Ovonic Metal Hydride Technologies for Photovoltaic Energy Storage Applications

Dennis A. Corrigan
Energy Conversion Devices
Rochester Hills, Michigan
Hydrogen stored as a solid can be transferred between battery electrodes to provide electrical energy as an output.

Hydrogen stored as a solid can be released to provide fuel for fuel cells or heat engines.
Hydrogen Economy Loop

1. Ovonic Solar
   - Electricity

2. Ovonic Electrolyzer
   - $H_2$ production
   - $O_2$ consumption

3. Ovonic Solid Hydrogen Storage
   - $H_2$ storage

4. Ovonic Regenerative Fuel Cell
   - $H_2$ consumption
   - $O_2$ production
   - Electricity

5. Ovonic NiMH Battery
   - Electricity

6. House
   - Electricity

7. Car
   - Electricity
Uni-Solar 30 MW PV Production Facility
Uni-Solar PV Product Competitive Advantages

- Low material cost achieved by using thin-film amorphous silicon
- Multijunction approach to improved energy conversion efficiency
- Low manufacturing cost achieved by using the roll-to-roll production process
- Flexible, lightweight and rugged products
- Superior performance at high temperatures and low light levels
- Proprietary technology protected by over 136 U.S. patents and 264 foreign patents
Uni-Solar Triple Junction Amorphous Silicon PV Cells

OVONIC™ SOLAR CELL PROCESSOR

Moving Stainless Steel Web

Manufactured by:
Energy Conversion Devices, Inc.
Machine Division
Rochester Hills, Michigan
U.S.A.

Model 30MW
Serial No. 007

Schematic of 30MW Continuous Roll-to-Roll Ovonic α-Si PECVD Processor
Uni-Solar PV Production Facility

30MW Machine – Chambers (L) Doors (R)
Uni-Solar 30 MW State-of-the-Art Thin-film PV Manufacturing Process
500 KW “SOLAR MINE” PV SITE

- Powers ChevronTexaco oil field operations in Bakersfield, California.
- One of the largest American PV installations US and the largest amorphous silicon solar cell array in the world.

- Annual Energy Generation: 902,000 kWh
- Annual Avoided Emissions:
  - $CO_2$: 930 tons
  - $SO_2$: 6,345 pounds
  - $NO_x$: 5,816 pounds
Diverse Solar Energy Applications
Solar Power for Rural Electrification
Uni-Solar PV Roof Integrated Products
PV Laminate systems for roofing membranes

- **UNI-SOLAR®** products are **easier to install** on commercial building’s requiring fewer man-hours for installation.

- **UNI-SOLAR®** products are **flexible and low weight** (less than 1 lbs/sq ft) compared to more than 5 lbs/sq ft for the competition
New Volume Manufacturing Facility in Springboro, OH
Advantages of Ovonic NiMH Batteries

- High Power
  - 1000 W/kg (HEV)
- High Energy Density
  - 80 Wh/kg (EV)
- Excellent Cycle Life
  - Life of vehicle
- Rugged and Safe
  - Abuse tolerant
- Environmentally Safe
  - No cadmium, lead or mercury
- Low Lifecycle Cost

Ovonic® Family of Batteries 10Ah to 110Ah
Automotive Battery Applications

NiMH Production EVs

NiMH Production HEVs

TEXACO Ovonics Battery Systems
Stationary Battery Applications

- Stationary power
  - Uninterruptible Power Supply
  - Telecommunications
  - Distributed Generation Applications

- Demand for reliable off-grid power systems for critical institutions:
  - Telecommunications systems
  - Medical facilities
  - Financial institutions
  - Municipal water supplies and other infrastructure
Ovonic Metal Hydride Production

Rare Earth Ovonic Joint Venture
50-50 Joint Venture with ChevronTexaco

Mission to develop and commercialize Ovonic Solid Hydrogen Storage Systems for Portable Power, Onboard Storage & Bulk Storage/Infrastructure
Ovonic™ Solid Hydrogen Storage provides key advantages over liquid hydrogen and compressed hydrogen storage:

- Safe
- Compact
- Reversible
- Low pressure operation
- Fast refueling
- Long cycle life
- Tailorable pressure
- Packaging flexibility
- Onboard waste heat utilization
Ovonic™ Solid H₂ Portable Canisters

- Size: 3.5” (OD) x 14” (length), 2 liters
- Weight: 6.5 kg
- Charging Pressure: 250 psig
- H₂ Capacity: 74-82 g reversible depending on air flow rate/temperature
- Cycle life: 500 cycles demonstrated
  - Capacity degradation less than 10%
  - No degradation of burst pressure
  - Wall stress within DOT specified limit
- Flexible design & packaging

Ready for Commercialization
HYDROGEN STORAGE TANK

Left: Ovonic Tank, 3.0 kg capacity @ 1500 psi

Right: Typical 5000 psi Tank, 0.78 kg capacity

(One kg Hydrogen = One gallon gasoline)

- Ovonic Onboard Vessel
  - Fast refueling (approximately 10 minutes)
  - Compact and low pressure
  - Ready for OEM experimental vehicle testing and validation
Ovonic™ Solid Hydrogen Bulk Storage (10 kg H₂)

- **Ovonic Bulk Storage System**
  - Ability to store high density hydrogen directly from an electrolyzer without mechanical compressor
  - Tailorable, scalable to customer specifications
  - Ready for validation and demonstration
The Practical Solution for Hydrogen Infrastructure

**Ovonic Solid Hydrogen Systems**

1. Centralized / Local Hydrogen Production from Conventional / Solar Power

2. Bulk Transport of Ovonic Solid Hydrogen by Ordinary Means

3. Ovonic Hydrogen Storage and Distribution at Retail Stations
   - Hydrogen generated through thin-film photovoltaics (solar electricity)
   - Electrolyzer producing hydrogen and oxygen from water and sunlight
   - Primary hydrogen storage at retail site with hydrogen dispenser
   - Fuel Cell or ICE powered vehicle with onboard solid hydrogen
Ovonic Technology Enables an All-Hydrogen ICE Vehicle

2002 Ovonic Hydrogen Prius

Drive Train

Electric Motor

Ovonic™ NiMH Battery System Technology

ICE with Ovonic™ Modifications

Texaco Ovonic Hydrogen Systems
Ovonic™ Solid Hydrogen Storage

- Hydrogen Sensor
- Expansion Tank
- Coolant Pump
- Solenoid Valve
- Heat Exchange

ICE Coolant Supply/Return