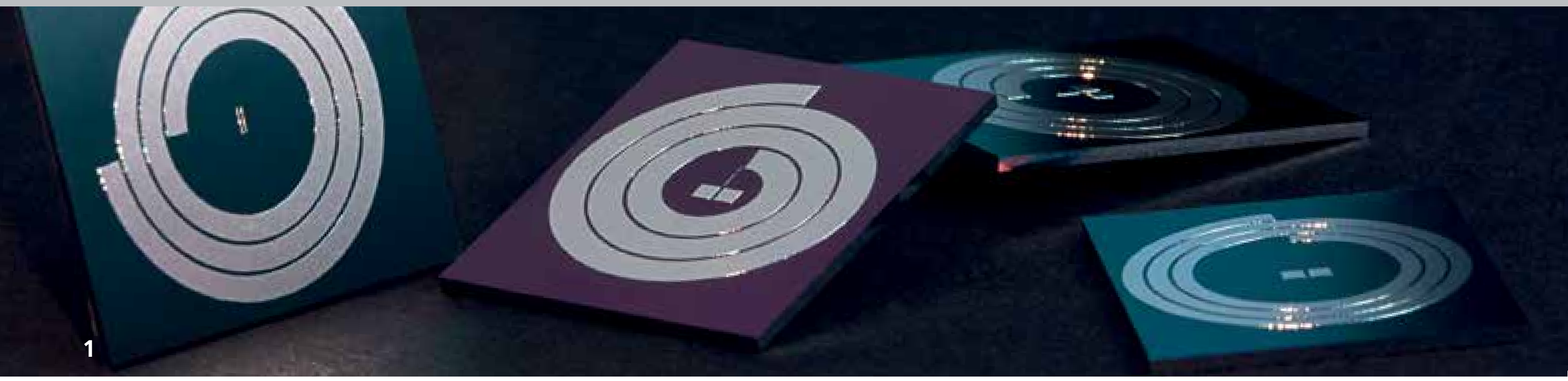
FRAUNHOFER INSTITUTE FOR INTEGRATED SYSTEMS AND DEVICE TECHNOLOGY



1 Diced planar-spiral inductors with air core and Al winding on Si-substrate

HIGH-Q SI-EMBEDDED 3D INDUCTORS

Air coils for power electronics

General description

A CMOS-compatible Si-embedded integrated inductor concept with high-Q factor is available to realize monolithic integration of power converters for portable electronics applications. The buried inductor is fully insulated from the Si-substrate by an oxide layer and can be manufactured with electroplated Cu. The Si-embedded spiral design suggests the highest Q-factor and integration density.

Features

- Fully CMOS-compatible
- Monolithic integration along with active electronics or silicon capacitors or as stand-alone bare die
- Easy design of inductance and Q-factor
- Core less design suitable for operation above 1MHz ($f_{Res} \geq$ 300MHz*)
- Low parasitic capacitance, e.g. as low as 208fF*

Advantages

- Considerably smaller footprint compared to conventional inductors
- Higher Q-factor (Q > 200*) compared to the planar RF inductors (Q = 7*)
- Lower power consumption of integrated circuits (DF = 0.0045*)
- No polarization losses allow for faster switching under high currents compared to ferrite-based inductors

Benefits

- High-profit due to an innovative product
- Increased market volume from expanded product options
- Reduced assembly effort by monolithic integration

* for a 1µH inductor

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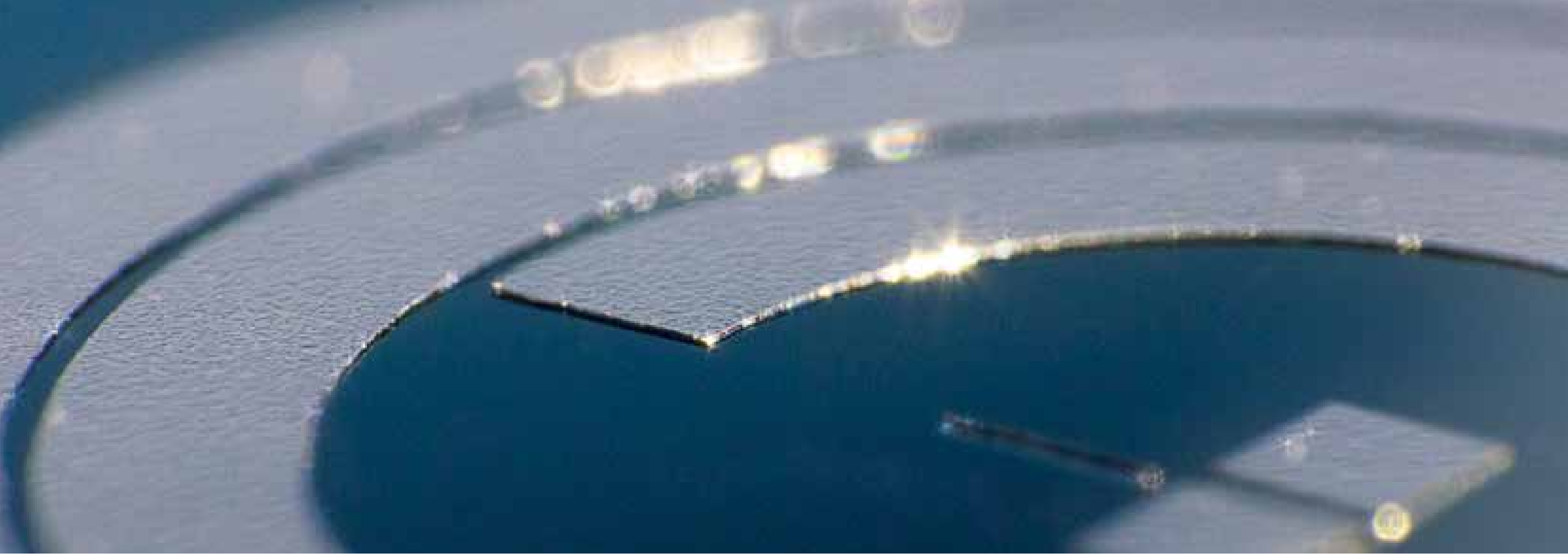
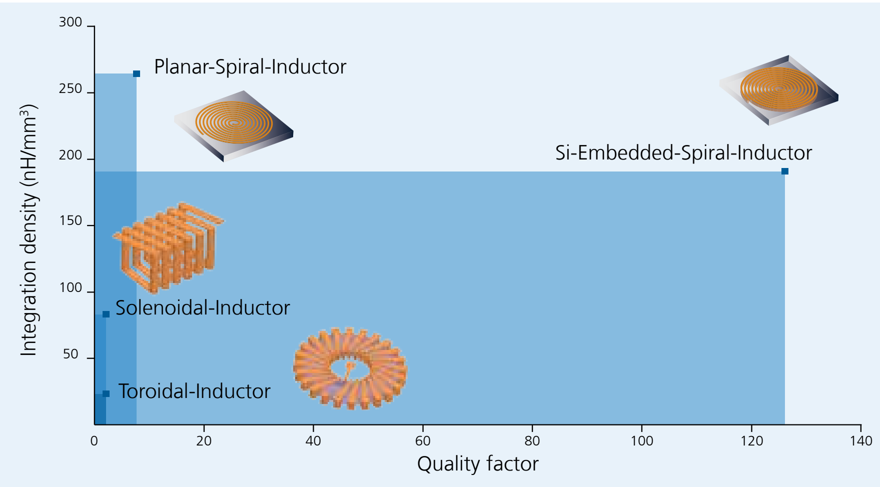


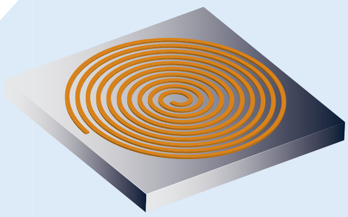


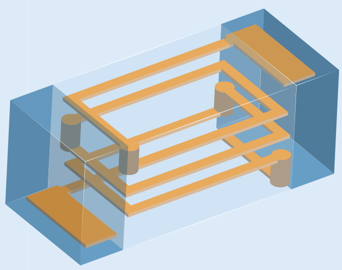
2 Detailed image of a high-Q planar-spiral inductor on a silicon substrate

Fig. 1 displays inductance density in terms of quality factor for solenoidal-, toroidal- and spiral-inductors.
Spiral-inductors are given in planar and Si-embedded models. Number of turns in all architectures is set to be 24.

Performance Characteristics

Technology	Material	Core	Area [mm²]	Volume [mm³]	Inductance [µH]	Inductance density [nH/mm³]	Series resistance [Ω]	Parasitic capacitance [fF]	Resonance frequency [MHz]	Quality factor at 5MHz	Dissipation factor at 5MHz
Planar-spiral on Si-surface	CU	Air core	19.2	3.92	1.04	264	4.23	174	375	7.61	0.13
Multi-layer inductor	CU	Ferrite core	1.28	0.64	1.0	1562	0.20	10142	50	157	0.006
	CU	Air core	1.28	0.64	0.06	8.75	0.20	181	5000	0.88	1.14
Si-embedded spiral	CU	Air core	24.2	5.19	1.10	212	0.16	208	333	221	0.005





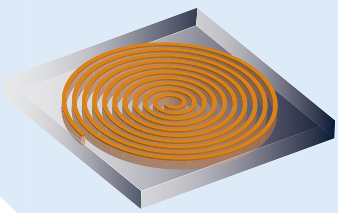


Table 1 indicates key geometrical, technological and electrical parameters of different inductor technologies