

# Additive Fertigungsverfahren für hybride keramische Elektronikkomponenten

80. Treffen SAET, Fraunhofer IKTS, Dresden

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# Outline

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1. Group “Microsystems, LTCC and HTCC”
2. Material Base
3. Multilayer Ceramic Manufacturing
4. Maskless Multi-Material 3D-Printing



# 1. Group Microsystems, LTCC and HTCC

Head of department, heads of research groups



**Dr.-Ing.  
Uwe Partsch**  
Hybrid Microsystems



**Dr. rer. nat.  
Arno L. Görne**  
Functional Materials  
for Hybrid Microsystems



**Dr.-Ing.  
Stefan Körner**  
Thick-Film Technology  
and Functional Printing



**Dipl.-Chem.  
Beate Capraro**  
Ceramic Tapes



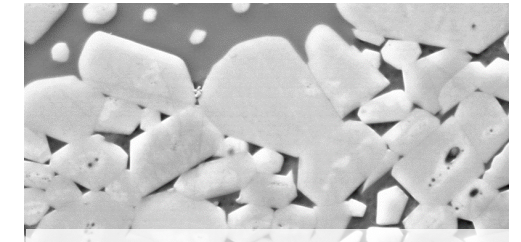
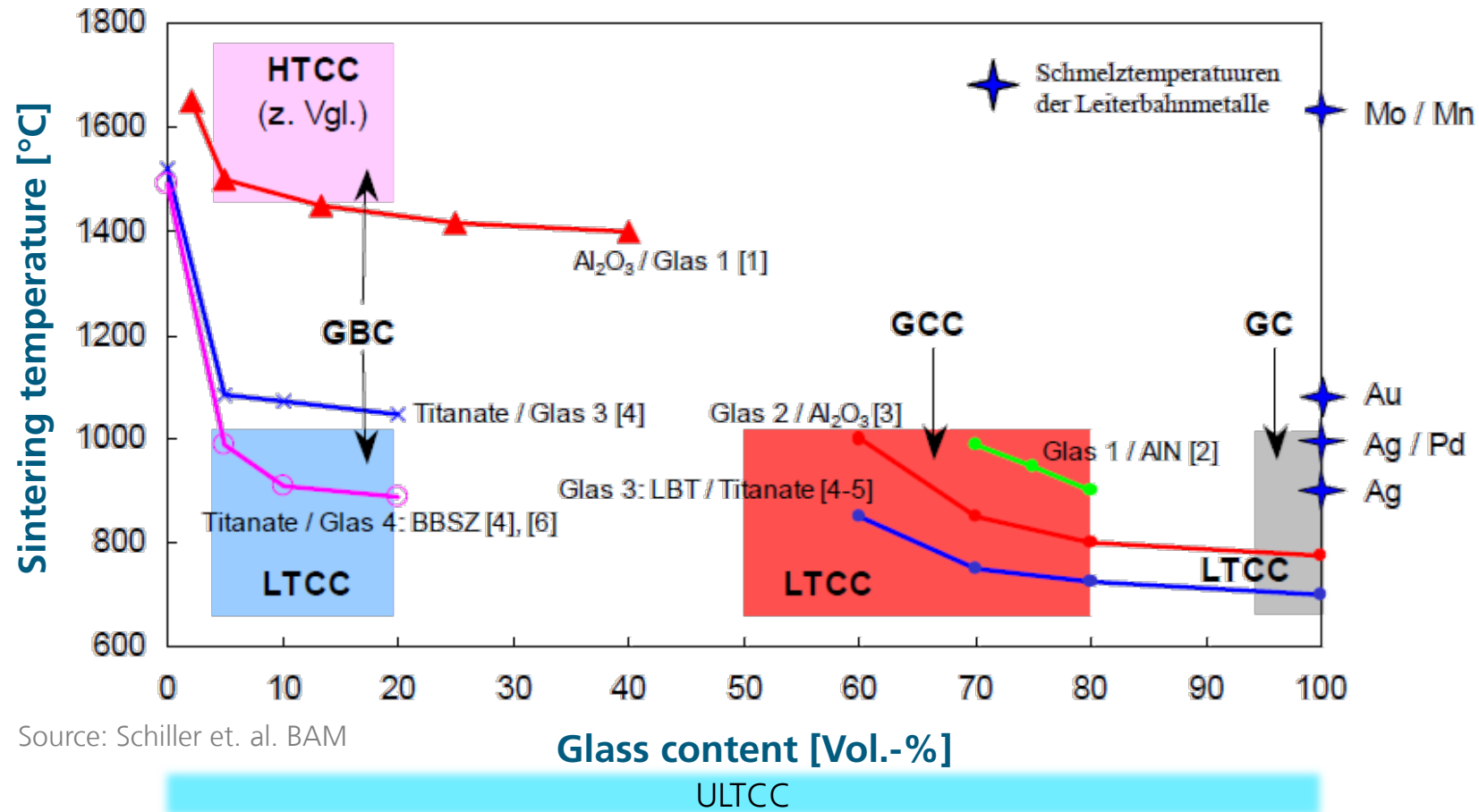
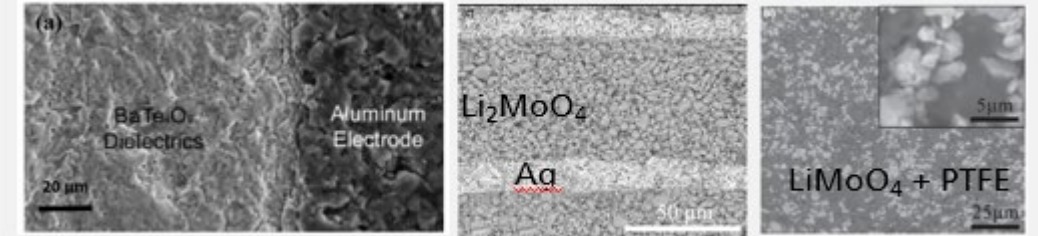
**Dr.-Ing.  
Steffen Ziesche**  
Microsystems,  
LTCC and HTCC



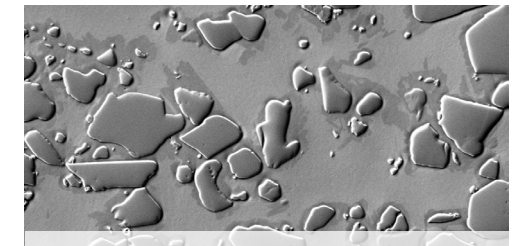
**Dr.-Ing.  
Lars Rebenklau**  
Systems Integration and  
Electronic Packaging

## 2. Material Base

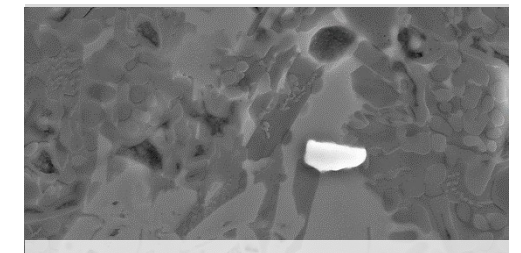
### Composition and sintering temperature



ESL 44009, 10k-fach



GT 951, 5k-fach



Ferro A6M, 10k-fach

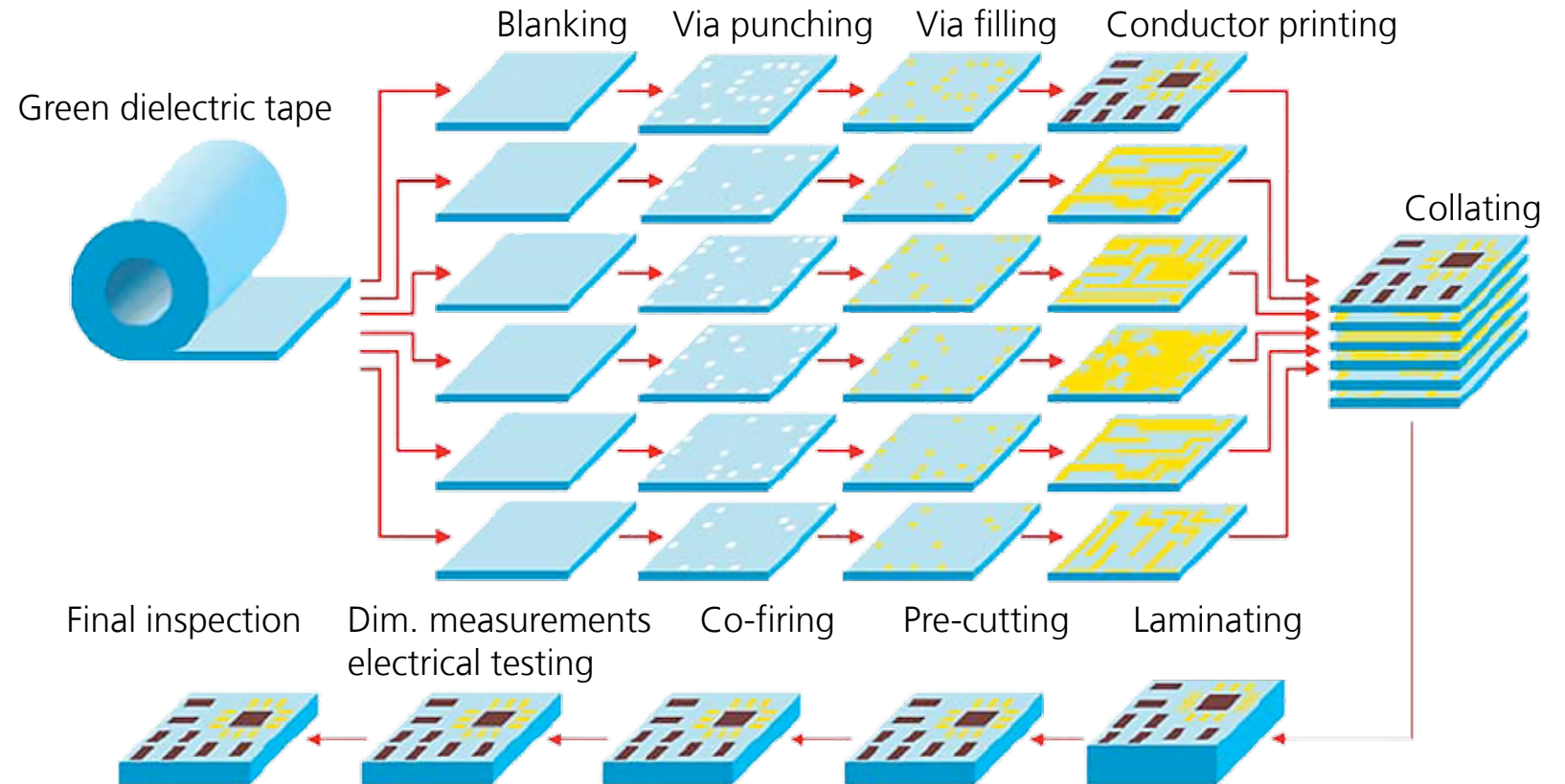


# 3. Multilayer Ceramic Manufacturing

## Manufacturing Technology

### Manufacturing process

- IKTS tapes/commercially available tapes
- Au, Ag and Cu, Pt, W + alloy pastes
- Processing of sheet sizes up to 200 x 200 mm
- Sheet thicknesses > 40 µm
- Via hole diameters > (50), 100 µm
- Conductor lines width > 30 µm
- Layer count > 40

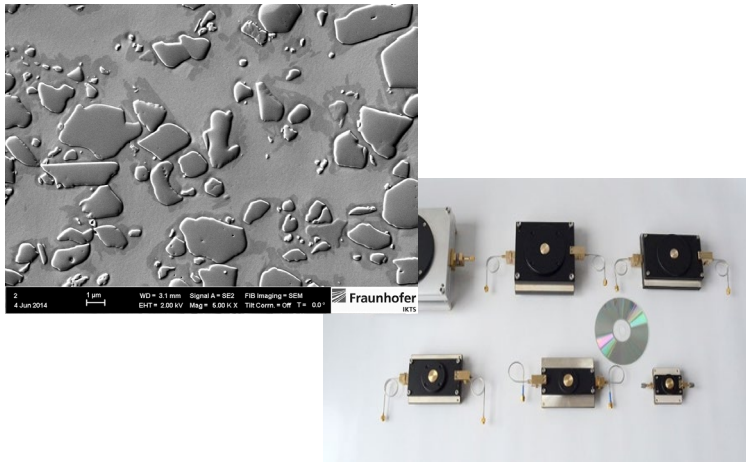


Source: DT Microcircuit

# 3. Multilayer Ceramic Manufacturing

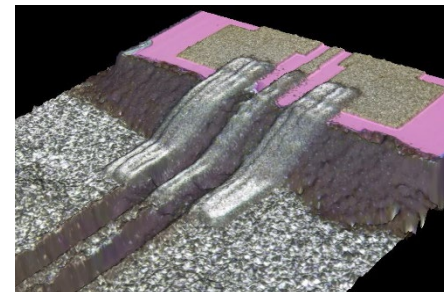
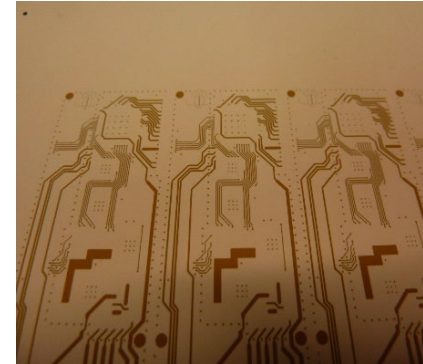
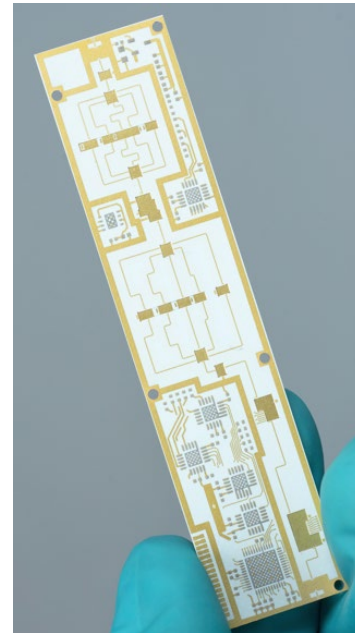
## High Frequency Components

### Dielectric Material Base

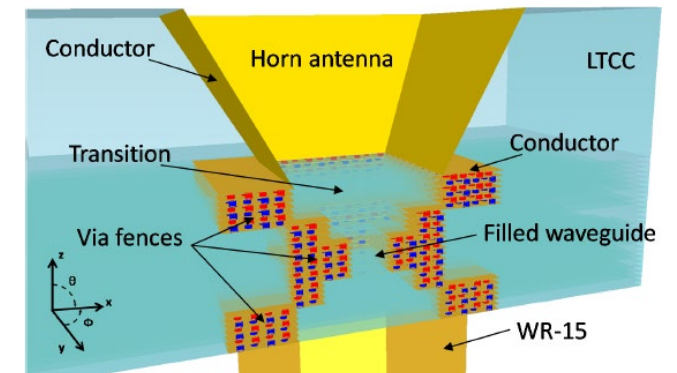
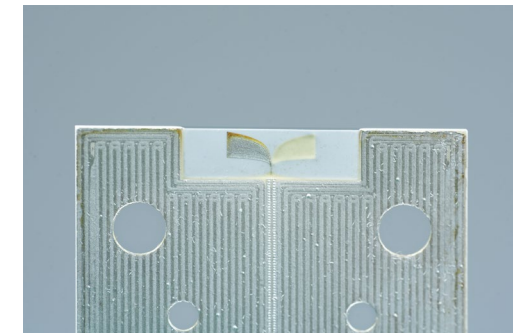


Parameter	Low loss ceramic
$\epsilon_r$	5.75 (@145 GHz)
$\tan \delta$	0,0023 (@145 GHz)
TCE [ppm/K]	7
$\lambda$ [W/mK]	2 - 10

### HF Multilayer Circuit Boards



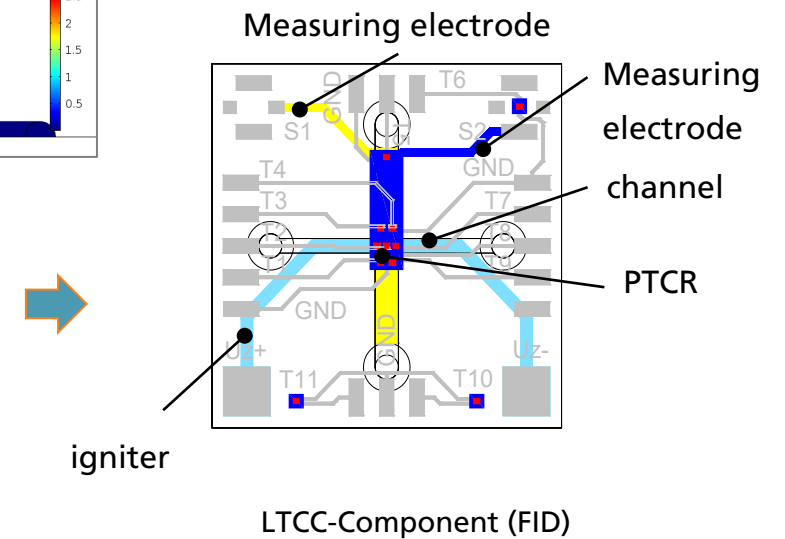
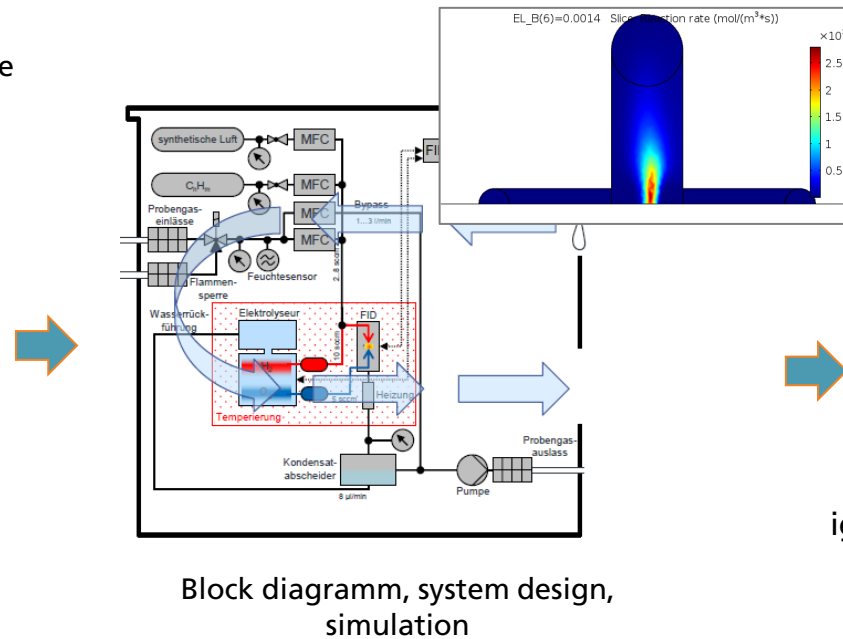
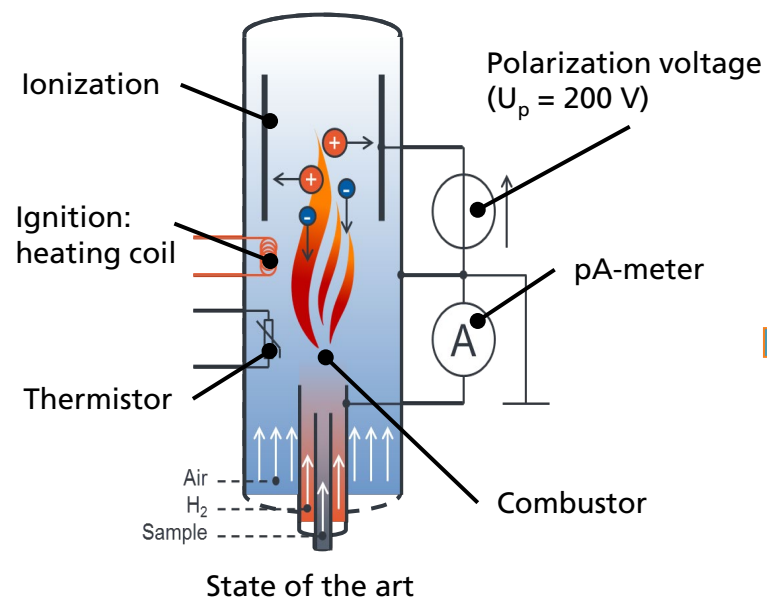
### Antennas



# 3. Multilayer Ceramic Manufacturing

## Sensor solutions

- 2,5D component with embedded circuitry, channels and chambers
- Miniaturised FID (cost-effective, inline-capable, reliable detection)
  - $\mu$ -reaction chamber ( $H_2$ -flame  $\rightarrow$  plasma ( $T > 1000^\circ C$ , measurement of ionization current)
  - Channel system for gas transport, Measuring-/ Ignition electrodes

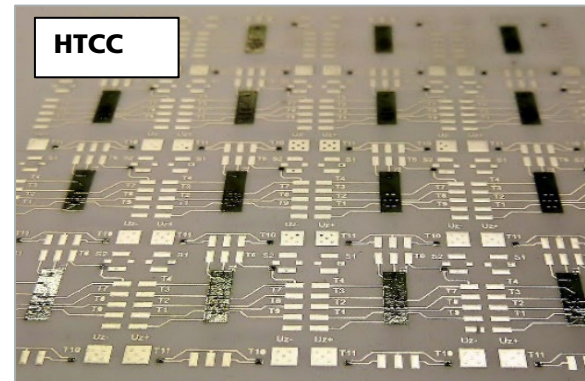
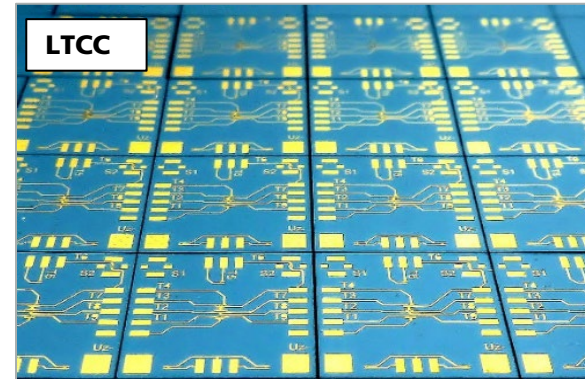
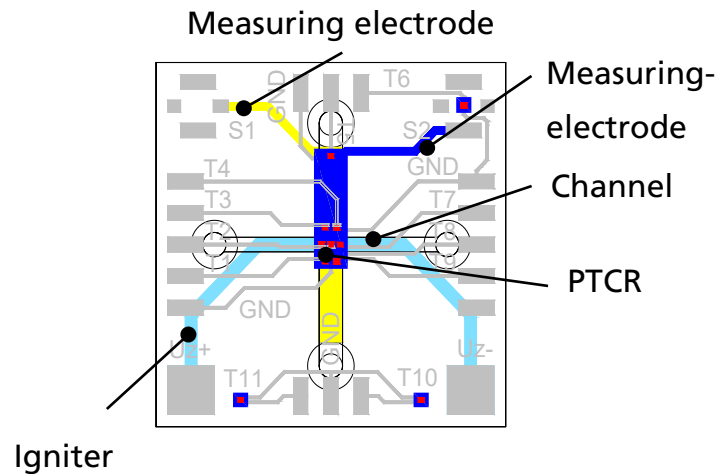


# 3. Multilayer Ceramic Manufacturing

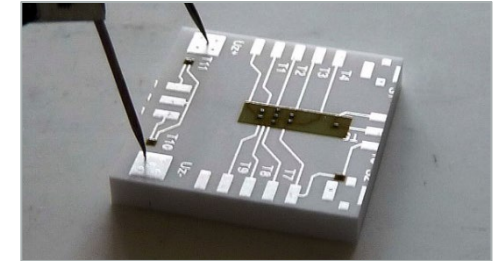
## Sensor solutions

### FID-Development

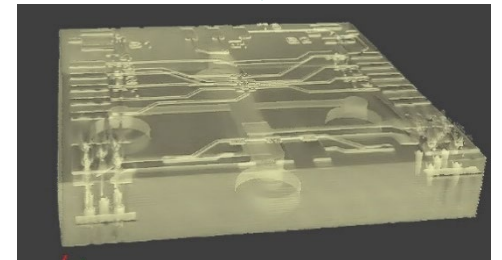
- Material characterization ( $T_g$ ,  $U_D$ ...)
- Component design (incl. CFD-Simulation)
  - Channel design, Ignitor, Media ports
- Component Manufacturing, Characterization and Test



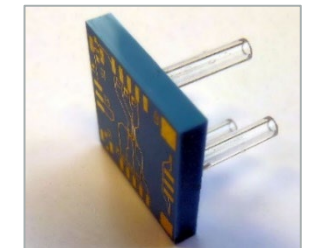
Multiple panel manufacturing  
4" x 4"



Tests Ignition- electrodes



Geometrical characterization (CT)

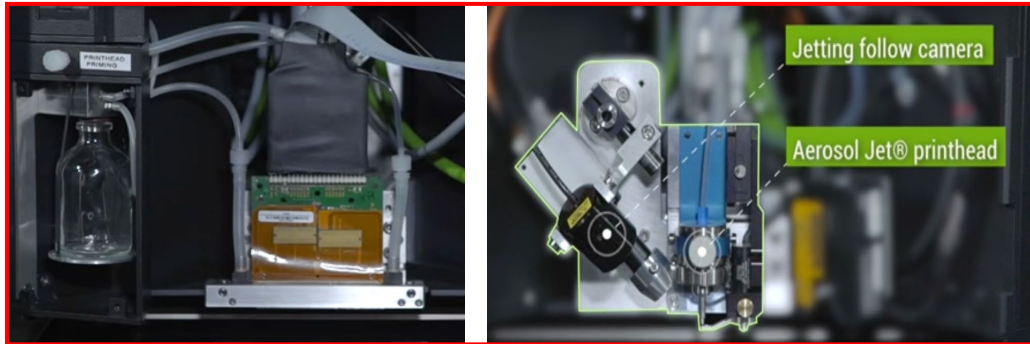


Functional test



## 4. Maskless Multi-Material 3D-printing

Hybrid Inkjet-/Aerosoljet Technology with integrated curing/sintering

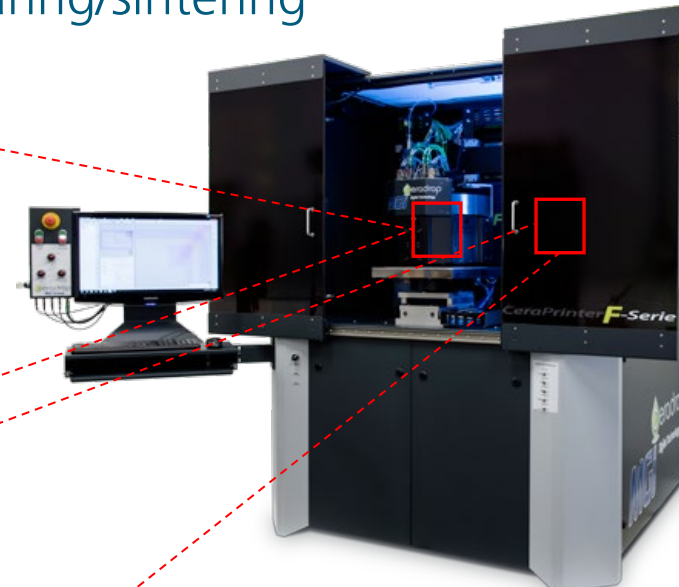


- From Cartridge to industrial printheads

- Aerosol Jet Head



- In-line characterization
- Integrated Curing/Sintering Module



Ceradrop F-Serie

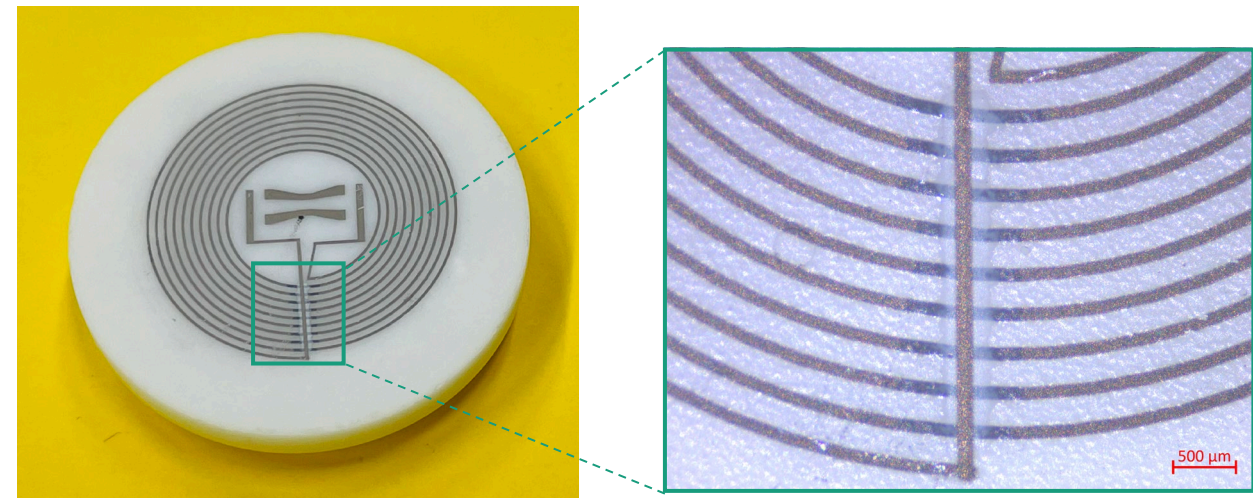
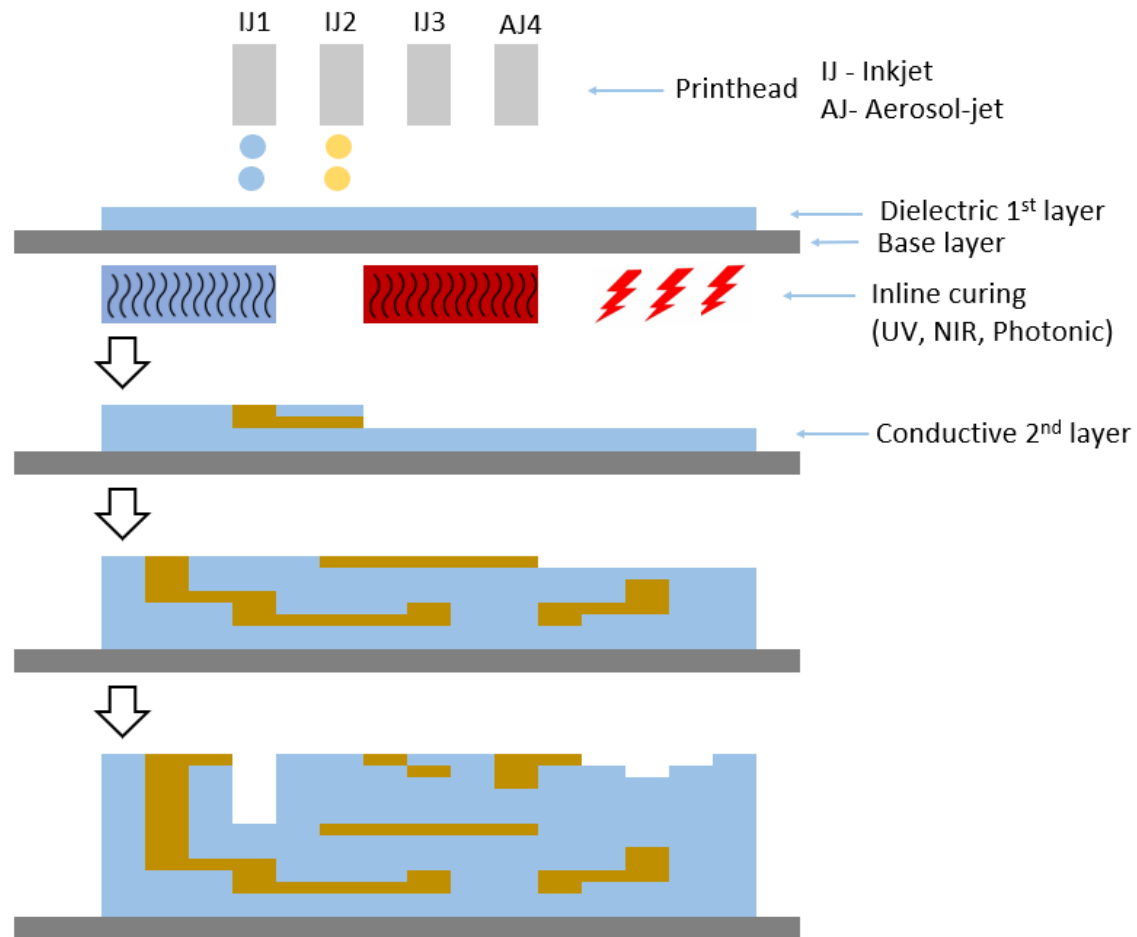
### Ceramic Interposer Technology

- Hybrid materials deposition technology (3 x Inkjet and 1 x Aerosol Jet Head)
- Fully digital, layer-wise print of up to 4 materials possible
- In-line multi-curing/sintering technologies integrated (NIR, UV, Photonic Sintering)
- In-line characterization device (Laser reflectometer)
- Suitable with a wide range of inks and pastes

Source (Pictures): Ceradrop

## 4. Maskless Multi-Material 3D-printing

### Multilayer printing of hybrid Components

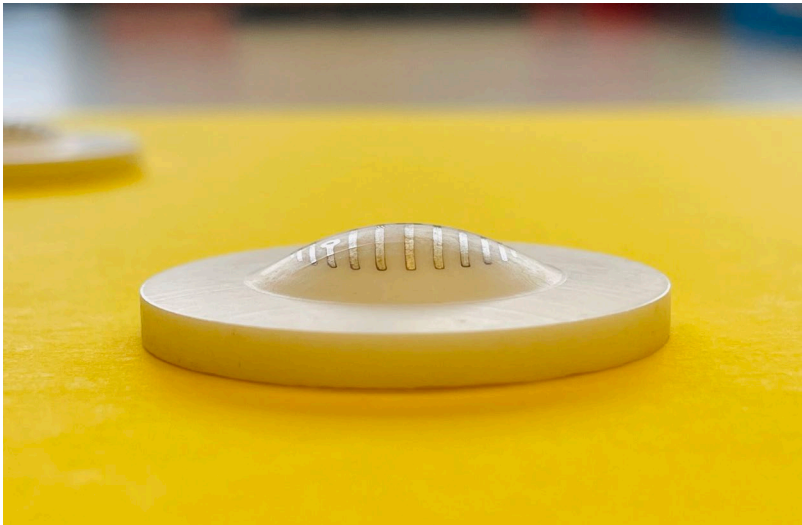


Design layout: J.A.M.E.S

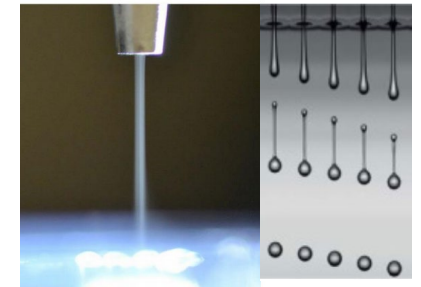
## 4. Maskless Multi-Material 3D-printing

Functionalized layer printing on 3D printed surfaces and cavities

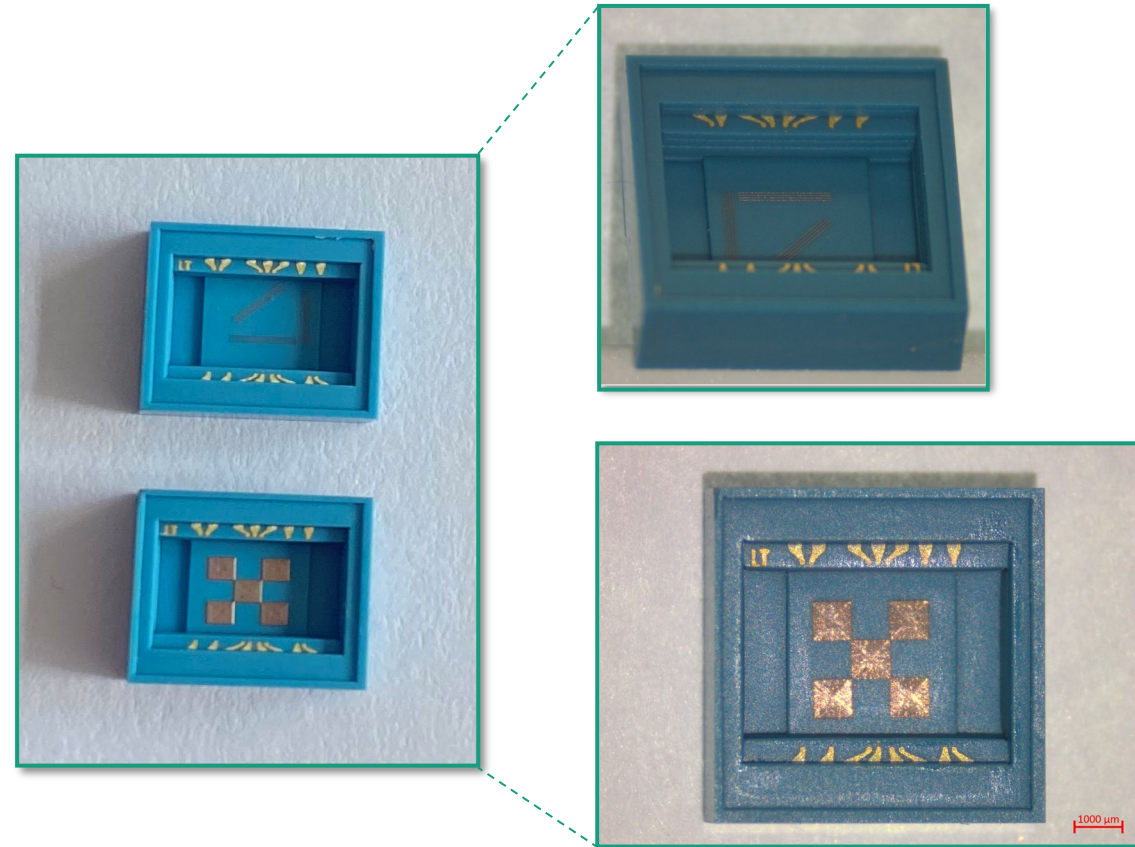
- Advantages over traditional printing techniques
  - High resolution, enhanced Performance, cost-effective and reduced material consumption
- Wide range of functional materials
  - Conductive, dielectric, and insulating materials



Design layout: J.A.M.E.S



Source: Optomec

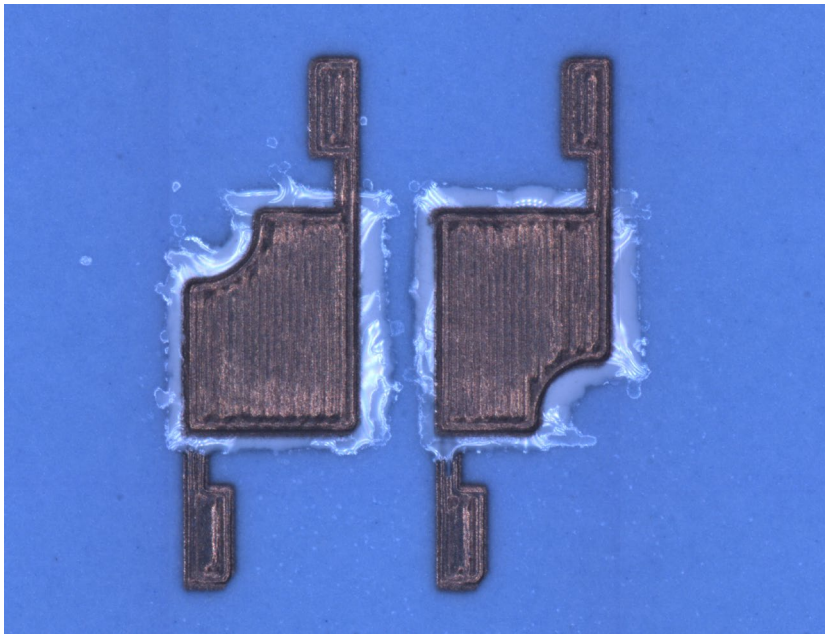




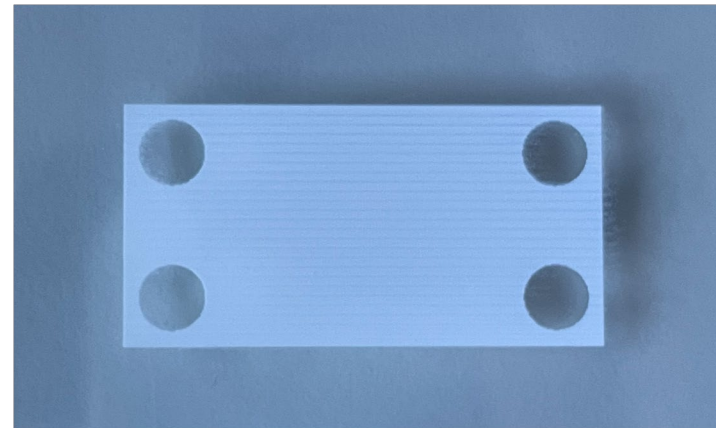
## 4. Maskless Multi-Material 3D-printing

### Multi-material printed components

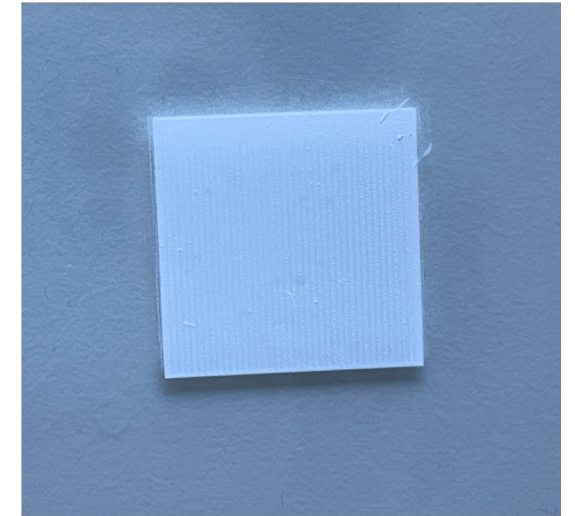
- Multi-material printing of dielectric and conductive layer together
  - Layer-by-layer deposition and cured between layers
  - Printing on different substrates
  - Surface roughness of dielectric printed structures around  $2\mu\text{m}$



Ag-Dielectric-Ag layer printed using the technology



Inkjet printed Alumina base structure (20 layer) cured with NIR



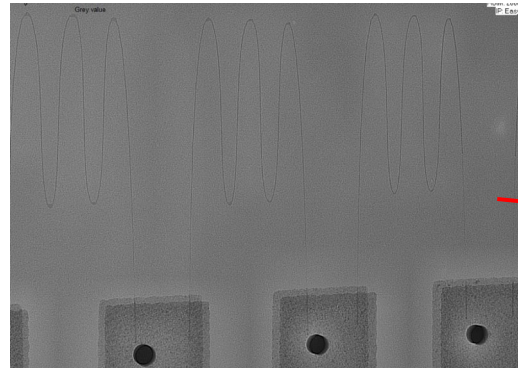
Inkjet printed Alumina base structure (25 layer) cured with NIR



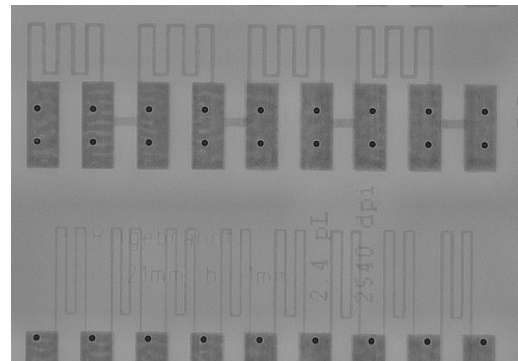
Aerosol jet printed Alumina structure

# 4. Maskless Multi-Material 3D-printing

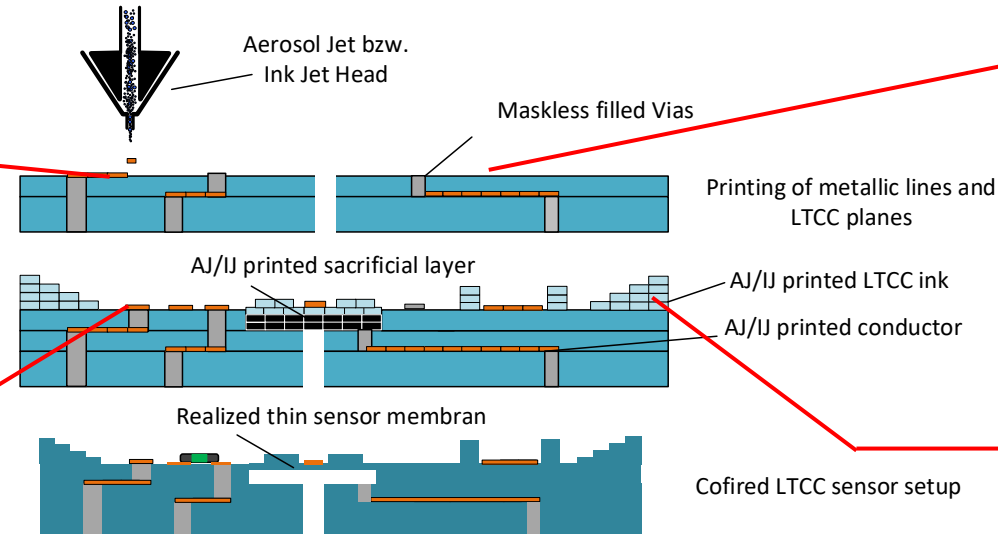
## Digital Printing on LTCC tapes



Aerosol Jet Printed high resolution structures in LTCC ✓

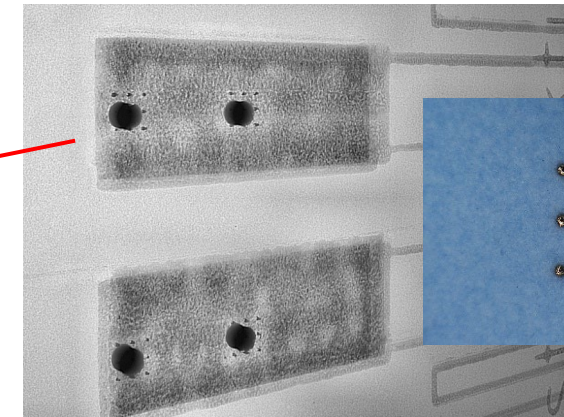


Reproducible printed embedded Ink Jet printed Structures in LTCC ✓

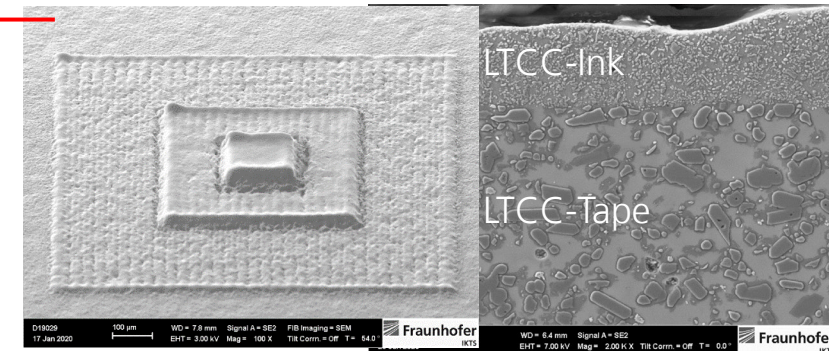
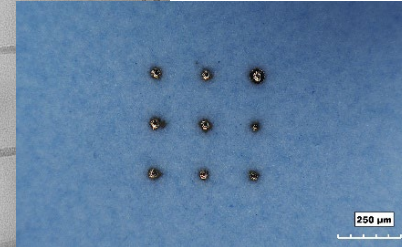


### Benefits of digital approach

- Fast development process – No order times of Masks
- Cost Saving
- Miniaturization (Line/Space, Vias)
- Layout correction very quickly
- More geometric freedom



Ink Jet filled 30 µm Vias ✓



Digital printed dielectric LTCC-Structures ✓  
(Membranes, Steps, Frames etc.)



# Contact

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