High-Tech Magnetic Materials vs. Performance
Soft Magnetic Materials

Steel
- Silicon Steel 3%
- Nickel Steel
- Silicon Steel 6%

Oxides
- Ferrites of various mixes and permeabilities

Powder
- MPP
- Sendust
- High flux cores
- Iron powder
- All with various mixes and permeabilities

Amorphous Alloys
- Cobalt based amorphous 2714A
- Iron base amorphous 2605SA1
- Nickel based amorphous metal 2826MB
- Nanocrystalline alloys
• Rapid solidification is the key to Amorphous Metal Technology
• Developed and commercialized by Metglas®, Inc.
• Capacity - 40,000 M tons/year with six casting lines in Conway, South Carolina
• Product available from multiple sources with Metglas®, Inc. licensing strategy

Metglas®, Inc. is the World Leader in Amorphous Metals Technology
Amorphous Metals Definition

• Metal alloys with noncrystalline atomic structures

• Product description
  - Amorphous metal
  - Glassy metal
  - Metallic glass
  - Metglas® alloy

Atomic Structure Is The Key To The Low Losses
Amorphous Metals Are Unique Materials

The Key Material Attribute...

Means Our Products Have Properties Which...

Provide Value In a Number of Products and Applications

“Easy to Magnetize and Demagnetize”

- Low Power Loss
- Low Temperature Rise at High Frequency
- Extremely Fast Magnetization
- Easy Conversion Of Electrical to Mechanical Energy

Electric Power Systems
Distribution, Industrial & Power Transformers

High Frequency Components
Computer and Industrial Power Supplies

Laser Power Systems
Semiconductor Processing, Surgery, Military (Radar)

Electronic Article Surveillance
Anti-theft Targets

Leverage the Properties for Miniaturization of
DC Hysteresis Loops

This Picture is Worth a Thousand Words
Soft Magnetic Properties
Permeability vs Coercivity

Metglas Alloys are the Superior Choice Based on the Required Optimization
Soft Magnetic Properties
Saturation Induction vs Coercivity

Metglas Alloys are the Superior Choice Based on the Required Optimization
## Magnetic Materials - Performance vs Value

<table>
<thead>
<tr>
<th>Performance</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Low</td>
<td></td>
</tr>
</tbody>
</table>

### Performance

- Ferrites
- Sendust (small)
- METGLAS Iron-based (sizes <15 mm)
- METGLAS Cobalt-based (sizes <15 mm)
- Silicon steel - 14/7 gauge
- Iron powder
- Some ferrites
- MPP Ni 80%
- High Flux Ni 50%
- Sendust Fe 70%
- METGLAS Fe 80%
- METGLAS Co 75%
- Supermendor
- Si Steel (.001, .002, .004”)
- Ni Steel (80% Permalloy®)

### Electronic and Electrical Applications

- Electronic
- Electrical
Low Profile Solutions for High Frequency - SMPS Design
Amorphous Metals

Electronic Components

Products
- POWERLITE® cores (iron based)
- MAGNAPERM ® high permeability cores (cobalt based)
- MICROLITE® choke cores (iron based)
- METGLAS ® square loop cores (cobalt based)

Applications
- Common mode filtering
- Harmonic filtering
- Power factor correction
- Current sensing application

Markets
- Distributed power generation (solar, fuel cell microturbines)
- Telecommunications
- Personal Computers
- Automotive
## MICROLITE® Toroidal Cores

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Higher BSAT for smaller component size</td>
<td>± BSAT 1.56 Tesla</td>
</tr>
<tr>
<td>High permeability (lower I²R loss)</td>
<td>± m~250 Less turns</td>
</tr>
<tr>
<td>Extended bias property (%L vs DC bias)</td>
<td>± Better retention</td>
</tr>
<tr>
<td>Lower magnetic losses</td>
<td>± 85 W/kg @ 100 kHz, 1000 Gauss</td>
</tr>
<tr>
<td>Higher thermal conductivity</td>
<td>± Ensures good dissipation</td>
</tr>
<tr>
<td>Higher Curie temperature</td>
<td>± 400°C</td>
</tr>
<tr>
<td>Excellent permeability @ high frequency</td>
<td>± 95% @ 1000 kHz</td>
</tr>
<tr>
<td>High continuous operating temperature</td>
<td>± 150°C (155°C for Class F)</td>
</tr>
</tbody>
</table>

**Iron-Based MICROLITE Cores - Low Energy Losses**
MICROLITE® Overview

MICROLITE Applications
• Output Inductor
• Input differential mode inductor
• Flyback transformer
• Power factor correction boost inductor

MICROLITE Manufacturing
• Tape wound toroidal core
• Made from an iron-based amorphous alloy
• Made from patented annealing process of the amorphous alloy

Strengths of Manufacturing Process
• 40 K tons capacity of Conway plant enables small lead-times
• Tape enables manufacture of custom cores without expensive retooling
# MICROLITE® Cores Relative to Other Material Systems

<table>
<thead>
<tr>
<th>Parameters</th>
<th>MICROLITE</th>
<th>Iron Powder</th>
<th>MPP</th>
<th>Kool Mu</th>
<th>Ferrite</th>
</tr>
</thead>
<tbody>
<tr>
<td>$B_{\text{SAT}}$ (T)</td>
<td>1.56</td>
<td>1.0-1.4</td>
<td>.75</td>
<td>1.1</td>
<td>.35</td>
</tr>
<tr>
<td>Perm</td>
<td>250</td>
<td>75</td>
<td>125</td>
<td>125</td>
<td>Gap dependent</td>
</tr>
<tr>
<td>Power Loss (W/kg)</td>
<td>&lt;80</td>
<td>680</td>
<td>65</td>
<td>140</td>
<td>&lt;65</td>
</tr>
<tr>
<td>% Permeability</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>&lt;25</td>
</tr>
<tr>
<td>Turns</td>
<td>1</td>
<td>1.8</td>
<td>1.1</td>
<td>1.1</td>
<td>2.1</td>
</tr>
</tbody>
</table>

**Assumptions**
- Based on 50% permeability with 50 Oe of bias
- 2500 perm ferrite was used for comparison
- Core loss comparison at 100 kHz and 1 kG BAC