Low Temperature Co-fired Ceramic (LTCC) Structures for Sensor and Fluidic Applications

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PURPOSE OF THE PRESENTATION

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- To point the significance of LTCC technology for micro-fluidic sensor applications
- To propose an effective method for 3-D structuration of LTCC
- To demonstrate the fabricated structures using the suggested method

AN OVERVIEW

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Situation → Use of LTCC technology has widespreaded to fields other than high frequency domain

Issue → The technology can be used effectively for realization of microfluidic devices

Question → What are the challanges and how to take them?

APPLICATION EXAMPLES

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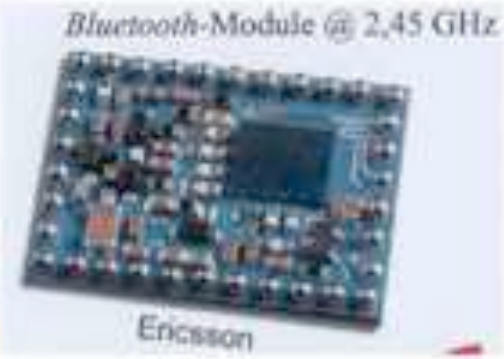
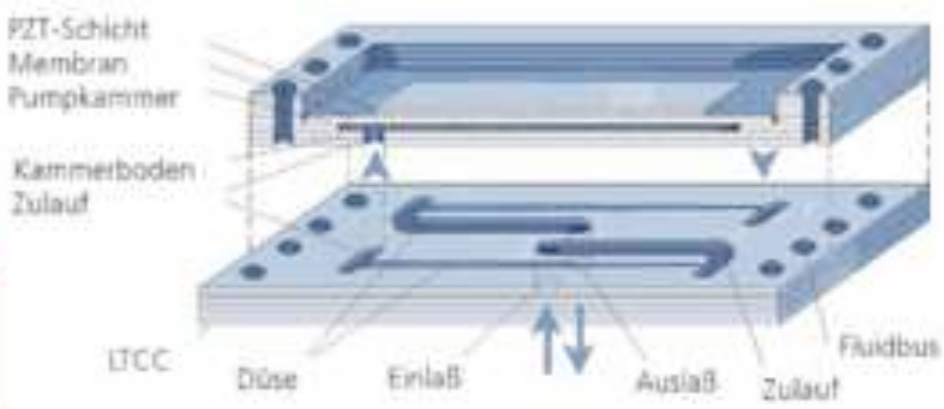
Source: Prismark/Binghamton University

EPCOS FRONT END MODULE

- Key component in new Nokia mobile phone architecture
- Integrates diplexer, switching, LC and SAW filters
- Analysis of LTCC integrates passives and SAW filter packages





OUTLINE OF THIS PRESENTATION

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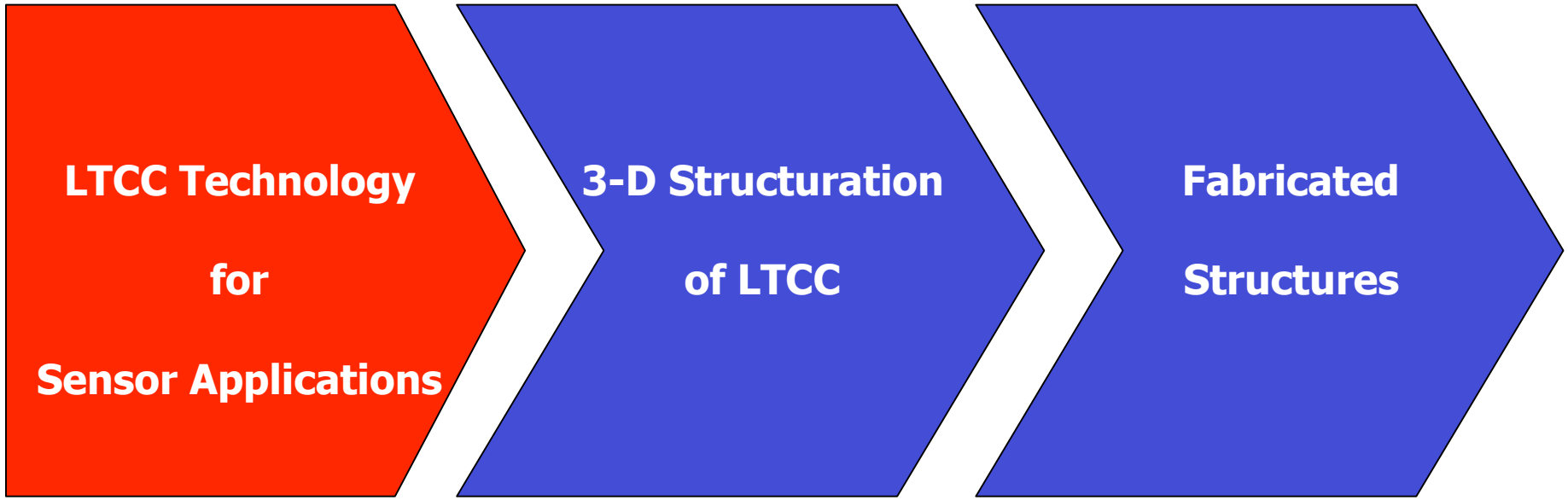

→Introduction

→Advantages

→Challanges

→Methods

→Sacrificial layer

→Application of sacrificial layer

→Structures obtained

→Comparison with other methods

→Next steps and Conclusions

WHAT IS LTCC TECHNOLOGY?

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Based on LTCC tapes of various thicknesses which

- sinter below 900°C
- are glass ceramics with excellent dielectric properties
- are screen-printed and co/post-fired with thick-film electronic passive components

LTCC MATERIALS SYSTEM

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	COMPONENTS		
	SUBSTRATE	PASSIVES	
Components	**Tape**	**Conductor**	**Resistor**
Function	Dielectric layer	Thick-film paste	Thick-film paste
Functional group	Dielectric powder	Precious metal, fine size powder	Conductive oxide, fine size powder
Glass	✍ Lowers T_{firing}, ✍ increases dielectric strength and density	✍ Lowers T_{firing}, ✍ increases adhesion to substrate and density	✍ Lowers T_{firing}, ✍ increases density ✍ surrounds conductive powder
Organics	Binder, solvent, dispersant for appropriate rheology		

ADVANTAGES OF LTCC FOR FLUIDIC SENSORS

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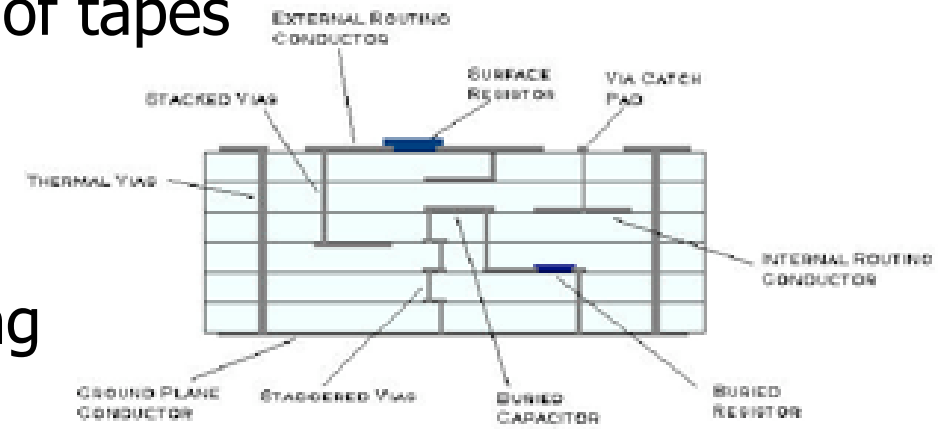
- Excellent chemical / thermal stability
- Ease of machinability of tapes
- Cost effective
- High density packaging
- Hermeticity of the structures
- Mechanical and electrical functions in one system



CHALLANGES

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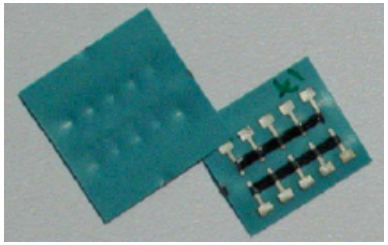
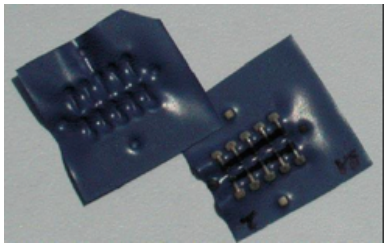
1. Physical Issues

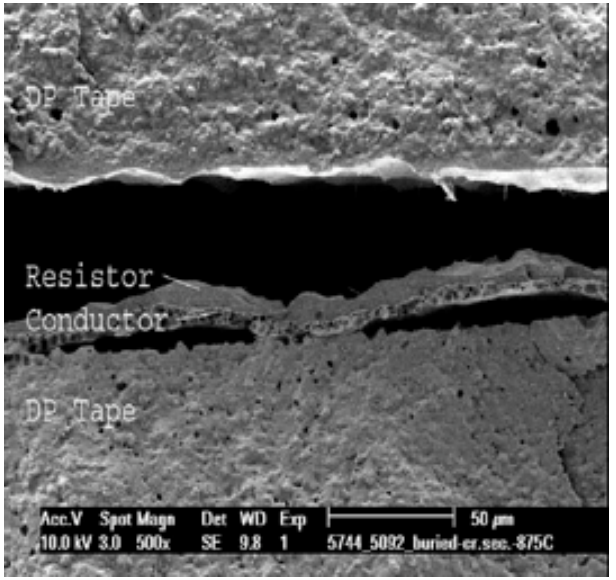
→ differential shrinkage

→ degassing

→ lamination







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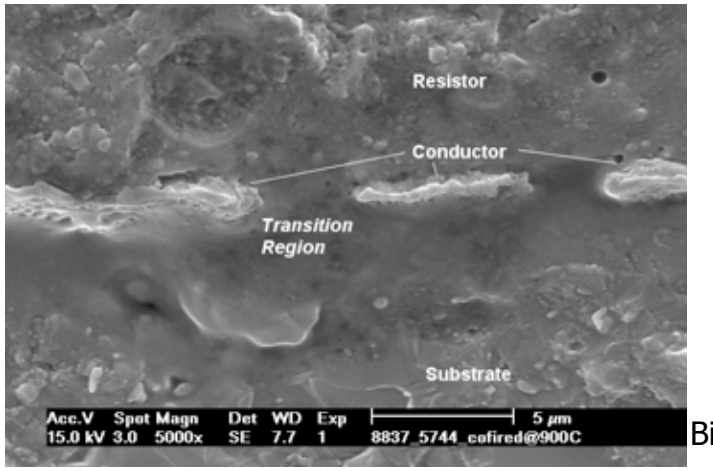
2. Chemical Issues

→ Interaction of components

→ Oxidizing /reducing conditions



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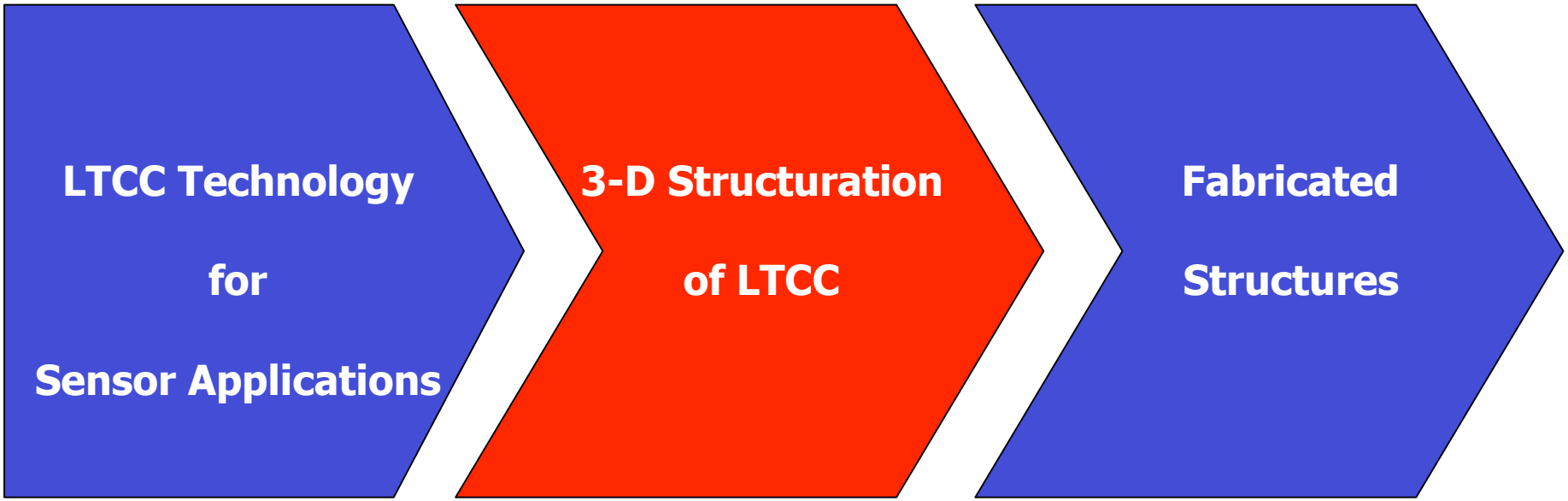

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METHODS FOR 3-D STRUCTURATION OF LTCC

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1. Passive Methods

Structuring by addition / removal of LTCC layer

2. Active Methods

Use of sacrificial layer such as carbon-black paste or glass frit

desired effects can be compensated by modification of firing profile and / or atmosphere, etc.

SELECTION OF SACRIFICIAL LAYER

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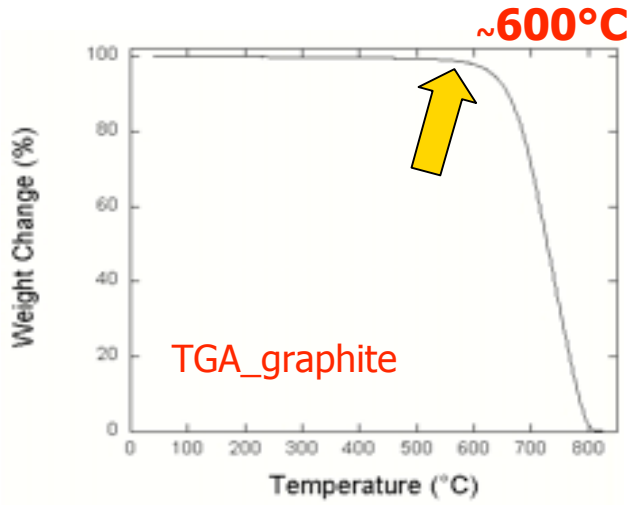
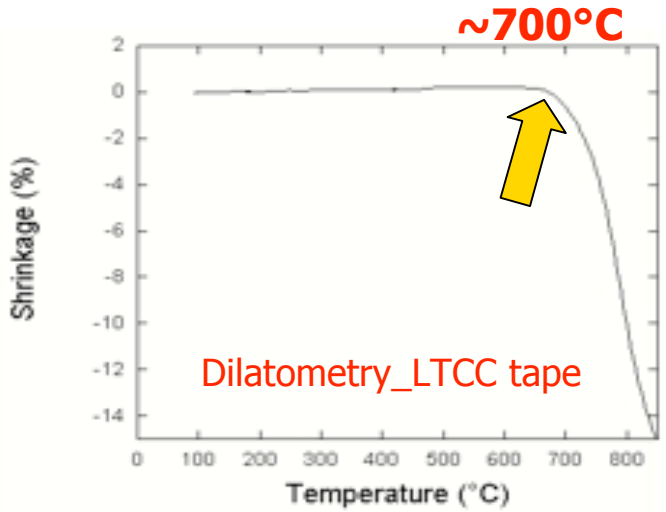
Graphite powder selected since

→burned in oxidizing atmosphere above ca. 600°C, which starts before onset of sintering temperature of LTCC as: $C+1/2O_2 \rightarrow CO_2$





→not reactive with LTCC

→ applicable as thick-film

PREPARATION and APPLICATION OF SACRIFICIAL LAYER

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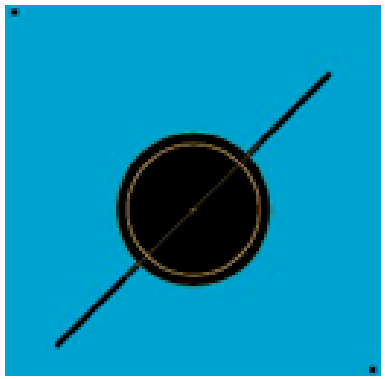
Same procedure as in thick-film pastes followed

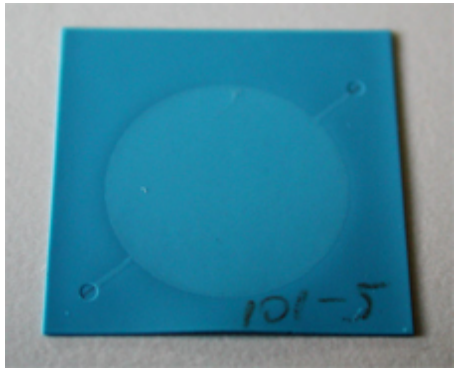
Product	Function	Specification	Supplier
Graphite	Functional element	1-2µ particle size	Aldrich, 28,286-3
Ethyl cellulose	Binder	control of rheology	Aldrich, 43,383-7
Terpineol	Solvent	slurry viscosity	Fluka, 86480
Acetyl acetone	Dispersant	dispersing additive	Sigma-Aldrich, P775-4

(28:72 ratio of functional elements to organics used)

Screen-printing on LTCC and lamination



Firing



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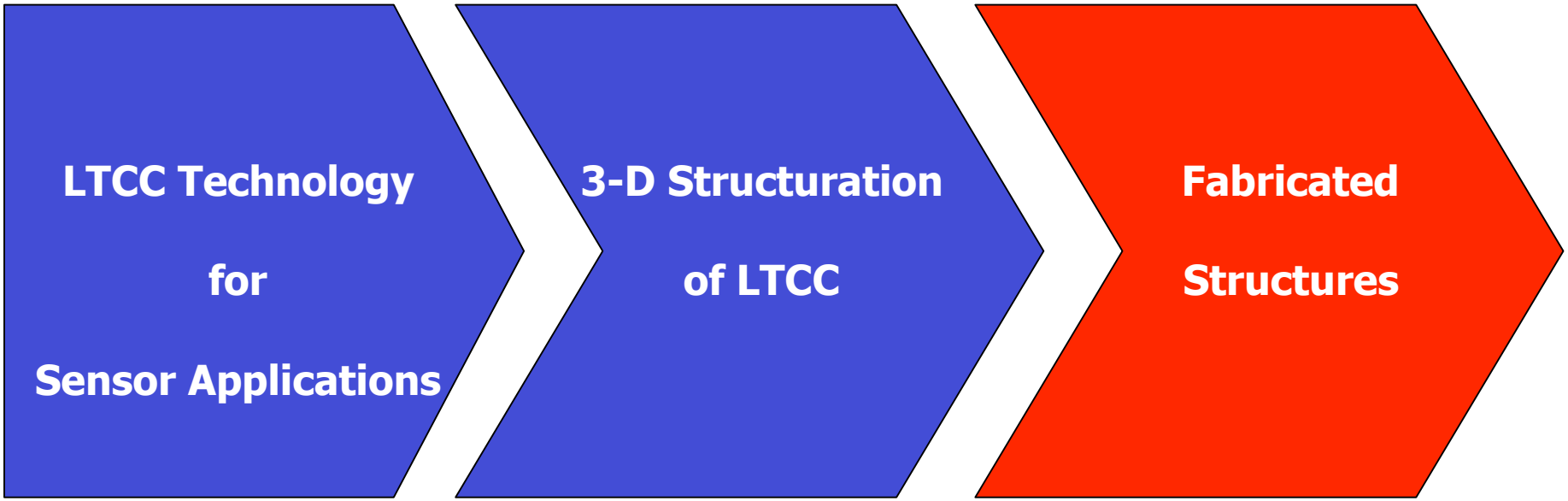

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3-D STRUCTURES FABRICATED

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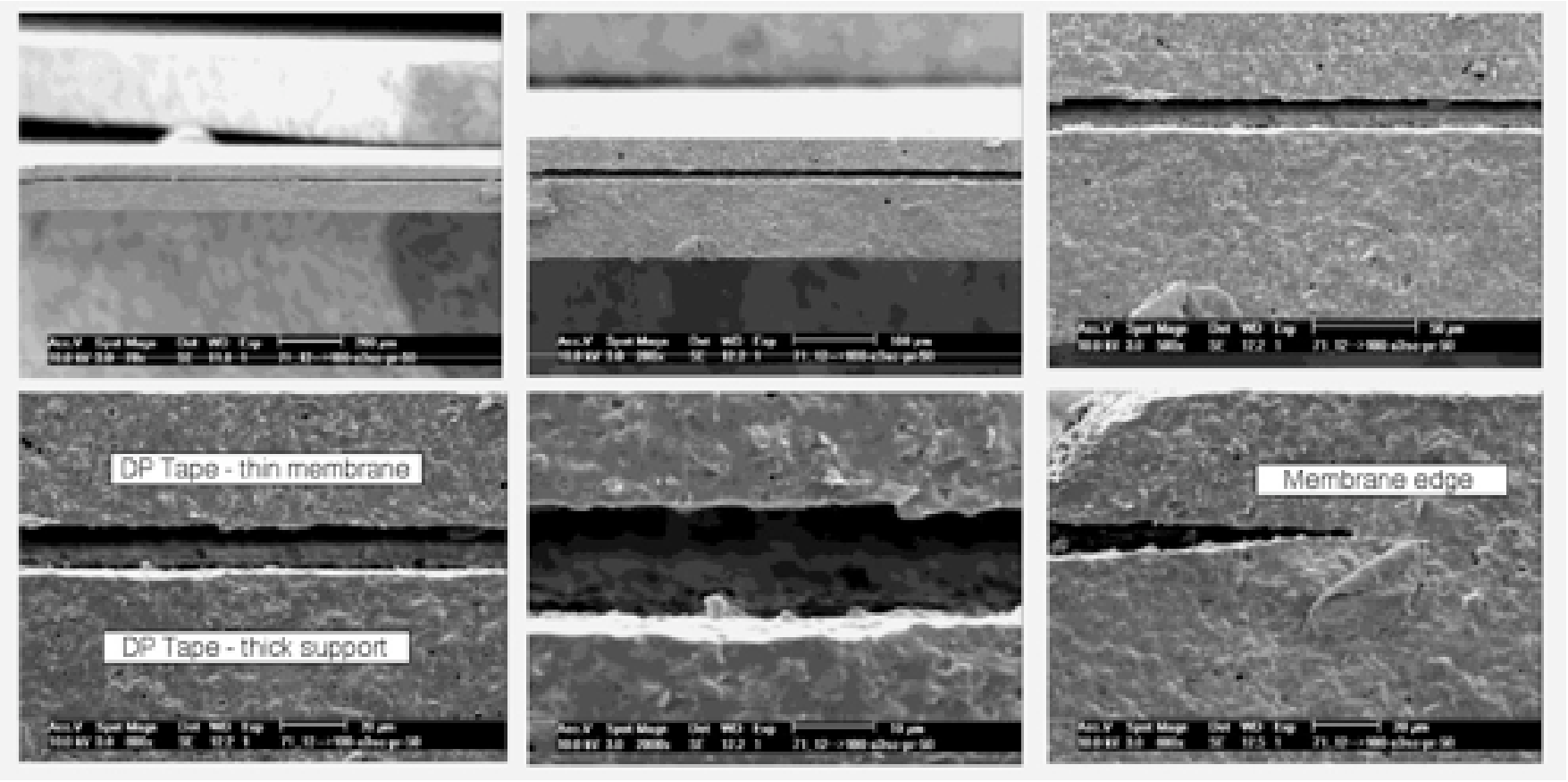

7 mm membrane, 40 µm thick, 15 µm spacing

COMPARED TO INNER LAYER METHOD

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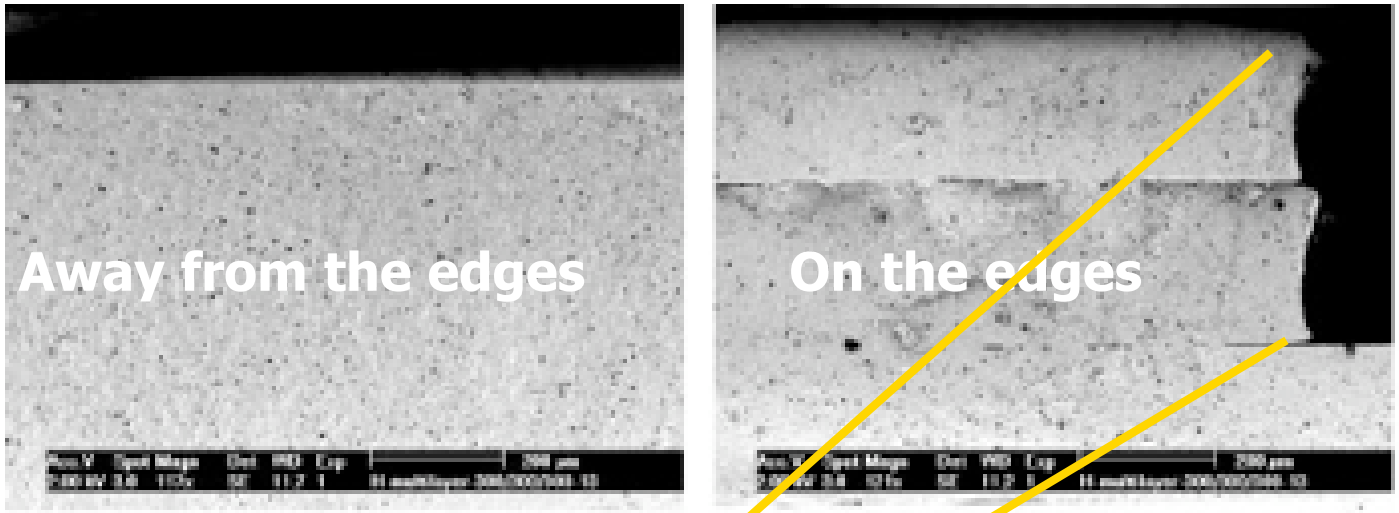
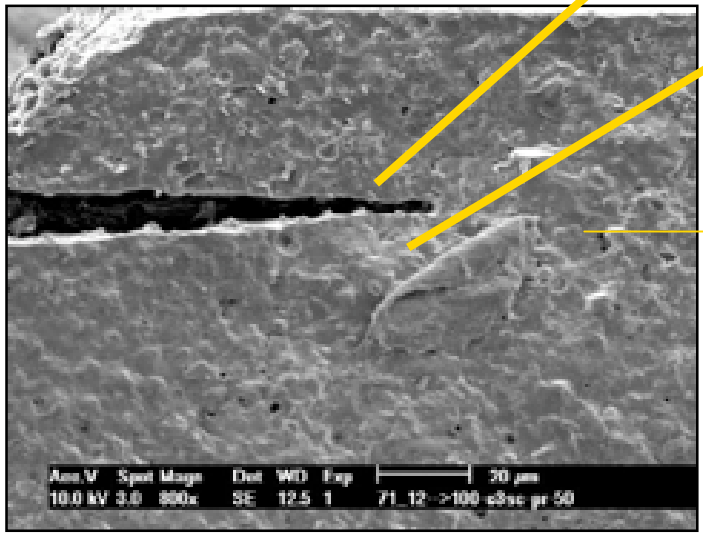
Structuration by inner layer modification



Structuration by sacrificial layer



Complete and homogenous structure

THERMAL SENSORS FABRICATED USING LTCC

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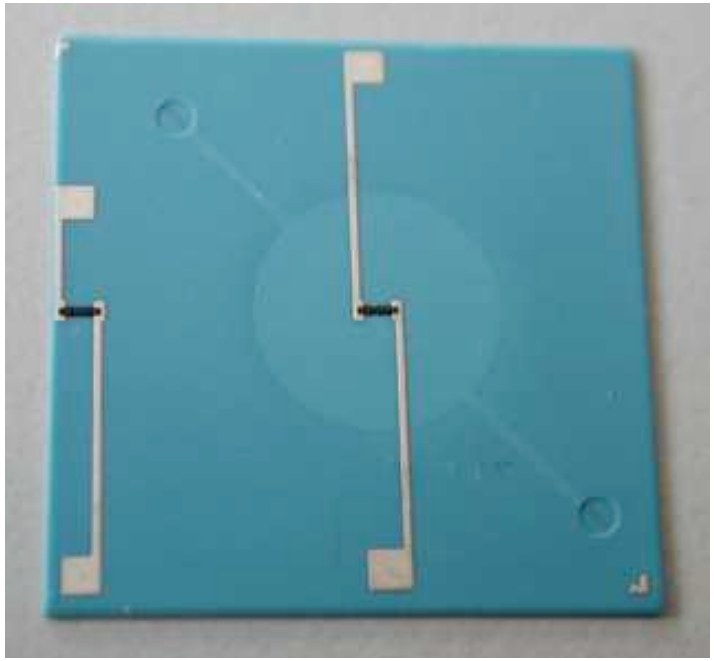
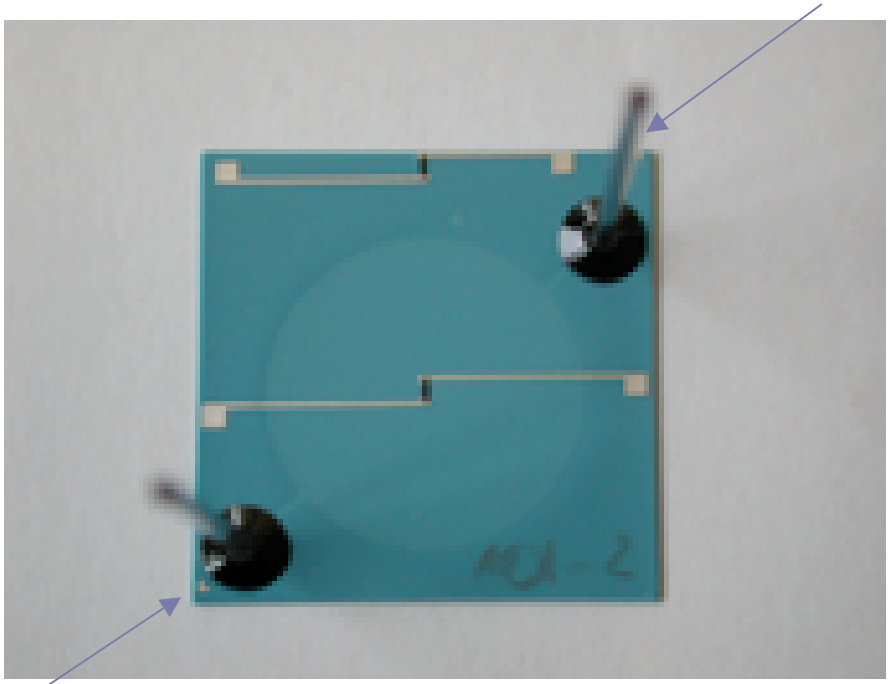
Screen printing and post-firing of sensing elements

Completion of the basic sensor





NEXT STEPS

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- Developing the paste properties for a better control on screen-printing quality
- Improving the lamination technique
- Application of non-destrcutive testing methods e.g. ultrasonic microscope, for examing the entire structure
- Measurements with the prototypes

CONCLUSIONS

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- Carbon-black paste is an excellent material as a sacrificial layer
- It is easy to produce, inexpensive and effective
- LTCC tapes of different thicknesses coupled with the paste increase structuring possibilities