Energy and Environmental Challenges

• Power capacity is not keeping pace with consumption
• At the current rate, total world energy consumption is expected to increase 57% from 2004 to 2030

• United States and China are the world’s largest energy consumers
• Developing countries consume non-renewable resources at an accelerating pace
• Resulting greenhouse gas emissions heighten environmental concerns

Greenhouse Gas Emissions

Global Emissions by Sector in 2004

- Forestry, 17.4%
- Agriculture, 13.5%
- Industry, 19.4%
- Transportation, 13.1%
- Residential and commercial buildings, 7.9%
- Energy Supply, 25.9%
- Waste and wastewater, 2.8%

Source: *Climate Change 2007: Mitigation*. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change

Greenhouse Gas Emissions by End Use in the Residential Sector, 2007

- Space Heating: 23%
- Water Heating: 13%
- Space Cooling: 14%
- Lighting: 11%
- Refrigeration: 6%
- Cooking: 3%
- Clothes Dryers: 4%
- Other Energy Uses*: 13%
- Other Electric Uses*: 13%


*Note: “Other Energy Uses” includes small electric devices, heating elements, and motors; such appliances as swimming pool and hot tub heaters, outdoor grills, and outdoor natural gas lighting; wood used for primary and secondary heating in wood stoves or fireplaces; and kerosene and coal. “other electric Uses” includes color TVs(6%), PCs(2%), furnace fans (2%), dishwashers (1%), freezers (1%), and clothes washers (1%).
Regulation and Policy Drive our Market

• Eco-friendly policies are moving the market WW
  • Energy Labeling, Energy Efficiency
  • 80+ program driving converter efficiency toward 90%
  • Adoption of inverters in motor control applications
  • Change from traditional lighting to LED, CFL
  • Regional Examples:
    • EU: EPBD (Energy Performance of Building Directive): All new buildings should consume zero energy from 2019
    • EU: New Energy Labeling system
      • For Eco-Design: <B grade prohibited for sale after July 2010
      • Only A-20% & A-40% products can be sold after July, 2013/14
    • US: Energy Star strengthening (eg, SEER12 → SEER16 for A/C)
    • China: New Energy Labeling System from June, 2010
    • Japan: ‘Top Runner’ program with APF since 2006
  • Clean energy and IT advances create whole new markets
    • Renewable energy: PV Inverter
    • Smart Grid: E-Vehicle Charger and Smart Metering
Fairchild Energy Savings Businesses

“Our greatest energy resource is the energy we currently waste.”
Former U.S. Secretary of Energy Spencer Abraham
Why Smart Grids?

Variable Generation
*High levels of penetration of embedded wind and solar generation on the horizon (Feed-in-Tariffs)*

Infrastructure Renewal
*Current system either reaching end of service life or operating at maximum capacity*

PHEVs
*Demand Response, Storage and Distributed Generation. All in one*

Environmental Concerns
*Public looking to our industry to provide solutions to climate change*

Empowering The Customers

**Choice**
*Customers want to shop for the best price…*

**Sustainability**
*They want to lower the impact of their energy consumption on the environment…*

**Convenience**
*They want to do so with little effort and no noticeable impact on quality of life…*
Current Grid vs Future Grid

Tomorrow’s Grid
✓ Distribute energy resources
✓ Flexible demand response
✓ Real-time distribution & customer data
✓ Real-time price signals
✓ Smart distribution system and processes
✓ Better customer information, choice & tools
✓ Energy storage devices

Today’s Grid
✓ Centralize power generation
✓ Limited 2-way binary demand response
✓ Limited real-time data
✓ Reactive outage management system
✓ Limited customer choices
✓ Limited energy storage
Emerging Smart Grid Market

- Phase I (in place)
  - Smart metering (AMR: Auto Meter Reading)

- Phase II (2010~)
  - Renewable energy system (solar, wind etc)
  - Battery charger/system

- Phase III (2013~)
  - Bi-directional converter & inverter connected battery systems
  - Communication systems for electricity monitoring & control (AMI: Advanced Meter Infrastructure)

Source: SEGIS: Solar Energy Grid Integration Systems
Emerging EV Charger in Smart Grid

**Power Source**
- Power Utilities
- Wind power
- Solar Energy
- Cogeneration
  Etc...

**Charging Infra**
- Residence
- Parking area
- Shopping mall/hotel
- Express way
- Petrol

**Vehicle**
- PHEV
- EV
Types of Green Car

- **Hybrid**: Engine + Motor
  - Battery 0.9 ~ 1.8 kwh
  - Improve fuel economy using electric power in inefficient engine operation area

- **Plug-in Hybrid**: Motor drive
  - Battery 4 ~ 16 kwh
  - Re Charge form external power source
  - Hybrid + EV

- **Electric Vehicle**
  - Motor drive only
  - Battery 10 ~ 30 kwh
  - Drive by electric energy (No engine operation)

- **Fuel Cell Electric Vehicle**
  - Battery 0.9 ~ 8 kwh
  - Powered by Fuel Cell
  - Drive by the electricity from chemical reaction of H2 and O2 in fuel cell
# Charging Technology

<table>
<thead>
<tr>
<th>kW</th>
<th>Time to full charge</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>250</td>
<td>5-7 min</td>
<td>Comparable charge time to refilling at gas station. Ultra high DC off-board charging</td>
</tr>
<tr>
<td>50-75</td>
<td>25-35 min</td>
<td>Not fast enough to provide similar convenience as gas station today. High DC off-board charging</td>
</tr>
<tr>
<td>10</td>
<td>3h</td>
<td>Only incremental benefit over slow charging at significantly higher cost. 3-phase AC charging</td>
</tr>
<tr>
<td>3</td>
<td>10h</td>
<td>Basic requirement for overnight charging for all plug-ins. 1-phase AC charging</td>
</tr>
</tbody>
</table>

- High attractiveness for user
- Comparable charge time to refilling at gas station
- Battery swapping
Example Plug-in HEV Configuration

- **HV Battery + BMS (180V-400VDC)**
- **DC/DC Converter**
- **12V Battery**
- **DC-DC boost Converter**
- **DC/AC Inverter**
- **DC Charge Port**
- **AC/DC Quick Charger (50kW)**
- **AC Link**
- **DC Link**

3-Phase AC 220V(JP) 380V(KR) 440V(NA)

Off-board Charger - Installed in garage or carport etc
Smart Metering

**Smart Meter Shipment by Region**

Source: Pike Research

**Trends/Requirements**

- High voltage tolerant, >1250V standoff voltage
- < 5 watts majority of meters, but smaller volume at about 16 Watts
- Power storage for radio after power fail, 20 minutes with bursts of communication
- Clean power for radio communication:
  - DC to DC switched
  - High efficiency for after grid power loss

**Products for Smart Meters**

- PWM Controllers
- Fairchild Power Switch (FPS)
- PWM+BJT+MOSFET
- DC/DC, OPTO
A Smart Home Example

Bidirectional Converter and Home Energy Management Console

Grid

DC Bus (380V)

DC Bus (48V)

Consumer Electronics, TV, PC & etc

Plug-In Hybrid EV

Solar PV

Smart Appliances, Washers, A/C, Refrigerator & etc

Energy Storage

LED Lighting

Smart Appliances, Washers, A/C, Refrigerator & etc
# Smart Grid Timeline

<table>
<thead>
<tr>
<th>Application/Market Segment</th>
<th>2010</th>
<th>2015</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AMI</strong></td>
<td>The first large-scale deployments underway</td>
<td>Substantial and growing market penetration and network infrastructure build-out</td>
<td>Significant and wide-ranging implementation</td>
</tr>
<tr>
<td><strong>Demand Response</strong></td>
<td>Limited reach (mainly commercial and industrial customers)</td>
<td>Substantial market penetration for residential, commercial and industrial</td>
<td>Commonplace with a wide variety of end-user service programs</td>
</tr>
<tr>
<td><strong>Grid Optimization</strong></td>
<td>A handful utilities beginning distribution/substation automation projects</td>
<td>Sensor technology embedded on the distribution network; automation becoming routine</td>
<td>Dynamic Sensing everywhere; Grid becomes an Intelligent Utility Network</td>
</tr>
<tr>
<td><strong>Distributed Generation Integration</strong></td>
<td>Nascent</td>
<td>Maturing, but still a small % of power generation</td>
<td>Approaching Mainstream More substantial presence;</td>
</tr>
<tr>
<td><strong>Energy Storage</strong></td>
<td>A few pilots among progressive utilities</td>
<td>Expected technology advancements and increased Distribution Generation penetration will boost storage’s role</td>
<td>Vital role in supporting Distributed Generation</td>
</tr>
<tr>
<td><strong>PHEV</strong></td>
<td>N/A</td>
<td>Smart Charging</td>
<td>V2G (vehicle-to-grid)</td>
</tr>
<tr>
<td><strong>Consumer Energy Management Systems</strong></td>
<td>Successful pilots continue to highlight consumer demand</td>
<td>Gaining transaction as “self-it-and-forget” technologies make energy management simple to use and cost-effective</td>
<td>Routine, Web-based</td>
</tr>
</tbody>
</table>

(Source: GTM Research)
Renewable Energy Growth

Annual Installations Worldwide [GWp]

- **25~75%**
- **10~25%**
- **10~55%**

![Bar chart showing annual installations from 2010 to 2014](chart)

![Line graph showing renewable energy growth from 2007 to 2014](graph)
Opportunities in PV Inverter Market

- The PV inverter market is the performance driven market requiring high performance power semiconductors including IGBTs, SuperFET and SiC diode-switches.
- The shipments of micro-inverters and distributed MPP tracking solutions are forecast to grow strongly. (77% CAGR for CY 2010-2015)

Products Required:
- Superjunction MOSFETs, Field Stop Trench IGBTs, Stealth Diodes
- High voltage (600 & 1200V) and Low Voltage (30V) Drivers
- Optocouplers, PWM Controllers, MPPT Tracking, Smart Power Modules
Only about 15% of the fuel energy is used to move the car or run useful accessories.
Robust Auto Solutions for energy efficient applications

- Engine Management
- Ignition, Glow Plug
- Injector control and supply
- HID Lighting
- Engine Cooling
- Transmission and Gearbox
- Electric pumps (water, fuel, oil)
- DC/DC in HEV / EV
- Electric Power Steering
- Braking (ABS, ESC)
- Electric Parking Brake
Automotive Power Modules for EPS

- EPS/EHPS:
  - Saves fuel (up to 7%)
  - Improves performance
  - Simplifies mechanical design
  - Increasingly adopted in new vehicles - conventional as well as EV/Hybrid

- APM Modules help to:
  - Optimize power output
  - Improve reliability
  - Ease design through integration of components
  - Ease installation due to compact design
Inverters in HVAC Compressors & Fans

Energy Savings and High Performance

Energy Saving
Inverter control can save average 40% electricity than conventional on/off control

Comfortable
In air conditioner,
- save cooling time (50% faster)
- Precise temperature control (±1ºC control)

Silent
In fan motor, Inverter can reduce audible noise
Fairchild Solutions for Motor Control

Fairchild provides all semiconductor products required for driving BLDC Motor

BLDC, PMSM Motor

Fairchild Shorted Anode Field-Stop IGBT
Motion Smart Power Module Portfolio

✓ Save space
✓ Compact design
✓ Easier to meet efficiency & EMI regulations
✓ Save development time
✓ Reduce time to the market

Application
Mid. Power
Industrial Inv.
System A/C
Low Power
Industrial Inv.
Package A/C
Room A/C
W/M
Refrigerator
E-bike
Power tool
Vacuum Cleaner
Pump
Dish washer
Fan motor

Capacity
0.1kW 0.5kW 1kW 2kW 5kW 10kW

Easier procurement
Lower assembly cost
Higher yield
Higher efficiency
High quality and reliability

SPIM
600V / 50A ~ 100A
1200V / 30A ~ 75A

SPM2
600V / 15A ~ 75A
1200V / 10A ~ 20A

SPM3
600V / 3A ~ 30A

SPM4
600V / 20A ~ 30A

SPM5
500V / 1A, 3A
250V / 3A

SPM7
500V / 1A

SPM45
600V / 3A ~ 15A
40V / 60A
60V / 40A

SPM45H
SPM45L

Save space
Compact design
Easier to meet efficiency & EMI regulations
Save development time
Reduce time to the market

Easier procurement
Lower assembly cost
Higher yield
Higher efficiency
High quality and reliability

Save development time
Reduce time to the market

Easier procurement
Lower assembly cost
Higher yield
Higher efficiency
High quality and reliability
Motion-SPM® is ideal for all types of motor driving solutions, especially 3-phase motor drive applications.

[Application Example]
Air-Conditioner System Block Diagram using Motion-SPM®
Energy Savings in Heating Processes

<table>
<thead>
<tr>
<th>Cooking Method</th>
<th>Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Induction</td>
<td>90%</td>
</tr>
<tr>
<td>Halogen</td>
<td>58%</td>
</tr>
<tr>
<td>Electric</td>
<td>47%</td>
</tr>
<tr>
<td>Gas</td>
<td>40%</td>
</tr>
</tbody>
</table>

Cost of heating ½ litre of water from 20°C to 95°C

Power Consumption for heating ½ litre of water from 20°C to 95°C
Induction Heating and Microwave Oven

- The global penetration rate of inverter based Microwave Ovens (MWO) was estimated to be just over 10% in 2005
  - Adoption of inverter technology for MWO will improve the efficiency and the performance of MWO
  - The share of inverter based MWO is projected to grow to 40 ~ 50%
- Chinese manufactures start to design Induction Heated (IH) rice cookers as the demand of multifunction capabilities increase
- Energy Efficiency labeling program in Asia will also drive the market growth of IH rice cooker and inverter based MWO
Energy Efficiency in Computers

- **80+ ATX**: Energy Star program for computer (V5.0) has affected every tier since July, 2009
  - Every ATX qualified Energy Star should deliver > 82% of efficiency @20, 50 and 100% of loads
  - As EPA’s program, 80PLUS market is dramatically increasing thru 2015

<table>
<thead>
<tr>
<th>Major Efficiency Level</th>
<th>&lt; 80+</th>
<th>80+ Gold Label</th>
<th>80+ Platinum Label</th>
</tr>
</thead>
<tbody>
<tr>
<td>Topology</td>
<td>N/A of regulation, but 70% efficiency of mainstream power</td>
<td>Over 88% at over 20% load (gold) &amp; start period of platinum (Over 90% at all load at 230V line)</td>
<td>Platinum (Over 90% at over 20% load at 230V line) will be major</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>80 PLUS Test Type</th>
<th>115V Internal Non-Redundant</th>
<th>230V Internal Redundant</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>20%</td>
<td>50%</td>
</tr>
<tr>
<td>80 PLUS</td>
<td>80%</td>
<td>80%</td>
</tr>
<tr>
<td>80 PLUS Bronze</td>
<td>82%</td>
<td>85%</td>
</tr>
<tr>
<td>80 PLUS Silver</td>
<td>85%</td>
<td>88%</td>
</tr>
<tr>
<td>80 PLUS Gold</td>
<td>87%</td>
<td>90%</td>
</tr>
<tr>
<td>80 PLUS Platinum</td>
<td>Not defined</td>
<td>90%</td>
</tr>
</tbody>
</table>

- Energy Efficiency in Computers
Energy Savings in Servers

- Server Power Supply Unit Block diagram (600-800W)
  - > 90% efficiency for 600/700W Server Power
Focus Areas

**Server Vcore/DDR**
- PowerStage56 25V
- Power33 25V PT8+
- Power56 25V PT7/8+
- Power56/33 Dual Cool
- DrMOS Multi-Chip-Module

**Server Point of Load**
- PowerStage56/34/33
- Power33 PT7/8
- Power56 PT7/8
- TinyBuck Integrated solution

---

MOSFET Power in Servers

---

**Most Efficient Performance as Small as Possible**

---

Note: All currents are TDC (Thermal Design Current)
MOSFET Power in Notebooks

Focus Areas

**Notebook Vcore**
- PowerStage 5x6 Duals 30V
- Power33 NCH 30V sub 3mOhm
- Power56 30VPT8S

**Notebook DC:DC/Battery**
- PowerStage Dual 30V – 3x3, 3x4.5, 5x6
- Power33 NCH 30V 3-30mOhm
- Power56 NCH 30V 3-15mOhm
- Power33 PCH 30V ST3
- Power33 NCH 30V Dual Cool™

**N VDC Notebook/Tablet**
- PowerStage Duals – 25V
- Power33 NCH 25V Dual Cool™
- Power33 PCH 25V ST3
- Power22 NCH 25V PT7
- CSP 20V NCH Zener PT7
- Power33 NCH 100V (LED BLU)

Cost Effective Performance as Small as Possible
Display Market Trends

Source: Displaybank and iSuppli

- LCD TV [LED BLU] Mset
- LCD TV [CCFL BLU] Mset
- PDP TV Mset
- CRT TV Mset
LED Backlight Unit for LCD TV

Reduced Thickness

- Slim
- 50 mm

Local dimming & scanning

Vividness

More image producing

- 120Hz
- 240Hz

Better contrast

Non-motion blur

Dark black

Low power

- 32" LCD TV (CCFL BLU)
- 46"
- 55" LED LCD TV
- LCD TV (CCFL BLU)
- LED LCD TV
Focus Areas

**LED BLU : Main Switching FET**
- N-CH PT5 100V
- N-CH PT5 150V
- N-CH PT7 40V
- Power33, Power56, SOT223 and DPAK

**LED BLU : Sync MOSFET**
- N-CH PT5 100V
- N-CH PT5 150V
- N-CH PT5 200V
- Power33, SOT223 and DPAK

**T-Con Board & Video Board :**
- PowerStage Duals – 30V
- Power33 NCH 30V PT7

Efficient and Reliable Performance as Cool as Possible
Energy Saving in Notebook Adapter

- Next gen of NB adaptor solutions to meet 92%+ efficiency
- High integration provides cost effective design
- Wider power range 75W~250W
- Allows for very slim design

- Current mainstream solution for NB adaptors
- Meets 90%+ efficiency, high integration, 75W~150W
Energy Savings: Standby Power

Why is this important?

- Current specs for cell phone chargers require <500mW under standby conditions
- Most chargers have standby power in the range of 30-150mW
- FCS has launched a <10mW solution
- Typical chargers are in standby >20 hours every day
- More than 1B chargers are sold annually

Energy Rating System:

Most chargers are rated 4-stars now
Lighting Product Life Cycle

Driving force: Energy saving, Environmental friendly and convergence
LED Lighting

LED will replace Halogen & incandescent lamp in near future for energy saving and there are new opportunities in special applications (street lighting, architectural, decorative, window display, channel letters, etc) using LED’s strong point.

• Climate change and high Power demands push each governments to release new regulations in Lighting and Building Industry world wide. → Released EISA Act of 2007(USA) to focus performance standard for selected light bulbs (72/53/43/29W new ones cover same light outputs in 100/75/60/40W current ones)

• Strong point of LED Lighting
  - High Efficiency( 1/3 power consumption against CFL )
  - Long life time guarantee (over 50K hours)
  - Better design flexibility
  - Easy to dim compared to CFL

• Weak point of LED Lighting
  - Big price gap between LED and CFL ( 7 ~ 8 times higher )
  - No standard platform in specific applications

• DOE, USA, offers $10M award to LED lighting suppliers to accelerate LED industry ( Bright Tomorrow Lighting Prize )
  - Output : 90lm/W in operating mode, over 90 CRI, CCT is between 2750 ~ 3000K, 25Kh life time guarantee with screw type
Benefits of NPT over PT
- No Lifetime Control Process ➔ Simpler Process
- Positive Temp Coefficient ➔ Thermal Stability & Easy parallel operation
- Ruggedness ➔ Large SOA (Safe Operating Area)

Benefits of Trench IGBT over Planar IGBT
- High current density ➔ Reduce chip size !!
- Increase current rating of module with smaller chip

Benefits of Field Stop over NPT
- Buffer layer terminates electric field in a shorter distance ➔ enables reduced die thickness
- Reduced die thickness ➔ Reduced Vce(sat) for the same Eoff
- Buffer layer improves minority carrier recombination ➔ Reduced Eoff due to reduced tail current

Retains NPT capability:
- Positive temperature coefficient ➔ Thermal Stability & Easy parallel operation
- Ruggedness ➔ Large SOA (Safe Operating Area)

Evolution of IGBT Technology

FS Trench IGBT

PT IGBT

NPT IGBT

FS Planar

FS Trench

SA FS Trench

WF thickness
SuperJunction Technology Innovation

- New energy-saving superjunction technology
  - Lower Rds(on) for reduced conduction loss
  - Lower capacitance for reduced switching loss

- Higher cell density
  - Achieved less than 20mOhm/cm² of A*R_{DS(on)}
  - P-epi filling after deep trench etching

SuperFET®
Conventional Multi-Epi Technology

SupreMOS®
Fairchild’s Deep Trench Technology

40% reduction in on-resistance per specific area over previous generation
Medium Voltage MOS Technologies

UltraFET Trench

- X1 Cell density

PowerTrench 3

- X2 Cell density
  - Increased Cell Density
  - Reduces Rds(on)

Power Trench 5 & 7

- X4 Cell density
  - Charge Balance technology
  - Reduces Epi Resistance
Mini-DIP Smart Power Module (SPM\textsuperscript{®})

- **Package Type**: Transfer Mold PKG (Ceramic Substrate Type)
- **Major Applications**:
  - Consumer appliance inverters
    (Low power Air-conditioners, Washing Machines, Refrigerators etc.)
  - Low power industrial inverters
    (Industrial inverter, Water pump, Treadmill, Sewing machine, Door controller, etc)
- **Feature**:
  - Reduced package size (44% compare with Mini-DIP SPM)
  - Integrated protection function
    Current, Voltage, Temperature
  - Improved power density with same die size
    Improved short circuit ruggedness
  - Built-in Bootstrap diode, NTC thermistor
  - 3-N terminal for low cost current sensing
μMini-DIP SPM®

- LVIC
- HVIC
- 6pcs of IGBT
- 6pcs of FRD
- 3pcs of B/D
- NTC
- Cu Wiring
- Al Wiring
- Lead Frame
- Ceramic (Isolation material)
- Adhesive
- EMC (Epoxy Molding Compound)

6pcs of IGBT
6pcs of FRD
3pcs of B/D
LVIC
HVIC
NTC
Cu Wiring
Al Wiring
Lead Frame
Ceramic (Isolation material)
Adhesive
EMC (Epoxy Molding Compound)
Packaging Challenges

• Thinner ceramic & thicker Cu DBC to improve thermal and electrical performance
  • for example: 0.5mm top and bottom Cu with 0.2-0.3mm Al2O3 or AlN ceramic
  • current capability: Cu thickness should be equal to or thicker than ceramic thickness

• Higher thermal conductivity molding compound
  • 5-10 W/m.K by filling higher conductivity filler material such as AlN ceramic in it
  • current : max 3W/mK by adding Al2O3 ceramic

• Lower cost DBC by increasing DBC manufacturing panel size
  • current : 5.5x7.5” → e.g 10x10” or 12x12”
  • breakthrough technology improving warpage and voiding

• Thermally enhanced (100-200W/m.K) DBC substrates better than current materials
  • Al2O3 – 24w/m.K or AlN DBC – 70W/m.K

• Electrically and thermally enhanced IMS substrate
  • 300-500um top Cu metal (current : 50-100um) thickness
  • 10-20W/m.K thermal conductivity insulator material

• Thick Cu wire bonding
  • upgrade current 1-2mil Cu wire to 10-20mil Cu

Fig. 7 : Thermal simulation results
Packaging Challenges

• Delamination-free interconnection technology through interface surface modification
  • Addition of adhesion promoter
  • Rougher surface materials (L/F, substrate, etc)
  • Better adhesion materials (EMC, coating, etc)

• Wire-less high power density module using new interconnection technology to improve power density, electrical and thermal performance
  • Clip or direct leadframe interconnect to die to improve electrical and thermal performance

• Dual cool heat dissipation high power module that expose both top and bottom metal outside to improve thermal performance

• Press-fit interconnection high power module to improve soldering interconnection reliability
  • Current: Ni or Ni-NiP or Ag or NiPdAu or bare Cu)

• Bare die embedded substrate multi-die packaging to reduce package size and to improve power density

• PQFN base high voltage power module meeting isolation voltage clearance requirement
Conclusion

◆ There are tremendous opportunities for energy savings in all types of electricity use
◆ The smart grid is driving major changes in the way we generate, transmit, store, and apply energy
◆ Energy awareness and new regulations are being applied all over the world for better energy efficiency.
◆ New, highly efficient solutions are available for appliances, lighting, computing, home entertainment
◆ Controlling power involves major packaging challenges in thermal performance, cycling life performance
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