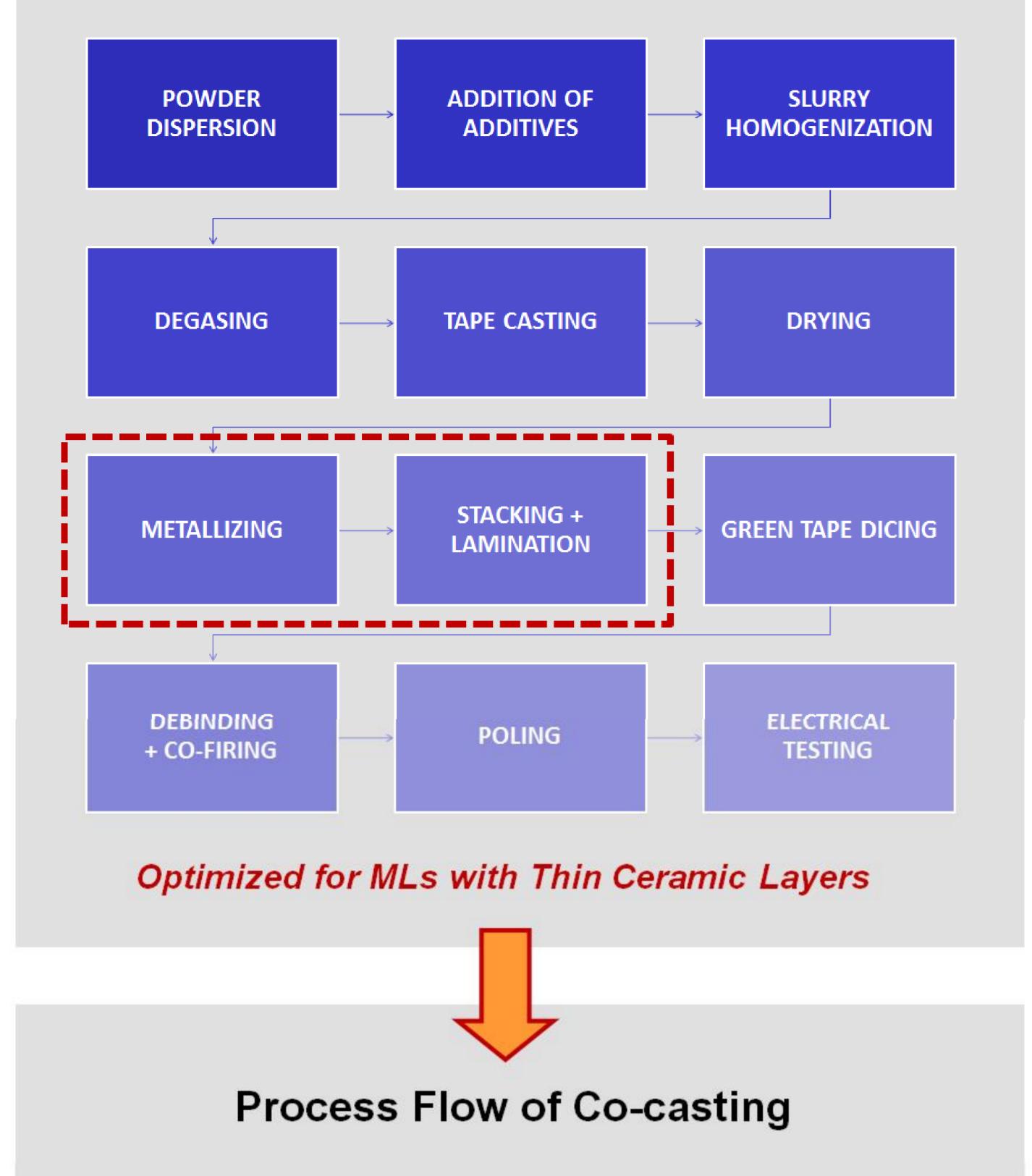
# A NOVEL CO-CASTING PROCESS FOR MANUFACTURING PIEZOELECTRIC MULTILAYER CERAMICS

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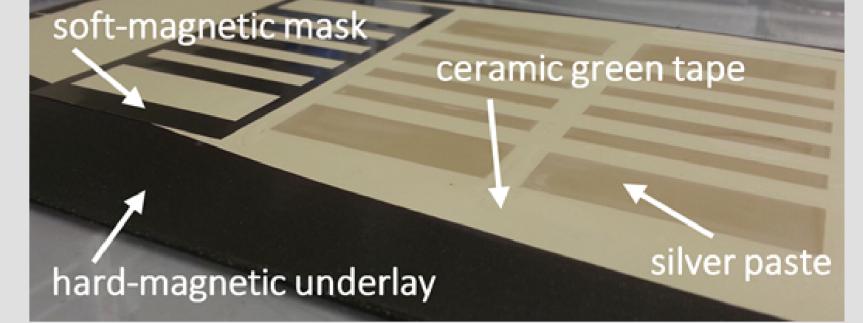
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## Fabrication of Multilayer (ML) Devices



## The Idea: Magnetic Fixation of the Mask

Defined metallization of the ceramic green tapes was realized by use of a magnetically attracted mask. The firm fixation of the mask guarantees electrode areas with a high edge definition.



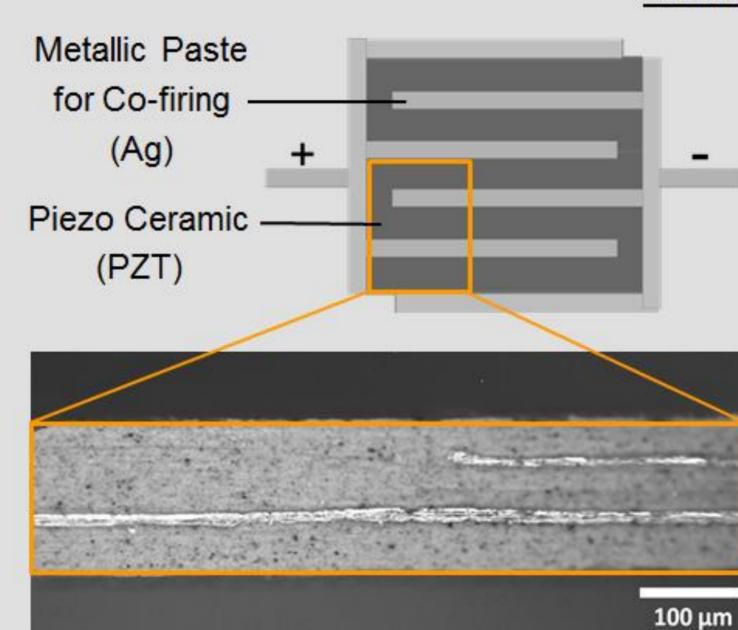


## Interdigital Electrode Structure

Problem:

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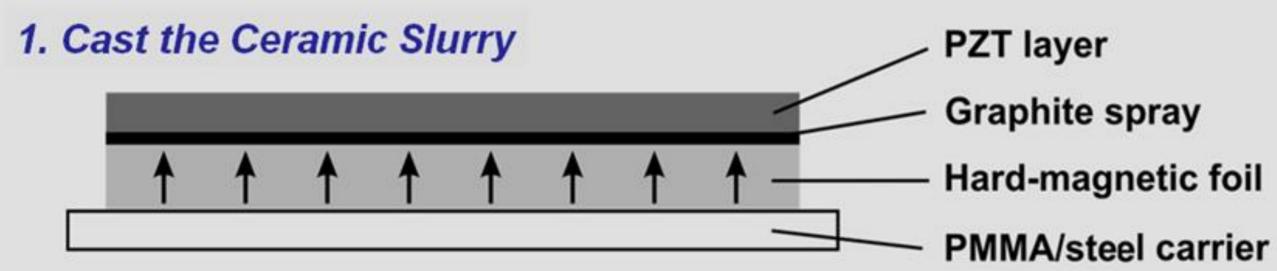
Freestanding ceramic layers with thicknesses below  $100 \ \mu m$  are not mechanically stable enough to contact the inner electrodes in a stepped layer structure.



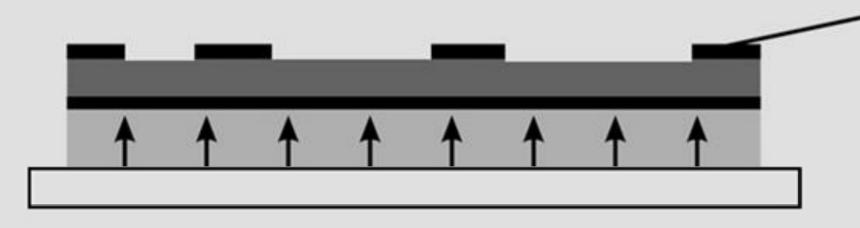
#### Solution:

An interdigital electrode structure allows contact of the inner electrodes from the ML sides. Therefore, a noncontinously metallized green tape surface and metallized areas with sharp edges are required.

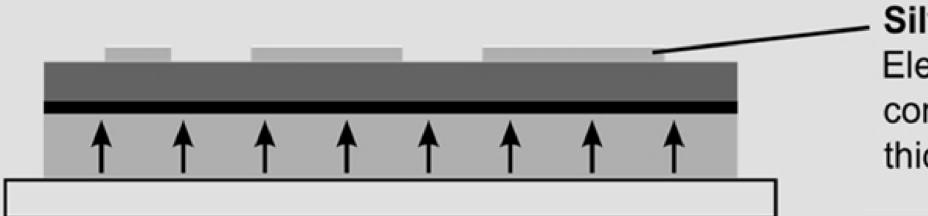
This cross section of a co-cast and co-fired @ 900 °C piezoelectric ML (consisting of three PZT layers and two silver inner electrodes) shows that the inner electrodes are continous only to one side.



#### 2. Cast the Metal Paste through a Mask

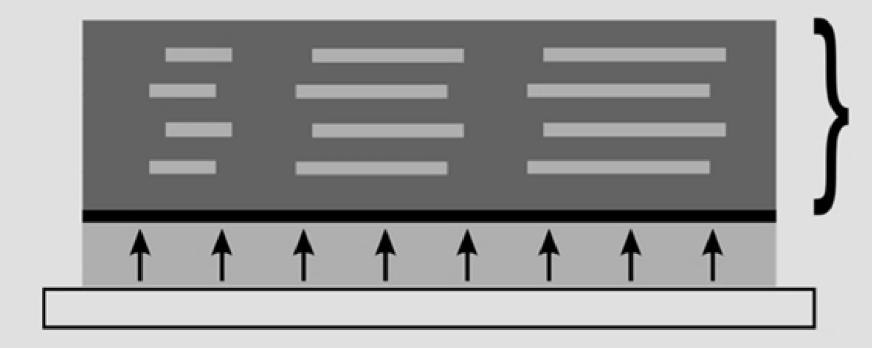


Shadow mask: Soft-magnetic steel foil guarantees good electrode edge definition

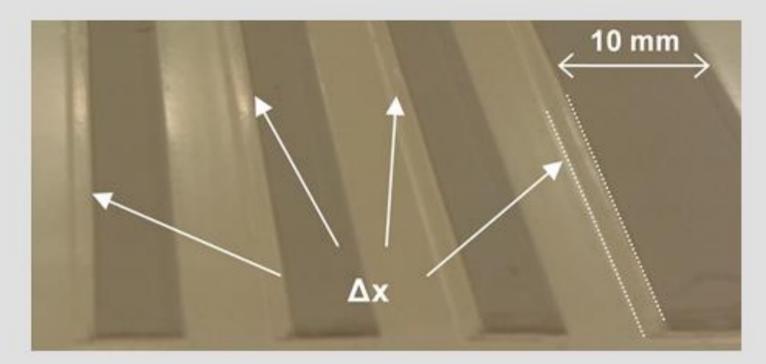


Silver layer: Electrode height is controlled by mask thickness

#### 3. Repeat Steps 1. and 2. with Lateral Shift of the Mask



Co-cast ML with lateral shifted sillver electrodes

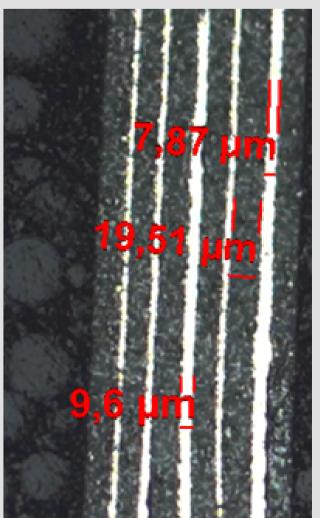


An alternating lateral shift  $\Delta x$  of the magnetically attracted mask leads to a small offset of every second electrode layer. After cocasting of several alternating layers this results in the desired interdigital electrode structure.

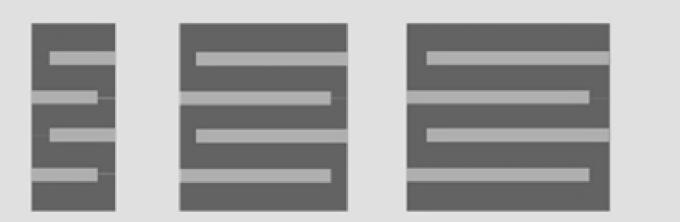
## Conclusion

- The novel co-casting process simplifies the manufacturing process of piezoelectric multilayer devices with thin layers.
- The stacking and laminating of very thin and flexible ceramic green tapes is no longer necessary.
- Layers with thicknesses down to 20 µm can be realized.

layer state	ceram	nic layers	; [µm]	electrode la	ayers [µm]	
wet	300	200	100	100	50	
dried	120 ± 10	83 ± 7	40 ± 5	55 ± 3	28 ± 2	
fired	73 ± 5	36 ± 3	20 ± 2	9±1	5 ± 1	<b>20,26 µŋ</b>



## 4. Dice by Cutting or Punching



Piezoelectric ML with interdigital electrode structure



**Piezoelectric triplelayer bending transducers** with interdigital Ag electrode structure fabricated by casting both ceramic and metallic layers. After co-firing and applying outer electrodes, the MLs were poled in silicon oil. Wire bonding was made provisionally with conductive epoxide glue.



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