Inkjet Printing: A Breakthrough Technology for High Definition 3D Ceramic Printed Electronics

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Outline

- Ceradrop knowhow

- Description of inkjet printing process / challenges

- How to overcome 3D PE challenges

  - Ink formulation specifications

  - Advanced software to solve printing issues

- Examples of 3D PE applications
MGI Group structure

The MGI Group

MGI
Digital Graphic Technology

EP and Inkjet Equipment Development
Finishing Technology
Ink and Software Development

CERADROP

Inkjet Equipment Development
Ink and Software Development
Printed Electronics Industry

KORA-PACKMAT

Feeding Technology
Substrate Transport

Industrial Mechanics Industry
InkJet Printing: principle and interests

PROCESS description
Inkjet for 3D PE is a breakthrough technology but specific and difficult topic

New CAM/CAD software

- New ink / printhead interaction
- Complex ink / substrate interaction
- Innovative drying and curing technologies
- Components coming from different software
- Dynamic accuracy and repeatability
- High level of reliability

Material adaptation

Inkjet 3D PE by adaptation of graphical state of art is a dream

Hardware
From functional materials to ink formulation optimization

- Inorganic material
  - Dispersion
  - Co-dispersion
  - Optimized slurry but non adapted for inkjet printing
  - Formulation
  - Adapting ink for chemical properties for inkjet printing
  - Ejection tests
  - Adapting ink for inkjet printing
  - Printing Trials
  - Adapted ink for the application requirements

Ceramics

<table>
<thead>
<tr>
<th>Dielectric</th>
<th>Insulative</th>
<th>Magnetic</th>
<th>Piezoelectric</th>
</tr>
</thead>
<tbody>
<tr>
<td>BaTiO₃</td>
<td>SiO₂ colloid/solgel</td>
<td>Ferrite</td>
<td>PZT</td>
</tr>
<tr>
<td>LTCC</td>
<td>TiO₂</td>
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<tr>
<td></td>
<td>Al₂O₃</td>
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</tbody>
</table>

Metals

- Aqueous / UV

**Notes:**
- Dielectric: BaTiO₃
- Insulative: SiO₂ colloid/solgel
- Magnetic: Ferrite
- Piezoelectric: PZT

**Materials:**
- Ceramic additives (inorganic binding, shrinkage matching)
- Dielectric: BaTiO₃, SiO₂
- Insulative: SiO₂ colloid/solgel
- Magnetic: Ferrite
- Piezoelectric: PZT

**Properties:**
- Electric driving setting
- Drop volume deviation
- Drop velocity
- Open time
- Spreading
- Capillarity behavior
- Layer stacking
- Layer drying

**Other:**
- Binders, plasticizers, surfactants, drying controllers.
3D Process workflow with dedicated software

- **Dxf, Step, Gerber**
- **Modeling tools**

**CAD files**

**Printing lattice**

**Printing Parameters**

- **Printhead**
- **Material**
- **Resolution**
- **Layer thickness**
- **Printing strategies**

**CeraPrinter**

- **Printing script**
  - **Vectors**
  - **Nozzles control**
  - **Drying control**
  - **Quality control**

### Printing lattice examples:

- Square
- Centered Square
- Centered SHIFT Hexagon
- Rectangle
- Centered Rectangle
- Centered FAB Hexagon

### Fab printing and variation:

- **Diamond**
- **Square and Rectangular lattice**
- **NpFab = 1**
- **NpShift = 0**
- **Pass order: Green Red**

### Shift printing and variation:

- **Trapezium**
- **Hexagon lattice**
- **NpFab = 1**
- **NpShift = 1**
- **Pass order: Green Red Blue Purple**

- **Square**
Piezoelectric 3D micropillars for medical probes

One material: PZT ink

40 µm pillar width

3D structures → Multilayers up to 800 µm height

3D high aspect ratio → TiO₂: photocatalytic activity

* PZT micropillars array

* JECS 29 (2009) 905–911

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3D components for **medical implant applications**

One material: **Alumina ink**

3D → Additional **IR in situ drying**

**Hole achievement**

Easy change of the design
3D Multilayer Ceramic Capacitors (MLCC)

Two materials: Ag and BaTiO$_3$ inks

1 in 3: tape casting, screen-printing and laminating
Better margins accuracy: 120 µm
Interleaving layers → high density

* JMEP 2012, 9 187-198
Complex MLCC manufacturing →
Three materials: Ag, SiO$_2$, Ferrite inks

Conductive, insulator and magnetic materials are printed together, layer by layer

3D → Additional IR in situ drying
Replace manual standard process
Thank you very much for your attention

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