Laser Direct Imaging Material and Process Developments for Next Generation Integrated Chipless RFID – **LDImagic**

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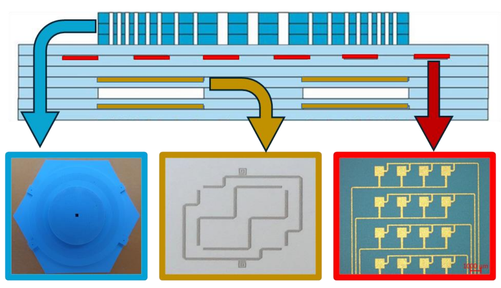
Introduction

Chipless RFID technology…

- …is a disruptive technology for identification, sensing and tracking
- …is a low-cost alternative to chipped RFID systems
- …can be used in IoT, storages, ports, and many more
- …can be scaled for different frequencies
- …needs high performance materials like substrates and metallizations to unleash full potential



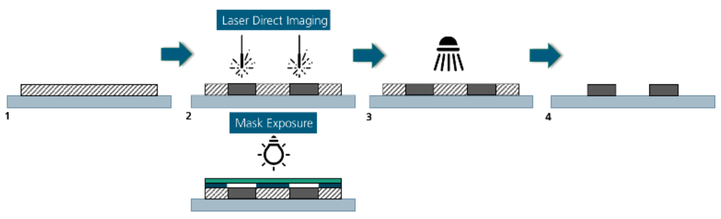
GRIN-lenses *Micro resonators* *Retrodirective antennas*

Low temperature co-fired ceramics (LTCC) materials…

- …offers outstanding high frequency performance
- …can be used in harsh enviroments
- …enables three-dimensional integrations including passives

PI pastes…

- ..provides precise metallization regarding line-space ratio and rectangular crosssections for high freuqency applications
- …can be processed in a mass-production process



PI technology process chain: 1. Screen printing of full area or rough structure. 2. Exposure using UV-Laser or photo mask. 3. Development using spray ablation method. 4. Developed structures.

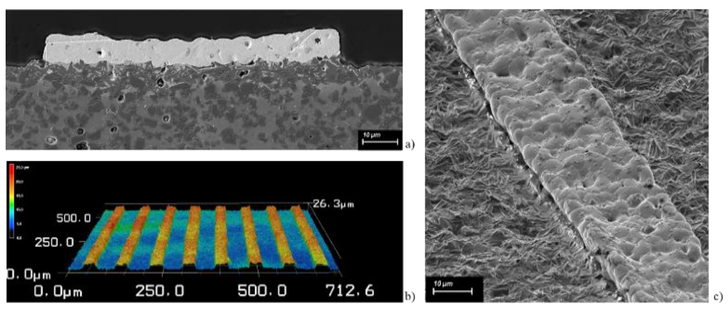
LDI-Pastes development

Paste manufacturing for high frequency suited LTCC

- Variation of solids like metals, alloys, oxides, glasses and additives are mixed
- Sequential mixing of powders with photosensitive organic components, e.g. like polymers, crosslinkers, plasticizers, antioxidants, solvents, inorganics and photo initiators

Paste processing

- Via Laser direct imaging using a µMLA (Heidelberg Instruments)
- Co-firing with the LTCC to create a monolithic, ceramic, passive RFID tag

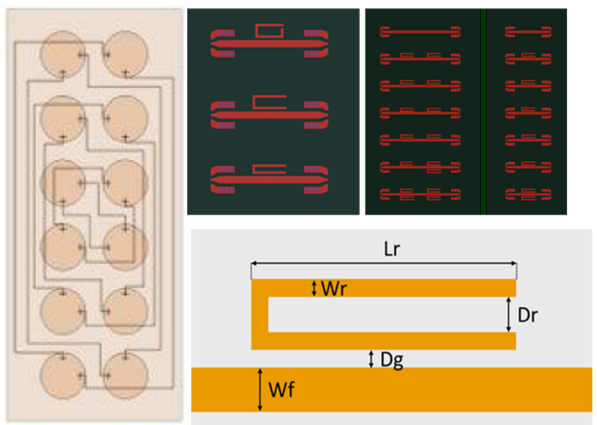


Images of sintered silver PI paste on LTCC (sintered LTCC) exposed with LDI. a) cross section FESEM image of 90 µm conductor line. b) surface topography image of 30 µm conductor lines. c) crossbeam FESEM image of 25 µm conductor line.

HF design and simulation

Chipless RFID tags design

- Retrodirective Van Atta arrays were used to ensure stable operation in dynamic environment
- ID-encoding was achieved by integrating the resonators with arrays lines, representing binary „0" at the resonator's resonant frequency and „1" outside it
- For higher data capacity, alternative encoding method was proposed by placing multiple arrays of different frequencies next to each other



RFID tag design: Left hand side – complete retrodirective antenna array, right top corner test layouts with varied micro resonators varied with different geometrical properties (bottom right corner).

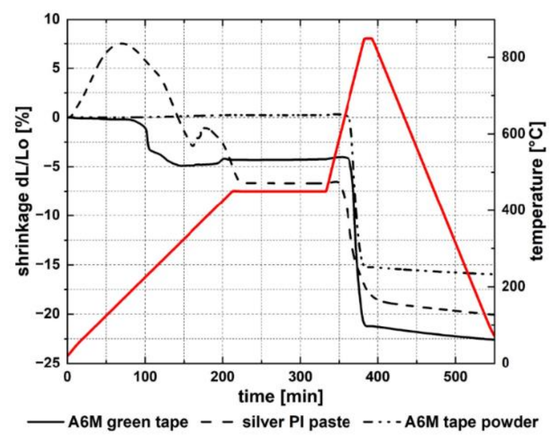
Test vehicle manufacturing

Shrinkage adjustment paste to Vibrantz A6Me LTCC

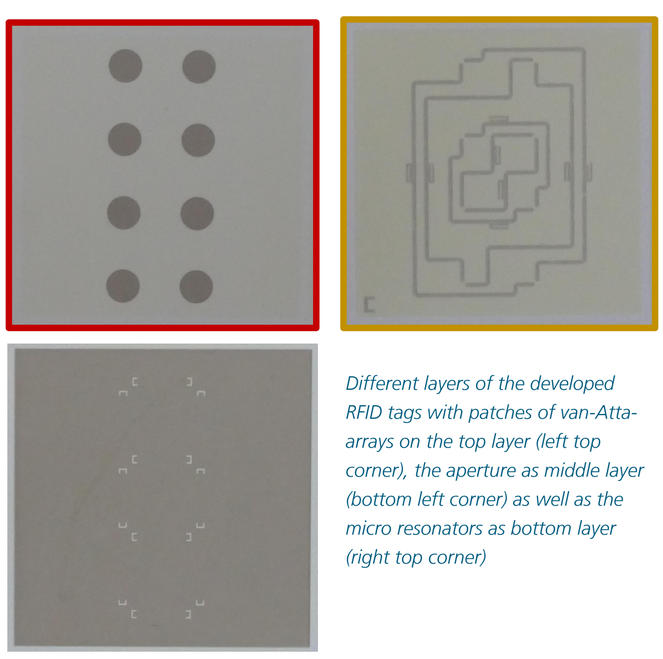
- Shrinkage measurement was done with tape laminates and pellets of dried pastes
- Adaption was done by varying solid components contents as well as particle shapes

Test vehicle manfacturing

- Metallizations were screen printed on single tape sheets
- Single tap sheets were stacked, laminated and co-fired



Shrinkage curves of LTCC A6M green tape, adjusted silver PI paste and LTCC A6M tape powder



Different layers of the developed RFID tags with patches of van-Atta-arrays on the top layer (left top corner), the aperture as middle layer (bottom left corner) as well as the micro resonators as bottom layer (right top corner)

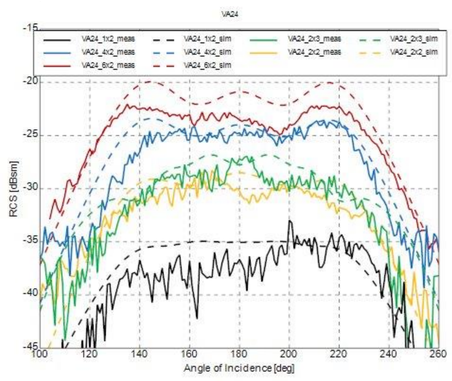
Characterization

Resonators

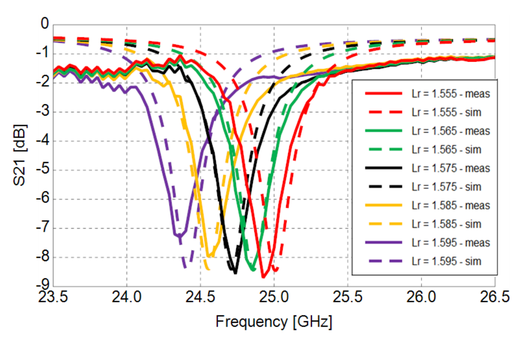
- A full scattering matrices of manufactured resonators were measured using ACP 250 coplanar probes and VNA

Van Atta arrays and tags

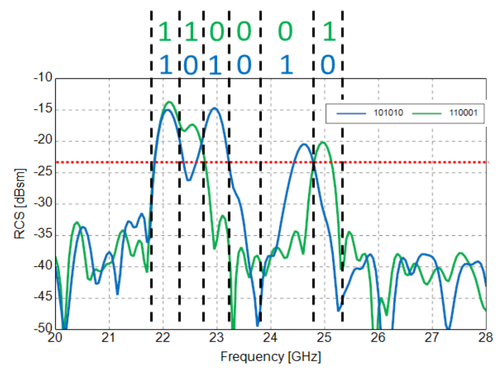
- Various array configurations (e.g. with different number of patches) and tags were measured in an anechoic chamber
- Achieved bit capacity reaches up to 2 (with resonators) and up to 6 bits (with multiple arrays of different frequencies)



Measured (meas) and simulated (sim) |RCS| characteristics of Van-Atta-Arrays with different patch numbers in dependence of angle of incidence.



Measured (meas) and simulated (sim) |S21| characteristics of single resonators with length differences of 10 µm manufactured with LDI process. The resonator lengths along the line Lr are given in millimeters.

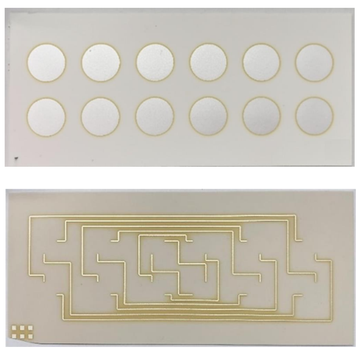


Measured RCS frequency characteristics of multiple arrays of different frequencies placed side by side. The absence of an array (and thereof lack of resonance) indicates a binary „0", while its presence indicates a binary „1".

Summary and Conclusion

Batteryless and chipless RFID tags were

- developed for localization and identification
- manufactured in LTCC technology using LDI structuring of metallization
- Adapted to two distinct frequency bands for different scenarios
- Capable to store from 2 up to 6 bits
- Demonstrated for potential applications in sea ports or logistic hubs providing long term stability against harsh conditions by fully ceramic materials



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