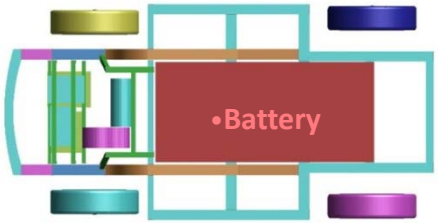
Achievements



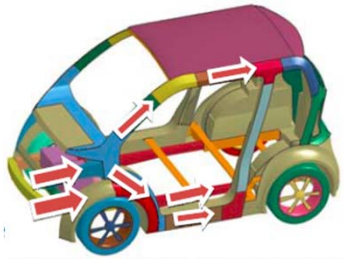
CAD Model of 1000 kg EV

Finite Element Model

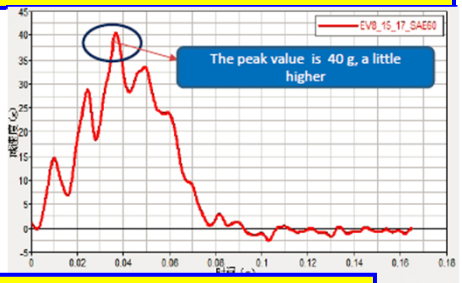




Influence of mass distribution of the battery and passengers on crash performance
Influence of using lightweight material on mass reduction and vehicle safety



Load path of crash force



The parameters that influence the crash pulse
– The height of the center of mass
– The thickness and structure of the front rail
– The thickness of the A pillar
– The thickness of the front wheel cover board
– The mass distribution of the battery

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TA#4 LIGHTWEIGHT STRUCTURES MANUFACTURING AND ASSEMBLY PROCESSES OF LIGHTWEIGHT CAR BODY

LAI Xinmin (SJTU), Li Yongbin (SJTU), YU Zhongqi (SJTU)

•Research Objectives

Study of advanced forming and joining processes of lightweight materials

Assembly variation prediction and control of car body

•Technical Approach

Study on stamping of AHSS & UHSS

– Statistical analysis and prediction model of HSS properties

– Robust optimization of forming process

Electro-Plastic Self-Piercing Riveting

– Construction of EP-SPR Prototype system

– Study of EP-SPR mechanism

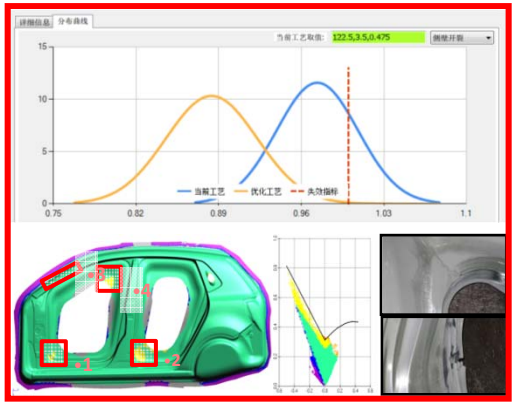
– Application of EP-SPR method to AHSS and Magnesium

Modeling and Prediction of Assembly Variation for Lightweight Vehicle Bodies

– Multi-materials auto body assembly variation prediction method

– Lightweight auto body assembly fixture robust design under low cost manufacturing mode

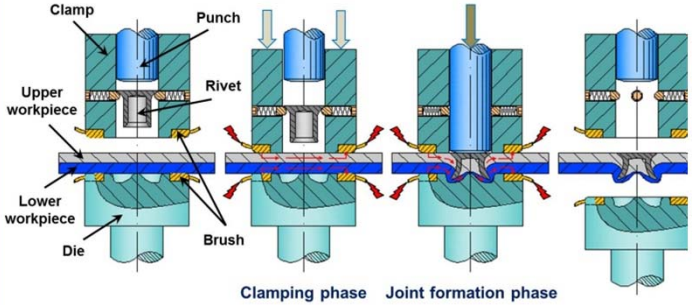
Achievements



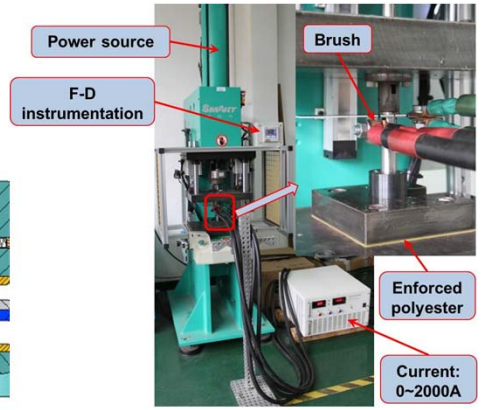
Develop agent model of sheet forming process in robust design

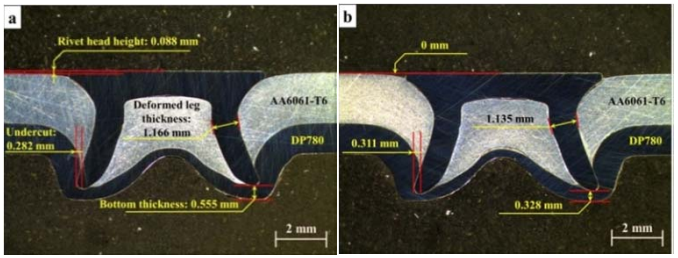
Develop an application software "Robust Design of Stamping Process"

Using the robust design software to solve engineering problem

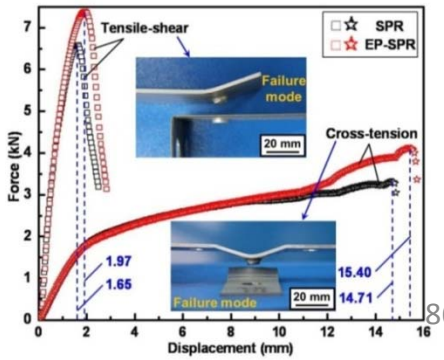


Schematic diagram of EP-SPR system





Traditional SRP EP-SRP



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TA#4 LIGHTWEIGHT STRUCTURES
HIGH VACUUM DIE CASTING AND SQUEEZE CASTING

Collaborators: LIU Baicheng (THU), XIONG Shoumei (THU), HAN Zhiqiang (THU)

•Research Objectives

•To develop high vacuum die casting and squeeze casting technologies and develop simulation technologies to support the manufacturing of aluminum and/or magnesium components for electric vehicles

•Technical Approach

•Develop a high vacuum die casting system, where the pressure in the mold can achieve less than 10 kPa within 1.5 s.

•Establish an experimental platform for squeeze casting of aluminum and/or magnesium alloys.

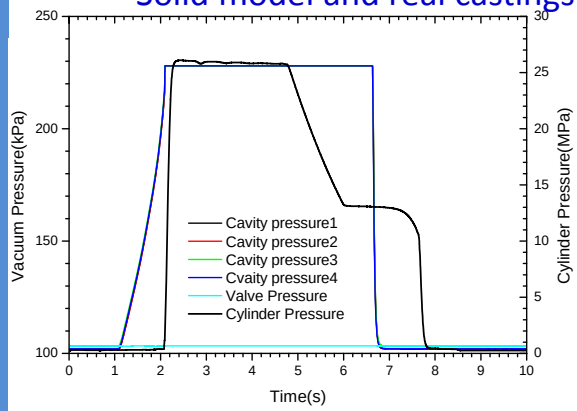
•Investigate the process-structure-property of high vacuum die casting and squeeze casting of aluminum and/or magnesium alloys.

•Develop numerical simulation technologies for high vacuum die casting and squeeze casting.

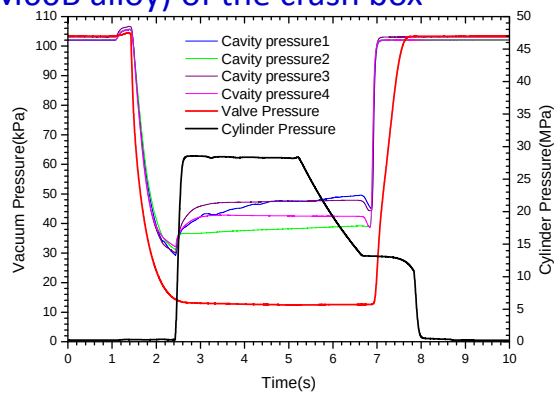
Achievements

Solid model and real castings (AM60B alloy) of the crash box

A Crash Box test casting was designed and developed under vacuum die casting condition

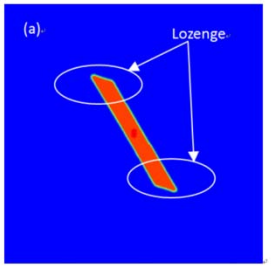


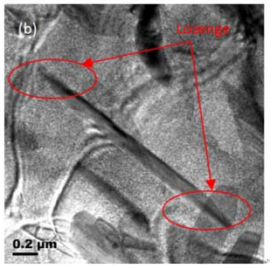
Back pressure in the cavity under convention die casting condition



Vacuum pressure in the cavity under vacuum die casting condition

Development of experiment station





Development of microstructure model for heat treatment of squeeze casting