Integrated Microtransformer on Silicon for High Frequency Power Applications

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Abstract

- In this presentation we will show a development of an integrated microtransformer on silicon fabricated using thin-film technology.
- The micro device is designed for power applications at higher switching frequencies beyond to 50 MHz.
- The microtransformer consists of a magnetic core and six identical coils.
- This configuration enables a wide flexibility of microtranfomer device. The device can be used as a microtransformer, as a microinductor and also as a common mode choke.
- The inductance value and transformer winding ratio is adjustable.
- For magnetic core a soft magnetic CoFe alloy is applied.

Introduction

- Significant development trends in the power electronics are miniaturization and increasing of system functionality. These aims are market driven and have an origin from portable electronics market [1].
- The miniaturization of portable devices requires the miniaturization of power management circuits.
- A method for miniaturization of passive components is increasing the switching frequency [2] in the range of a few MHz to much higher frequencies.
- A permanent increase of the switching frequency sets new requirements for inductive components.
- Inductors and transformers should provide smaller inductance and smaller size [3].
- These requirements can be fulfilled by using thin-film technology and integration of magnetics on silicon

Design

- Design microtransformer is shown in the Fig. 1.
- Design was simulated using Finite Element Method (FEM) with software tool Ansys Maxwell®.
- Device footprint 2.5mm x 2 mm.
- One coil consists of 9 turns with cross-section of 20 µm x 15 µm.
- Magnetic core has a thickness of 5µm

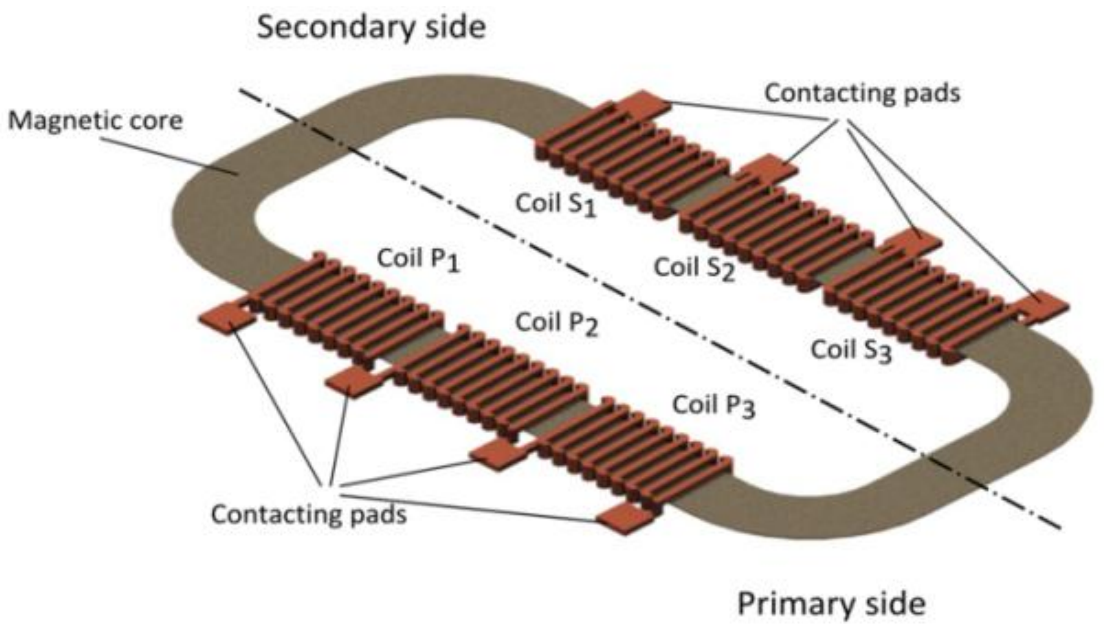

Fig.1: Proposed design of adjustable magnetic device

Fabrication

- The micro transformer is fabricated under cleanroom conditions using high aspect ratio microstructure technology (HARMST), combining UV depth lithography and electroplating. Process steps are shown in the Fig.2. Detailed fabrication process is described before [4].
- Electroplated CoFe alloy was used for fabrication of a magnetic core.
- Coils were fabricated using Cu electroplating.
- As an insulation and embedding material, a polyimide is applied
- After fabrication, devices were diced. Completed device is shown in the Fig.3.

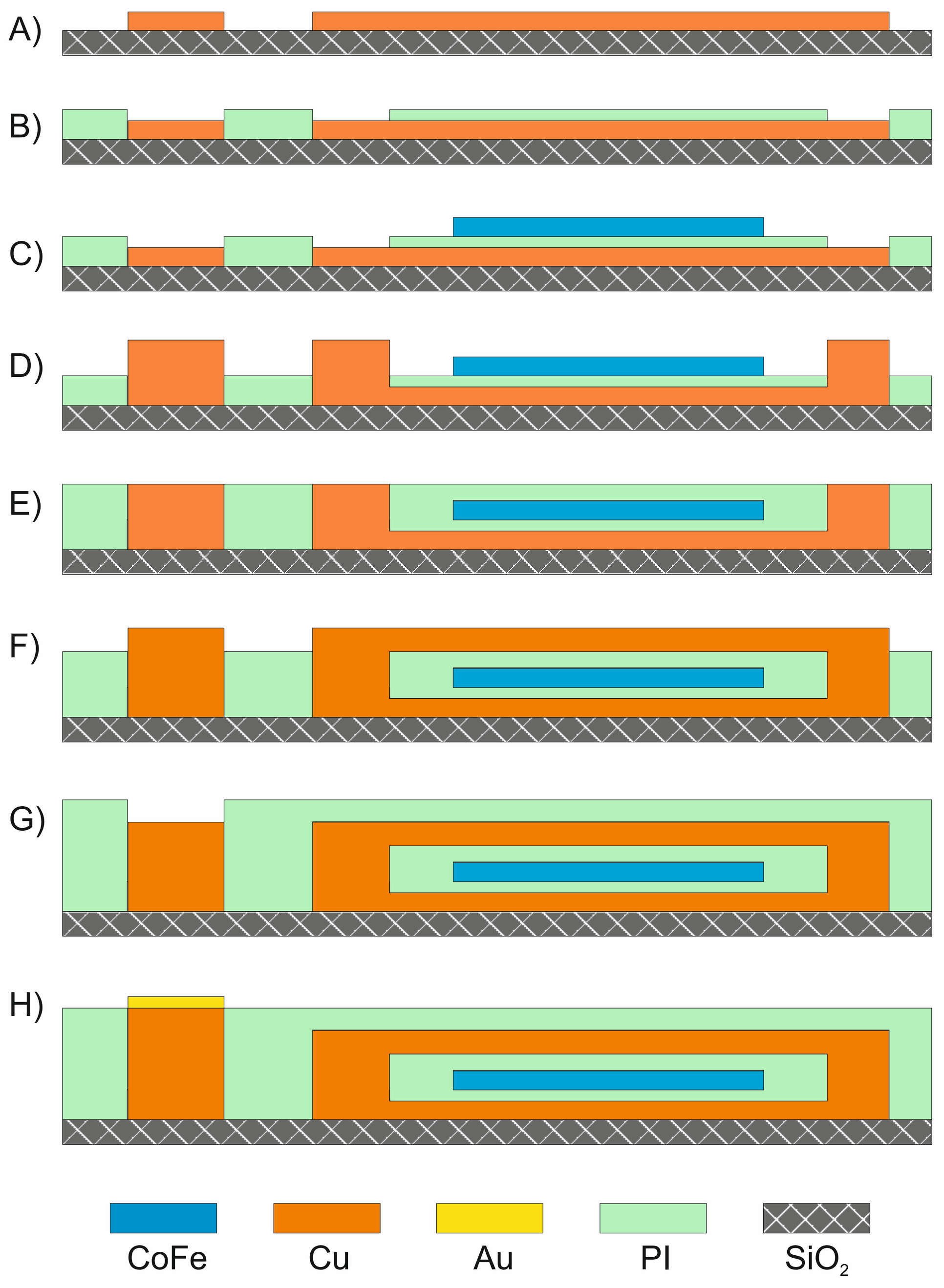

Fig.2: Process flow of micro-transformer device

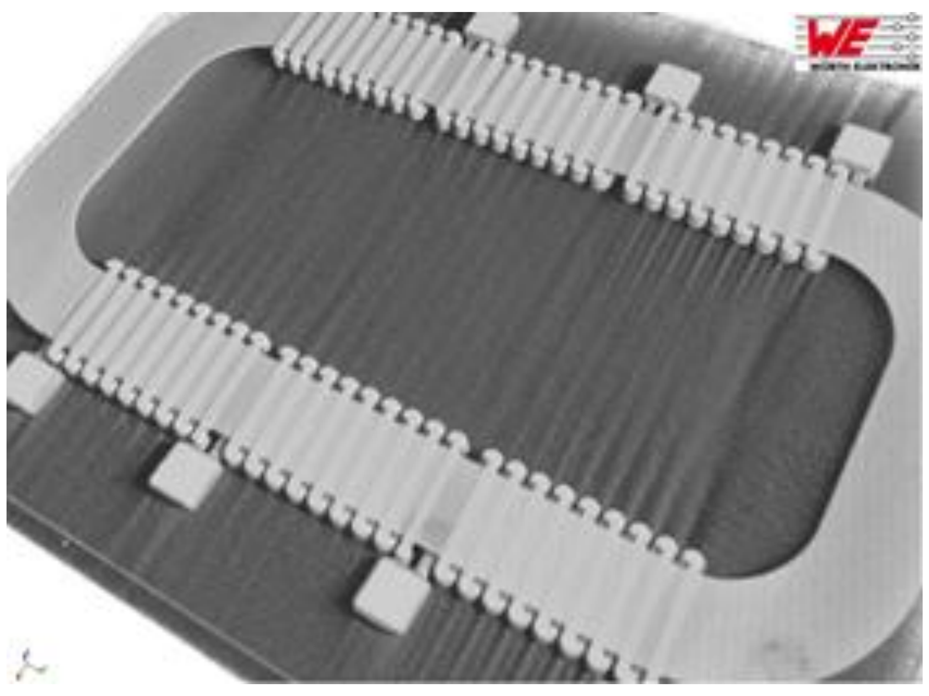

Fig.3: x-ray micrograph of completed microtransformer device

Test Results

- For testing, a device was mounted into QFN package
- Measurement results are shown in the Table 1.

Table 1: Measured parameters of micro device

Parameter	*Measured values*
Inductance **(1 coil)**	12 nH
Inductance **(2 coils)**	22 nH
Inductance **(3 Coils)**	33 nH
Max. Inductance **(6 coils)**	116 nH
Q **(1 coil)**	3 at 40 MHz
R_{DC} **(1 coil)**	350 mΩ

- Figure 4 shows characteristics of an inductance as a function of frequency.

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Test Results

- The inductance is stable up to 40 MHz.
- Figure 5 shows DC-Bias characteristics of micro-transformer device with CoFe magnetic core.
- Saturation current of the microtransformer with CoFe magnetic core is 650mA.

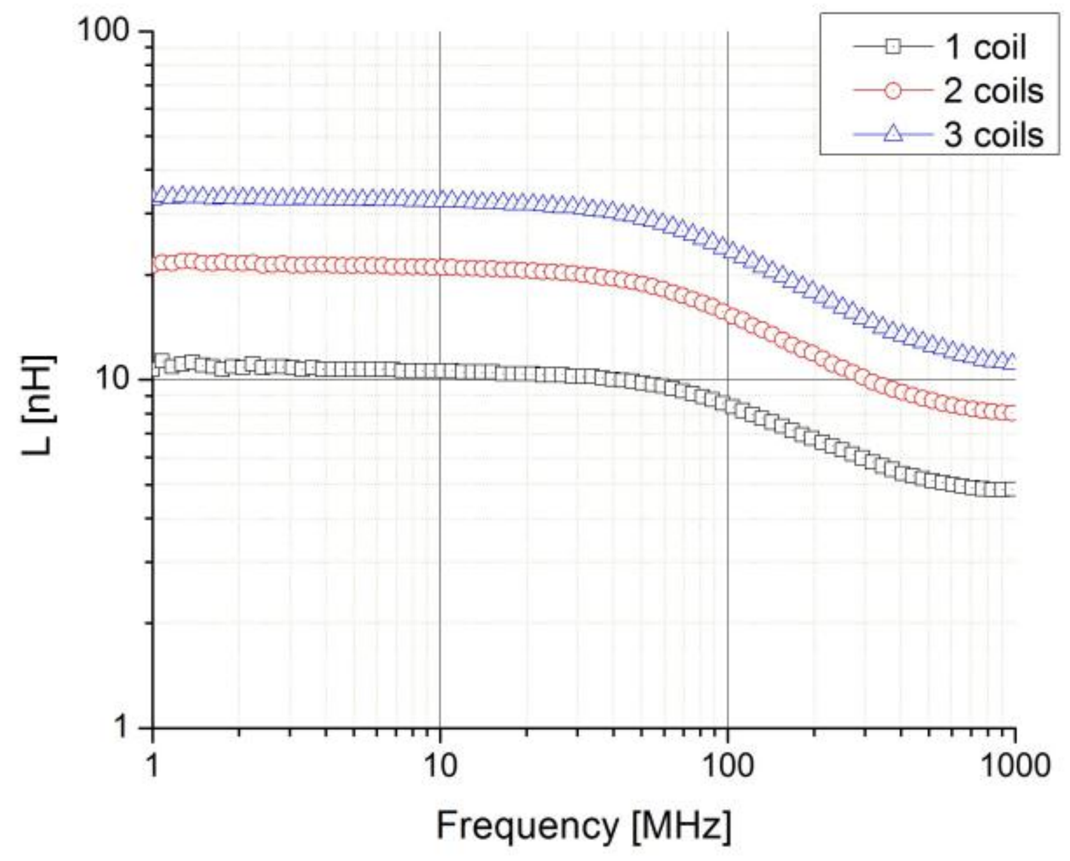

Fig.4: Inductance-Frequency behavior

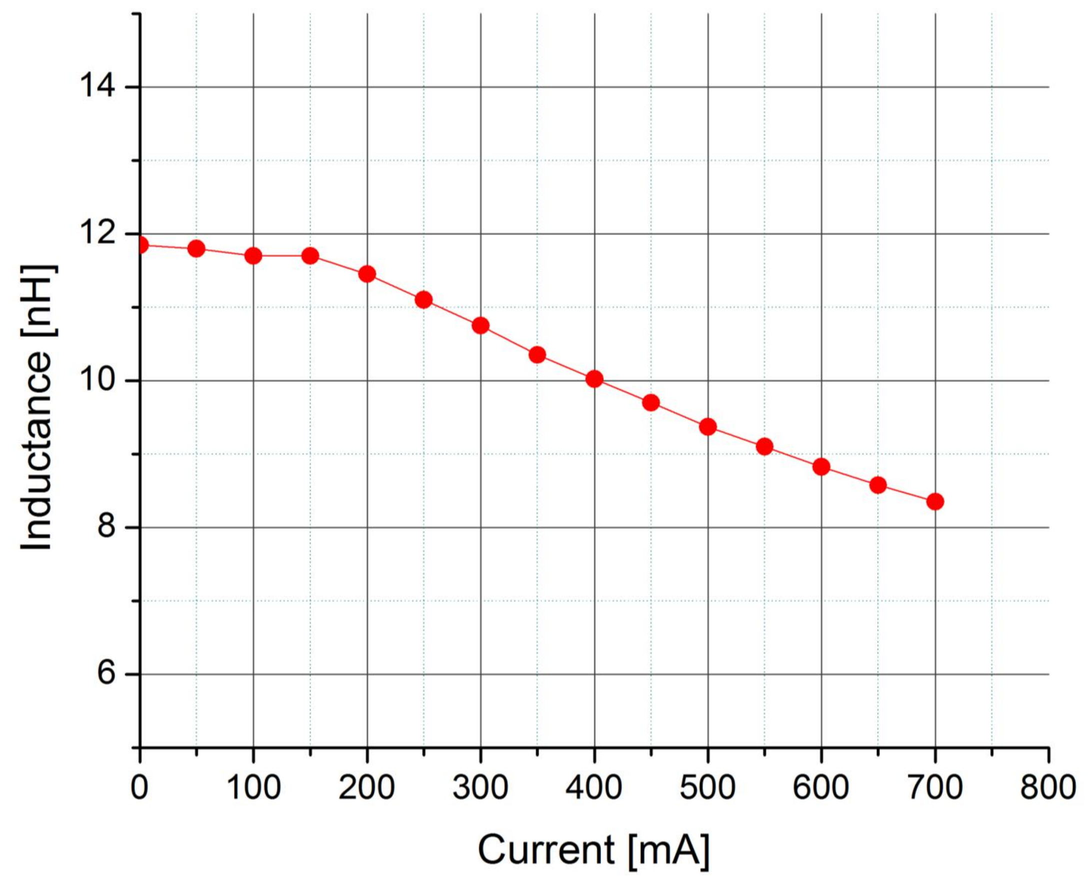

Fig.5: DC-Bias characteristics of micro-transformers with CoFe magnetic core (one coil measured)

Packaging

- Packaging of devices is in progress
- FO-WLP eWLB technology (Fan-out wafer level packaging and embedded wafer level grid array) is applied for packaging process
- Package size: 3.2mm x 2.3mm x 1mm
- Design of WLP package is shown in the Fig.6.
- For contacting, balls are attached on the bottom side of package.
- Small metal areas serves to improve a cooling of device

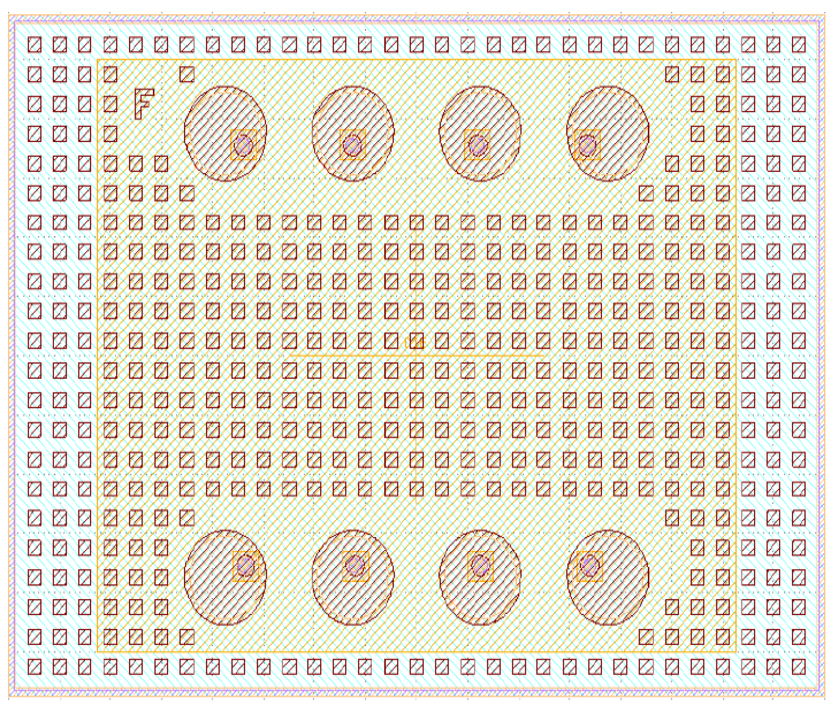

Fig.6: Bottom view of microtransformer package

Conclusion

- Microtransformer device designed and fabricated using thin-film technology.
- The magnetic core is fabricated using Co-Fe alloy

Conclusion

- Inductance stable up to 40 MHz
- The maximal inductance of device is 116 nH (all six coils connected in series).
- Very good DC-bias property
- Microtransformer can be successfully applied at high frequencies

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Reference

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