Laboratoire d'Analyse et d'Architecture des Systèmes

Spiral type micro-inductor with CoNiFe core for integrated DC/DC converters

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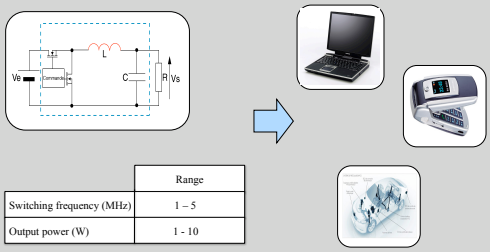
Investigation field

Micro-inductors integrated on silicon for low power DC/DC converters dedicated to embedded equipments

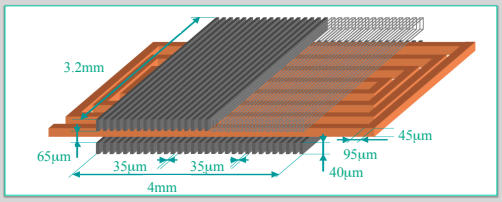


	Range
Switching frequency (MHz)	1 – 5
Output power (W)	1 - 10

Micro-inductor topology

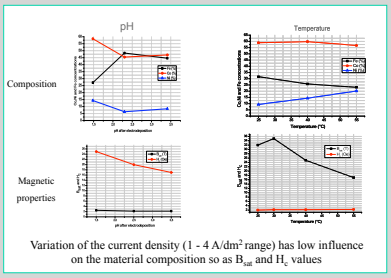
Spiral-type copper conductor sandwiched between two CoNiFe magnetic laminated layers

N = 10 turns L ≈ 1µH



- Laminated core to reduce eddy current effects
- Air gap to increase peak current and stored energy capabilities
- High width coil to reach low value DC resistance

CoNiFe bath - Study of the optimal depositing conditions



Variation of the current density (1 - 4 A/dm² range) has low influence on the material composition so as B_{sat} and H_c values

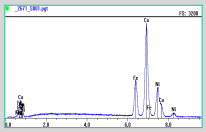
BATH COMPOSITION

$FeCl_2$ 31.8 g.l^{-1}
$CoCl_2$ 57 g.l^{-1}
$NiSO_4$ 26.28 g.l^{-1}
$NiCl_2$ 73.69 g.l^{-1}
5-sulphosalicyclic acid 10.17 g.l^{-1}
$H3BO3$ 40.19 g.l^{-1}
Naphtalene 1,3, 6 tri acid 1.54 g.l^{-1}
Additives

CHOSEN DEPOSITING CONDITIONS

Bath temperature :	40°C
Current density :	3A/dm²
Ph :	1.5

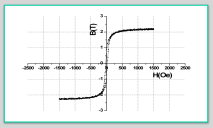
Composition and properties of the magnetic deposited layers



Composition of the magnetic layer determined by quantitative energy dispersive X-ray analysis

$Co_{60}Ni_{15}Fe_{25}$

Hysterisis loop measured by SQUID and Vibrating Sample Magnetometer



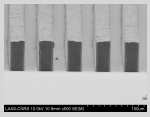
MAGNETIC MATERIAL PROPERTIES

Saturation flux density (B_{sat}) : 2.2T
Coercivity field (H_c) : 24 Oe
Relative permeability (μ_r) : 250

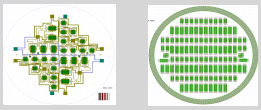
Resisitivity(ρ) : 30 µΩ.cm

Technological steps sequence

The inductor fabrication is based on a low temperature process using photolithography and electroplating techniques and requiring thick photoresist knowledge



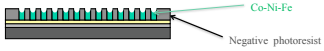
Optimization of the process of a negative strippable thick photoresist



Using the negative photoresist allows to:

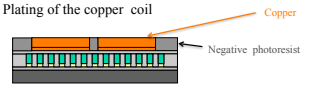
- divide by 2 number of masks
- multiply by 5 the number of components on the wafer

1 Plating of the magnetic core first level in negative photeresist mould

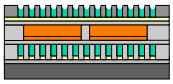


2 Planarisation of the magnetic layer with Su8 photeresist and CMP operation

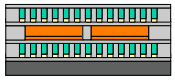
3 Plating of the copper coil



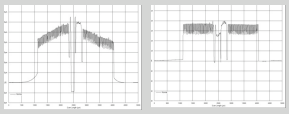
4 Plating of the second magnetic level after copper CMP operation



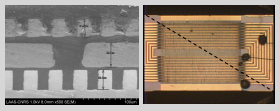
5 Final planarisation of the second magnetic layer with Su8 photeresist and CMP operation



Copper profile

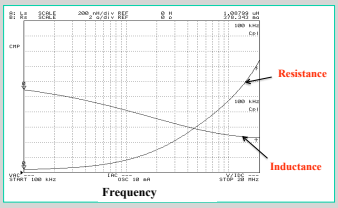


Before CMP After CMP

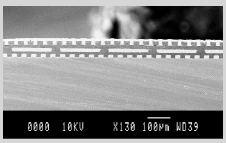


MEB & optical view of the inductor such realized

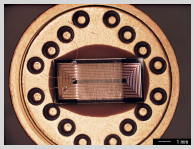
Micro-inductor electrical characterization



Impedance analyser measurement (Agilent 4294A)



Cross-section showing the concuctor (center) and the laminated core



Top view of the complete integrated micro-inductor

Conclusion and prospective

✓ **Validation of a low temperature process allowing a spiral-type micro-inductor fabrication**

✓ **Optimization of a CoNiFe bath and depositing conditions**

◆ **Modelling and simulation of the micro-inductor topology to evaluate the high frequency behaviour (core losses, EMI assessment)**

◆ **Fabrication of a micro-inductor prototype for a specific DC/DC converter in the view of the full integration**