An intro to Liquidmetal
Challenging parts – an example

- Manufacturing metal parts often leads to obstacles
- A common example is precision assemblies that closely fit together
- Devices often go into the body, or machinery, and must be durable and precise
- This typically results in significant secondary operations
What are my traditional options?

Plastic molding → Not durable enough
Metal stamping → For precision – secondary ops
Die cast metal → Alloys lack strength, precision
CNC machining → Costly
Metal Injection Molding (MIM) → Potentially won’t meet dimensional precision reqs.
Results driven – tradeoffs minimized

• Each process leads to tradeoffs, but every engineer knows their optimal outcome
• In our example it is:
  – Corrosion resistant and biocompatible
  – Cosmetic surface
  – Hard surface
  – Precise fit
  – Elasticity
What about amorphous metals?

High volumes of precision parts in a single step.

*Precision, strength and finish* that far exceeds the world’s best metal molding methods.

*Part-to-part consistency* that rivals precision machining.

No other metal can be molded in this way.
Based upon a scientific breakthrough

• Funded by NASA, Caltech-formulated alloys melt into a viscous state similar to plastics, and solidify with the dense, amorphous atomic structure of a glass

• Bulk Metallic Glasses are a new class of materials with unique properties and countless applications

• Liquidmetal® has a comprehensive patent portfolio commercializing the technology
Application characteristics

Where we can help customers:

*If you need three or more of these, then you may have an amorphous metal application*

- Exceptional dimensional control and repeatability
- Excellent corrosion resistance
- Brilliant surface finish
- High Strength
- High hardness, scratch & wear resistance
- High Elastic limit
- Non-magnetic
- Complex shapes that can be molded
Dimensional precision applications

Automotive and Industrial Sensor Housings

Medical Equipment

Surgical Devices
Strength applications

Gearbox Components and Gears
Small high-performance medical devices
Automotive Variable Valve Rocker Arms
Surface finish applications

Consumer Products
Musical Instruments
Auto Interior Parts
Sporting Equipment
How we make parts

Liquidmetal®
Medical Grade

Liquidmetal®
Industrial

MIM
Specialty alloys
## Primary Liquidmetal markets

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<th>Medical</th>
<th>Automotive</th>
<th>Consumer</th>
<th>Industrial</th>
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Application development capabilities

We build successful customer programs:

– Physical property testing
– Corrosion studies
– Surface treatment development
– Solid modeling
– FEA (finite element analysis)
– Development of test samples
– DFM (design for manufacturing)
– CFD (computational fluid dynamics)
– Molding studies
– CNC part feature development
Manufacturing and inspection capabilities

Post molding processes include:
- Insert molding
- CNC machining
- Waterjet cutting
- Bead blasting
- Welding
- Surface treatments
- Laser marking
- Passivation
- PVD
- Part washing/cleaning
- Oxidation/Black Finish

• Inspection, materials testing and analysis: XRD, DSC, MTS, SEM, CMM, optical microscopy, hardness testing, 3D microscope
Back to the example - results

- Using amorphous alloys, the Liquidmetal team manufactures this component:
  - Few-to-zero trade-offs:
    - Hard (53 HRC hardness)
    - Strong (1524 MPa)
    - Surface finish (down to 0.025 Ra µm)
    - Precise (± 0.08% as a % of feature size)
  - High volumes
  - Elastic (1.8%)
  - No post-molding processing
Commercializing amorphous metals

Certified alloys

Certified molds

Certified molding machines

Licensed manufacturers

• Standard material specifications
  - Standardized measures of strength, hardness, resistance to corrosion, elasticity, biocompatibility ...
  - Specific weights of metals
  - Maximum amounts for specific impurities
  - Form factor
  - Batch control with alloy chemistry

• Molding processes
  - Melt temperatures
  - Vacuum levels
  - Injection pressure profiles
  - Mold temperatures
  - Cooling times and temperatures
  - Control over foreign materials
  - Lot control with molding parameters
Liquidmetal trains customers to be experts

- Growing the adoption of a new technology requires education and transparency
Strategic partnerships and licensees

**Partners**
- DongGuan EONTech Co., Ltd
- ENGEL AUSTRIA GmbH
- Materion Corporation

**Licensees**
- Apple Inc.
- SAGA Plastic
- The Swatch Group
Business strategy

• Accelerate adoption of amorphous metal technology
  – Field parts - *Engage a large, addressable market*
  – Global sales and marketing focus with medical and automotive markets
  – Strategic licensing

• Expand production
  – New 41,000 sf facility
  – Medical grade, industrial grade alloys, and MIM
  – Lower costs with a focus on quality

• Integrate strategic operations between US and China
  – Alloy production, mold fabrication, and machine development
  – Quality management
  – Engineering, research and development
The New Liquidmetal

Volume production. Lower cost. Global R&D.

• Global footprint: production capabilities in California and Dongguan, and extensive sales coverage throughout North America and the European Union

• Offering medical and industrial grades of amorphous metal and MIM solutions

• Joint research and development leveraging the best science available from the US and China

• Expanded 41,000 sf facility supporting volume production
Now you can™

liquidmetal.com