SOLIDICA

- "Direct metal" manufacturing company – we produce machines to allow customers to "print" metal parts
- Solidica has developed a breakthrough enabling technology
  - Patent pending
  - User friendly (safe, low power, etc.)
- Many high growth applications
  - Direct manufacturing, optical cable management, MEMs, advanced materials

Significant Milestones

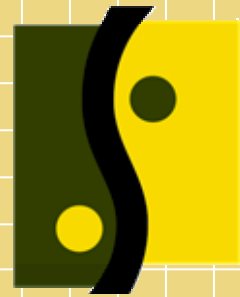
- Major milestones
  - Q1 00 company formed
  - Q2 00 concept feasibility demonstrated
  - Q3 00 alpha machine complete
  - Q4 00 first customer commitment
  - Q1 01 4 betas sold
  - Q3 01 1st beta ships

Additive Manufacturing Technology

- Industry Status: work on metal largely based on existing processes for other materials
  - Exceptions – LENS type processes which were designed for metal
- Current model: rapid prototyping in metal requires the use of liquid metal (SLS, LENS, Soligen, infiltration based systems, etc.) or very high temperature and pressure (HIPing)
- **Solidica:** involved in developing RP/RT/RM based on solid state consolidation technologies.
  - Ultrasonic object consolidation (UOC) is the first technology Solidica will apply in a machine.

Solid State Approaches to Additive Manufacturing

- Vapor deposition processes are usually slow and complex
  - Chemistry control, vacuum chambers
- Solid state
  - Numerous techniques in use in the P/M and welding industries
- Selected a method based on ultrasonic joining



What is Ultrasonic Object Consolidation ?

- Ultrasonic energy is used to create a solid state bond between two pieces of metal
  - e.g., aluminum, copper, brass, nickel, titanium, etc.

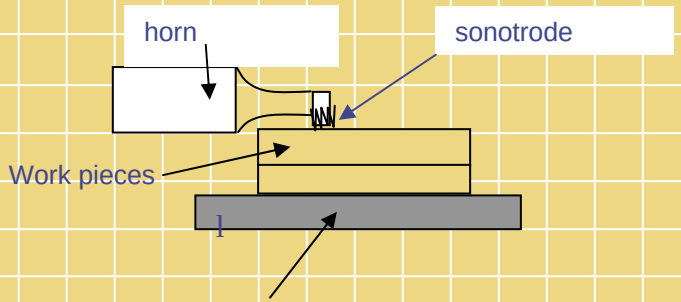


Figure 1a. Basic ultrasonic joining arrangement

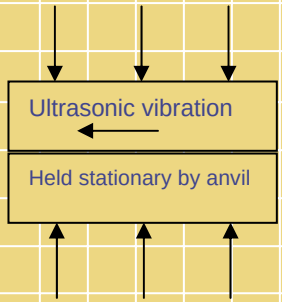


Figure 1b. Interfacial vibration of workpieces cause by ultrasonic excitation

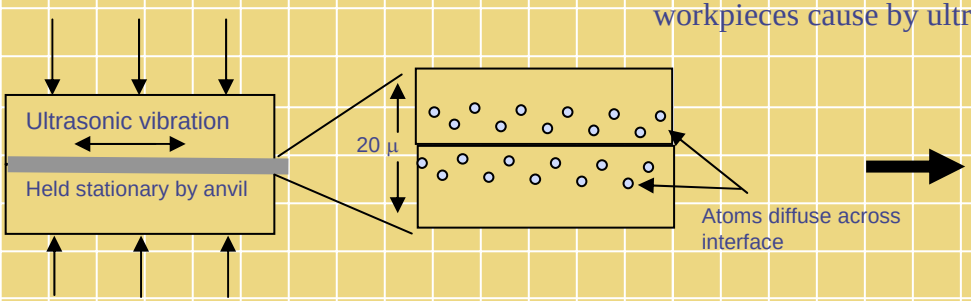
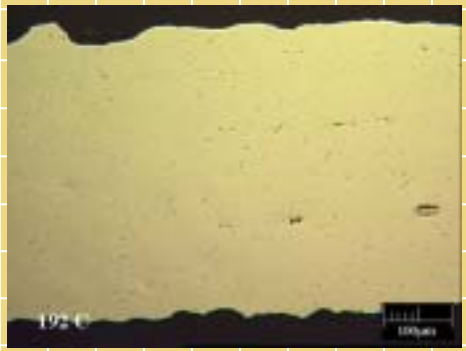


Figure 1c. Friction at interface breaks up oxides

Figure 1d. Diffusion occurs across atomically clean interface

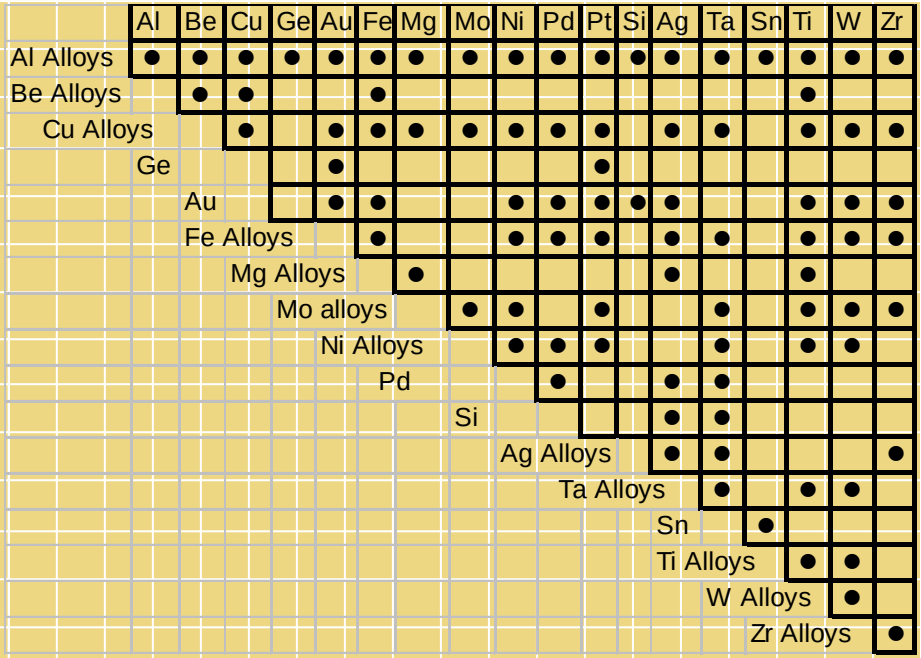


True metallurgical bond forms in solid state

Ultrasonic Object Consolidation

- A wide range of metals can be joined
- Although process can be used on thicker sections, it is ideally suited for thin sections and foils
- widely used in electronics industry; trillions of joints produced annually
- simple, robust process with few variables
  - lack of liquid-solid transformation makes process easy to control

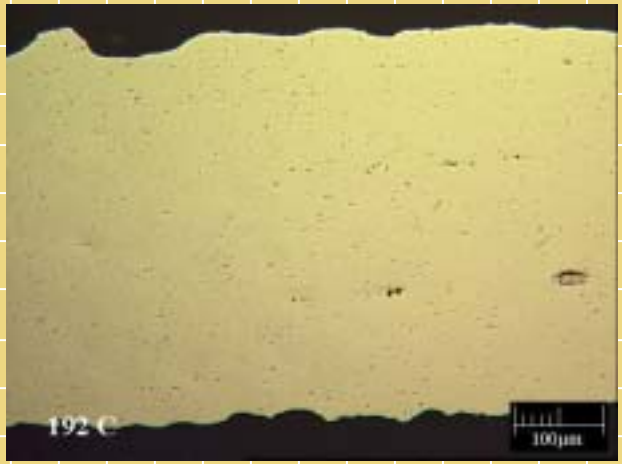
- Example material combinations for UOC



Solidica will introduce aluminum as its first UOC material

Advantages

- Solid state “direct metal” technology
  - Eliminates environmental and user hazards
  - Suitable for light laboratory setting
  - Opportunities for better accuracy
- Flexible, useful in a wide range of applications
  - Tooling
  - Direct manufacturing
  - Range of materials



Multilayer aluminum specimen

Fifteen layers of 0.001” Ti foil

Product

- Turn key rapid prototyping system incorporating UC process

Development Plan

- Two thrusts: product line extensions and new high growth products

- RP Product Line Extensions
  - Materials
    - Steels
  - Machine tool accessories and retrofits
  - Custom systems for manufacturing applications

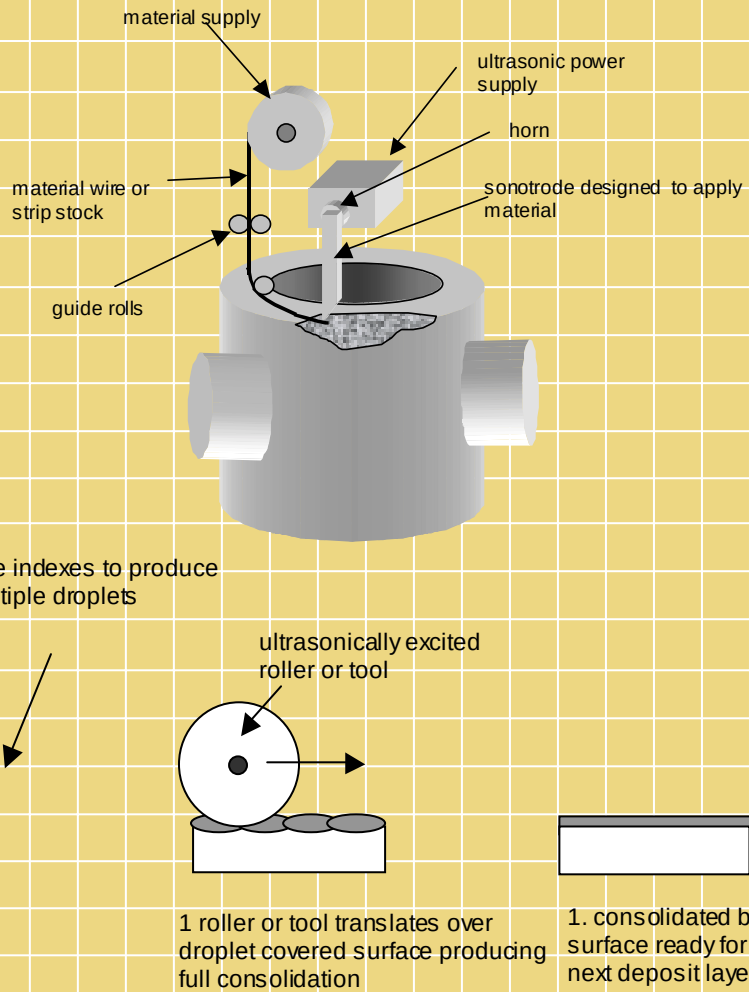
- Small diameter feedstock version
  - Concept feasibility studies 02 (NASA SBIR)
  - Beta design/test 03
  - Launch product 04

Maintenance and Repair Related Applications of UOC

- Repair
  - Use UOC to add material to worn areas
- Update designs
  - Modify existing parts or tooling via material addition
- Tooling for low volume production
  - Replace aging parts
- Health monitoring
  - Embedded optical fibers
- Increase durability
  - Surface modification and cladding

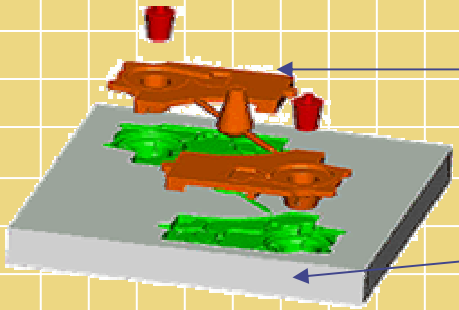
Repair and Component Update

- Add material to selected locations
  - Repair worn locations
  - Change part geometry to updated design intent
- Alter tooling
  - Plastic injection molding
  - other
- Multiple build materials
  - Enhance performanc of existing components with new surface compositions



Low Volume Tooling

Current



1. Prepare CAD file of tool
2. Write CNC Machining Program
   1. Rough cut
   2. Finish cut
3. Write programs for EDM electrodes
4. Program EDM machine

1. Do CNC milling
   1. Rough cut
   2. Finish cut
   3. Machine electrodes

Do EDMing

Low Volume Tooling

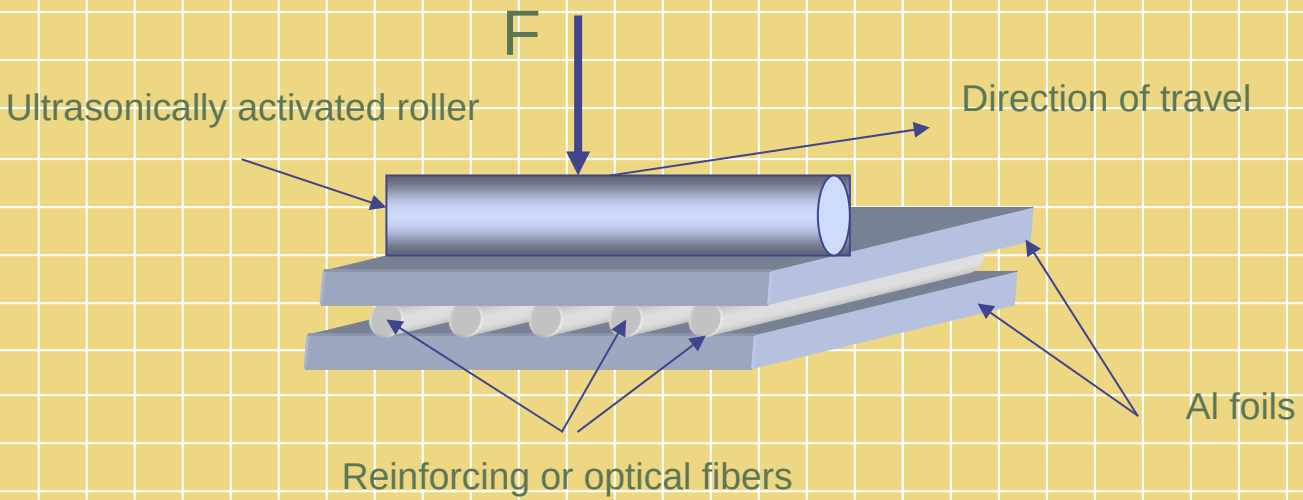
Solidica

1. Prepare CAD file of tool
2. Use RPCAM to prepare machine program

Build finished tool on Solidica Form-Ation

Metal Matrix Composites and Smart Materials via UOC

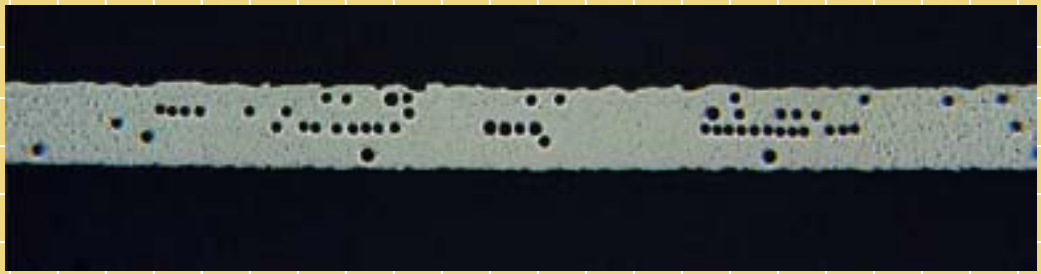
- Solid state, high speed, low cost approach



- Net shape fabrication technology allows a wide range of geometries, and eliminates most joining

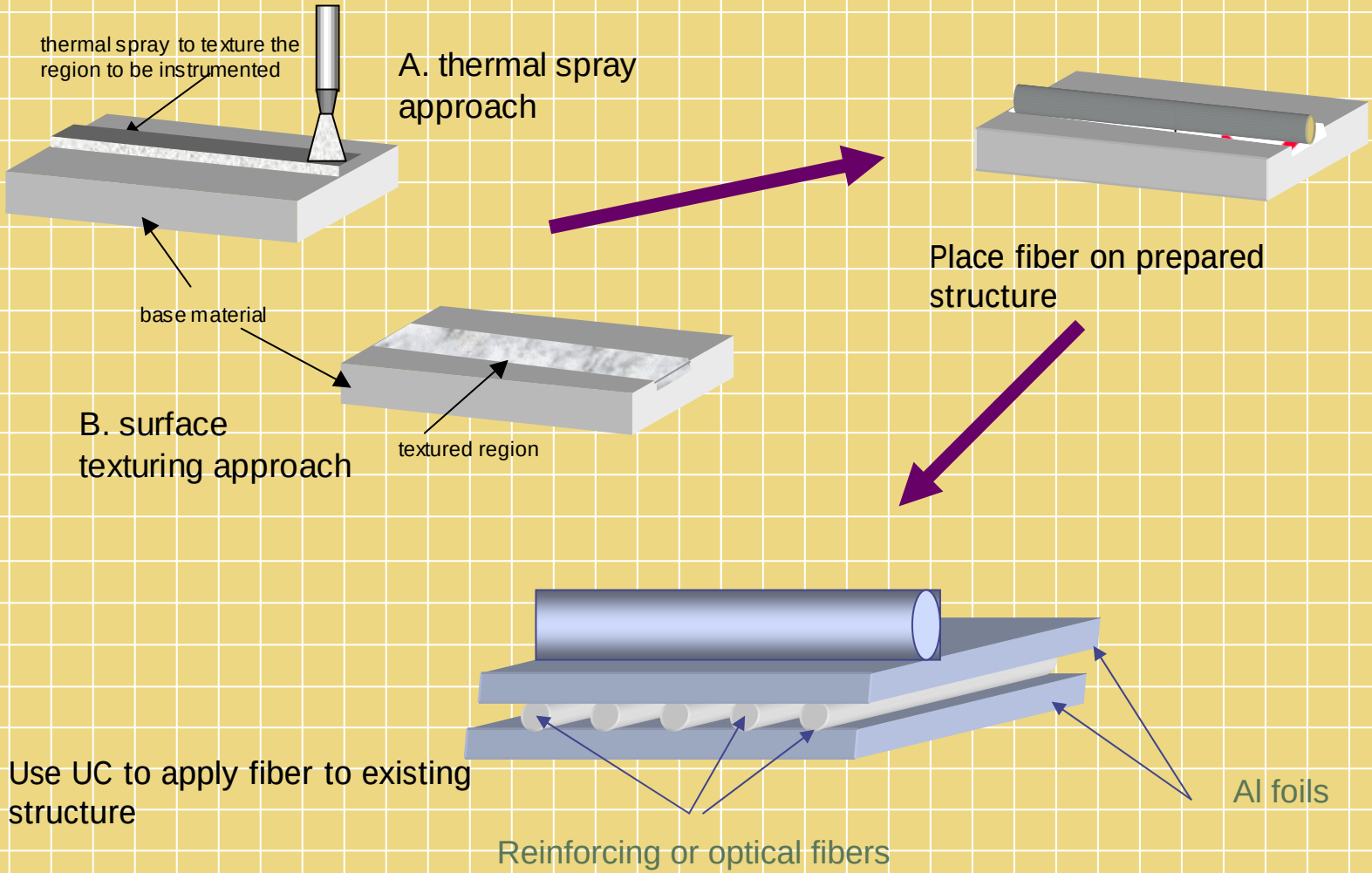
Embedded Fibers

- Metal matrix composites and smart materials
  - Structural fibers
  - Optical fibers
  - Shape memory fibers
- With automated fiber placement, very high speed and low cost is possible



Optical fibers embedded in Al

Applying optical fibers to existing structures for health monitoring



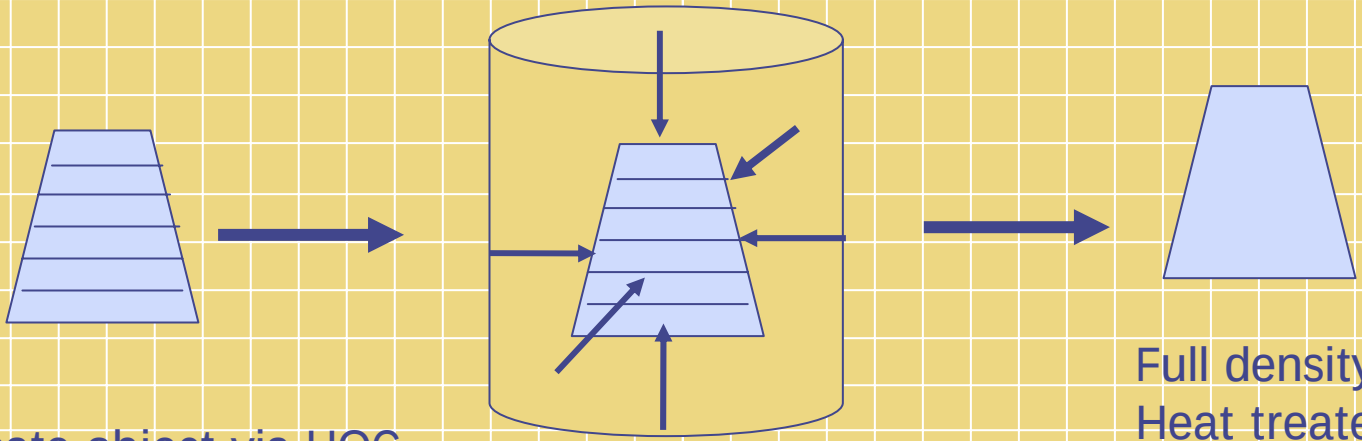
Improve Performance of Existing Systems

- Surface/component upgrades
  - Ballistic applications
    - Layered structure provides energy absorption
    - With or without embedded fibers
  - Structural MMCs
    - Upgrade selected components
    - Apply to surface of aging components to provide stiffer structure
  - Active Structures
    - Shape memory alloys, piezo ceramics, etc. to control surface behavior

Optical fibers embedded in Aluminum via UOC

Charpy specimen made with UOC

Secondary Processing Opportunities



- Analogous to HIPing of turbine engine blades after investment casting to attain desired properties

Summary

- UC technology being commercialized for RT/RP applications
  - Many maintenance and update applications for technology
- Next generation system design will address some of these
- Embedded fiber, dissimilar metals applications also have potential