Electromagnetically Actuated Gas Diverting Valve Using LTCC Tape

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Low Temperature Co-Fired Ceramics (LTCC)

- What is it?
- Why LTCC?
  - 3-D Structures
  - Compatible w/Thick Film Technology
  - Temp Stability
  - Structurally Sound
  - Self-Packaged
  - Cheap (compared to Si)
Gas Flow Diverter (Overview)

- What Does it Do?
- How Does it Work?
  - Push/Pull System
  - Electromagnetic Actuation
    - Permanent Magnets
    - Spiral Alternately N/S
    - Magnetic Force
      - opens/closes pathways
  - 800 micron pathway
Gas Flow Diverter (Methodology)

- Design
- Photolithography
  - DuPont Riston®
- Perm. Magnets
- Some Calcs:
  Resistance: 108.78Ω
  For 10mA ≤ I ≤ 30mA
  1.09 V ≤ V ≤ 3.26V
DuPont Riston®

- Dry Photoresist
  - Laminate onto Semi-Fired tape
    - Facilitates Etching
    - Mechanical Support
  - Expose to UV light
  - Develop
    - Line size is half of desired
  - Etch with BHF
  - Strip (Acetone)
- Riston® 9015

* Schematics Courtesy of Patricio Espinoza
Developing Results

- Perfect Develop for 9015
- Varied:
  - Exposure Energy
  - Hold Time
  - Spray Pressure
  - Type of Riston
Bonding Results

- Bonding Layers Together

Glass

Nothing
Etching Failure – Why?

- Not Etched Completely through 125 micron thick tape
- Material Blocking BHF Access to Bottom
SEM Pictures

- Backscattered Electron Imaging – Sensitive to Atomic # ⇒ White in Pictures is Glass. Also faces on dark portions ⇒ Crystalline Structure

Not Etched

Etched
Energy Dispersive X-ray Analysis (EDX)

- Analyzes what elements are present

Not Etched

Etched
SEM and EDX Analysis Results

- Glass still present after etching
- Si completely removed $\Rightarrow$ SiO$_2$ completely etched by BHF
- Other glasses remain (i.e. PbO, Al$_2$O$_3$)
- Need another etchant to remove these glasses
  - Phosphoric Acid (H$_3$PO$_4$)
- Result: Pure H$_3$PO$_4$ cleaned extra material out, but Riston® did not hold
What’s Next?

- Combination BHF, $\text{H}_3\text{PO}_4$  
  - Etch and Clean at same time
- Different Etchant than $\text{H}_3\text{PO}_4$? (HCl, Nitric)
- Higher Temp Etch. 90 degrees C?
- The Very Long Run  
  - Manifold for Fluid Injection Analysis
  - Want to make Inexpensive and Portable Water Analysis Device