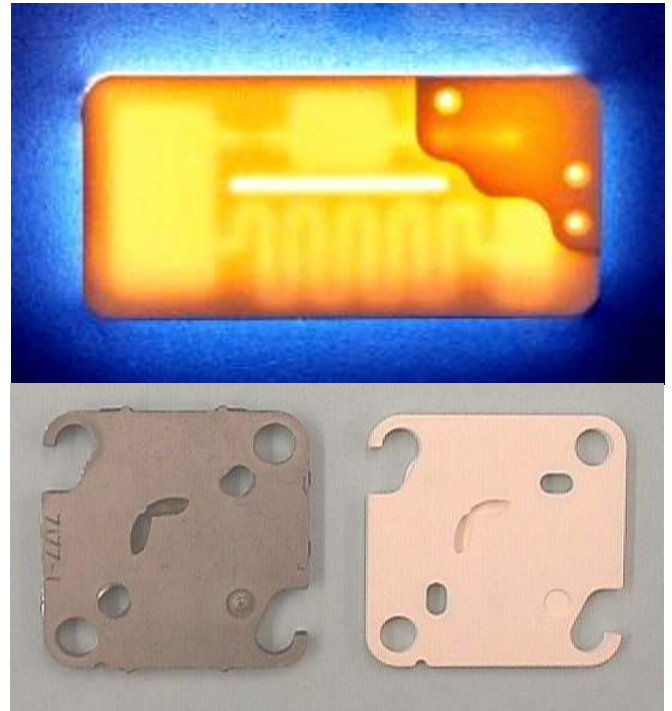


## Strength in Miniature

Imagine transforming a complex fluid-handling instrument into the size of a cell-phone. Microfluidic devices can simplify and miniaturize fluid handling systems to help make them more affordable and transportable well outside the confines of a lab.

While plastic, glass, and silicon are used to make certain microfluidic devices, only ceramic and metal can provide the performance required for the most demanding applications. Whether you need high temperature, high pressure, chemical resistance, or durability, CAM-LEM can provide custom integrated packages that stand up to your requirements.

Our unique Inteform processes create ceramic and metal components that can internally convey liquids or gases without requiring seals or assembly. In our automated CL-100 system sheet materials are cut and laminated layer by layer. The parts are then processed into final form. With features from 50 microns to over 150 mm, our parts can handle everything from tiny drops to high-flow continuous operation.



Parts made by CAM-LEM using its Inteform Thinsheet process on the CL-100 machine

## Applications

- Gas or liquid handling components
- Sensors, analyzers, miniature diagnostic devices
- Micro chemical systems, "lab-on-a-chip"
- Packaging for or alternative to MEMS devices
- Microreactors, heat exchangers
- Fuel cells, hydrocarbon fuel reformers



CAM-LEM's automated CL-100 system for manufacturing your ceramic microfluidic components

## Benefits

For equipment manufacturers

- Integrate parts to cut assembly & connections
- Add functionality and improve performance
- Reduce overall system size
- Use for over 70 MPa or 1300°C (10kpsi, 2400°F)

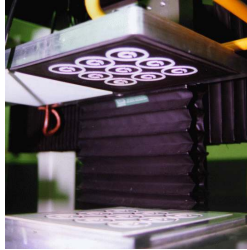
For microfluidic system developers

- Develop high-performance applications
- Evaluate new designs without costly tooling
- Directly metallize ceramic and attach electronics.
- Handle a wide range of volumes and flows

## Process

Building objects layer-by-layer makes it easy to quickly create even challenging designs by breaking down the geometry into simple and reliable unit operations.

In our Inteform Thinsheet process sheets of ceramic tape are laser-cut in an outline matching the computer model of the desired part at the current elevation. Desired sections of material are extracted from the sheet (example at right) then stacked and bonded to prior layers on a separate platform. Once all layers have been added a thermal process removes the plastic binders and other organic materials, then sinters the remaining ceramic particles at high temperature to fuse it into a solid component.



Gripper holding sections of nine parts just after pickup

## Materials

The tape-cast sheet feedstock contains ceramic powder and polymer binder. Any sinterable ceramic or metal powder is a candidate for use in our processes. Feedstock and other development costs may be required for custom materials.

### STANDARD CERAMICS

Alumina\* (92%, 96%, 99%)  
Zirconia

### CERAMIC LAYER THICKNESS

Standard:  
0.2 to 0.6 mm (0.006 to 0.024 inches)  
Custom:  
0.03 to 1.3 mm (0.001 to 0.050 inches)

### STANDARD METALS\*

316L stainless steel

### METAL LAYER THICKNESS\*

1.0 to 18.0 mm

\* Metal parts are created using the related Inteform Powdershape process. Please contact CAM-LEM for detailed specifications.

CAM-LEM, Inc.  
1768 E. 25<sup>th</sup> St.  
Cleveland, OH 44114

Tel: 216-391-7750  
Fax: 216-579-9225  
sales@camlem.com

www.camlem.com

## Specifications

General capabilities of parts we can fabricate using our Inteform Thinsheet manufacturing process.

### PART SIZE

Standard: 150 mm (6 inch) cube or less  
Possible: 350 mm (14 inches) or more

### FEATURE SIZE

X-Y Freestanding feature	2.5 mm (0.1 inch) dia.
Minimum wall thickness	1.0 mm (0.04 inch)
Minimum inside radius	0.1 mm (0.004 inch)
Minimum hole/slot	0.1 mm (0.004 inch)

Z Minimum vertical feature	layer thickness (unless machined)
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### ACCURACY

General tolerance	$\pm 0.5\%$ (in X-Y) layer thickness (in Z)
Special tolerance	Possible through green/finish machining

### CUTTING SPEED

Ceramic Tape	
0.38 mm (0.015") layers	15 mm/sec or more
0.17 mm (0.007") layers	25 mm/sec or more
Other materials	5 - 80 mm/sec

### PROCESS SPEED

Typical jobs take 1 to 3 minutes per layer, per part  
Setup time varies based on material, size, and other factors

### MATERIAL PROCESSING (for standard materials)

Drying solvent-laminated parts	Overnight
Sintering smaller parts	Overnight
Sintering larger parts	2-3 days

### METALLIZATION

Add conductive circuit traces on alumina ceramic  
Glass-sealed ceramic packages

### CAD COMPATIBILITY

Uses the widely used STL and DXF file formats  
STL is for 3D models, DXF for layered designs  
IGES, Pro/E, and other files are also accepted

All specifications represent typical values, and cannot be guaranteed for all materials and designs.