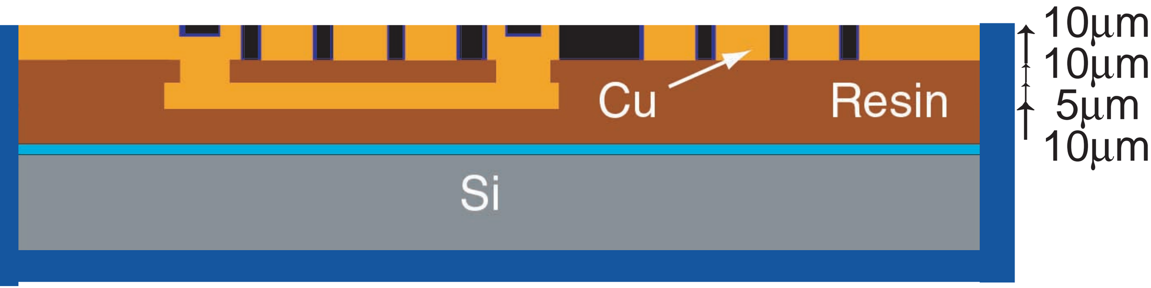
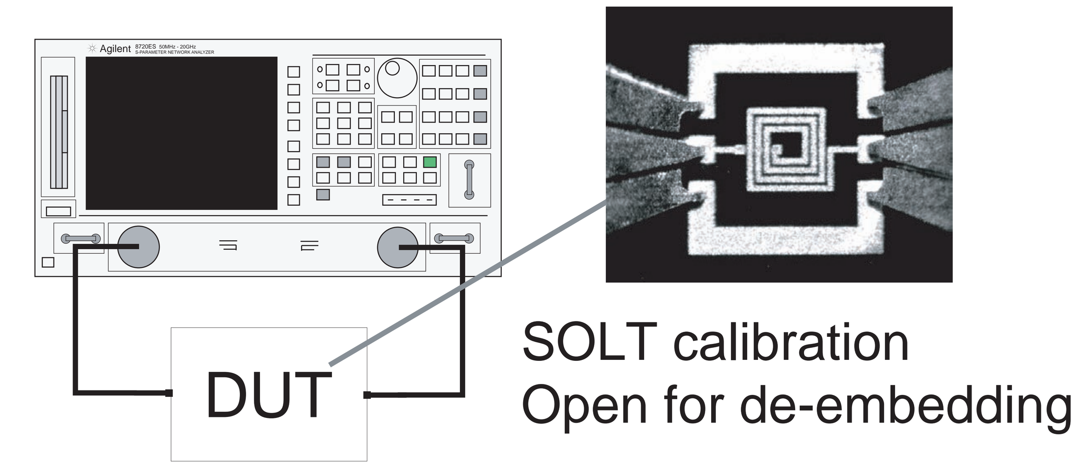
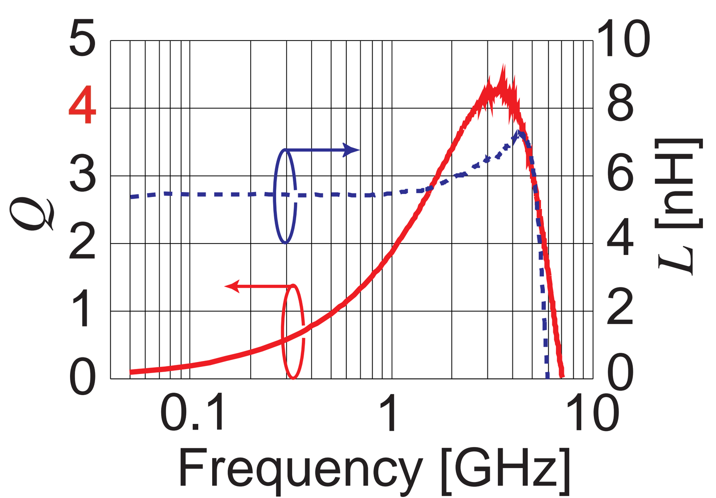
Spiral Inductor Using WL-CSP

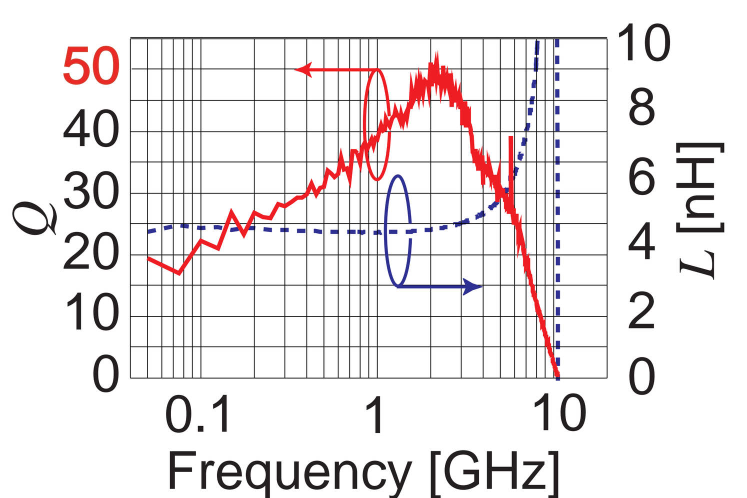
1. 1st Resin coating (10μm) → Curing
2. 1st Cu electroplating (5μm)
3. 2nd Resin coating (10μm) → Curing
4. 2nd Cu electroplating (10μm)





SOLT calibration
Open for de-embedding





$$Q = \frac{-\mathrm{Im}\{Y_{11}\}}{\mathrm{Re}\{Y_{11}\}}$$

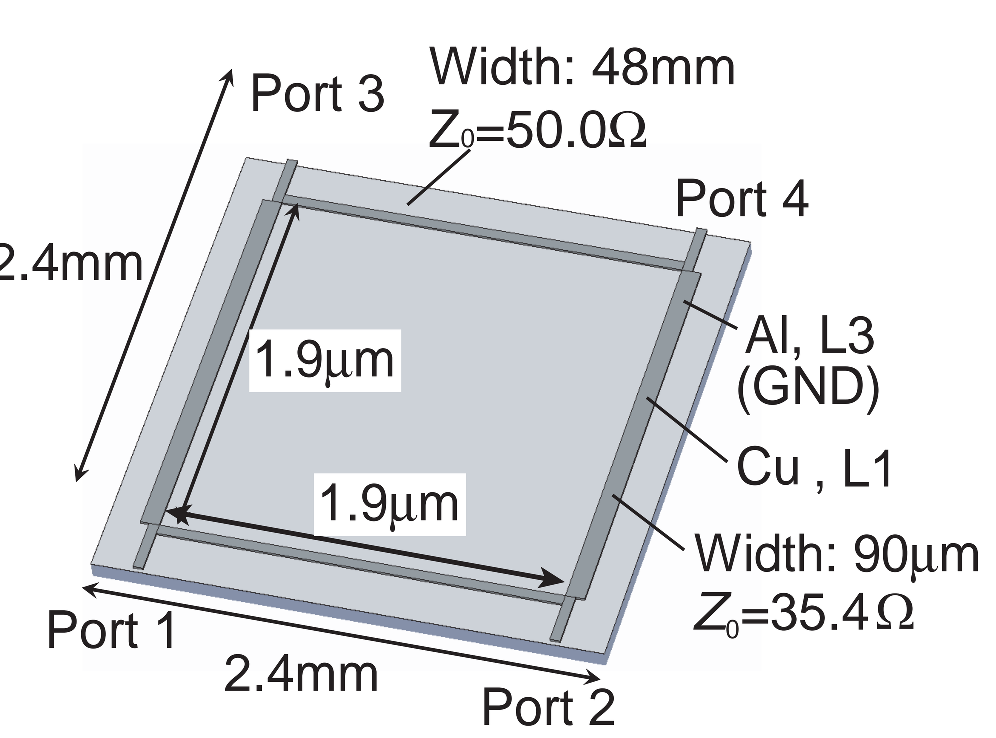
$$L = \frac{1}{2\pi f}\mathrm{Im}\left\{\frac{1}{Y_{11}}\right\}$$

3 turns, M3 (top layer)
Film thickness : 1μm
Line width : 20μm
Line pitch : 4μm
external diameter :450μm

3.5 turns, Cu 2nd (top layer)
Film thickness : 10μm
Line width : 30μm
Line pitch : 20μm
external diameter :460μm

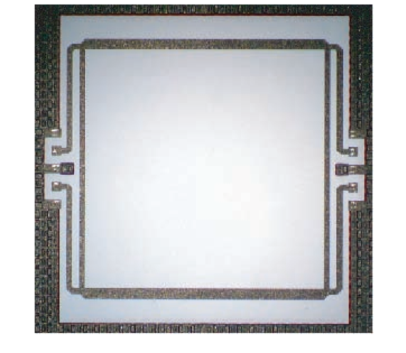
The Q factor of the inductor using WL-CSP technology is more than ten times higher than that of the inductor using normal Si CMOS process.

3dB90° Directional Coupler



Output impedance of each port: 50Ω
Degree of coupling : 3dB
Center frequency: 25GHz
Cu(1st&2nd) thickness: 10μm
Resin thickness: 10μm
Al thickness: 2μm

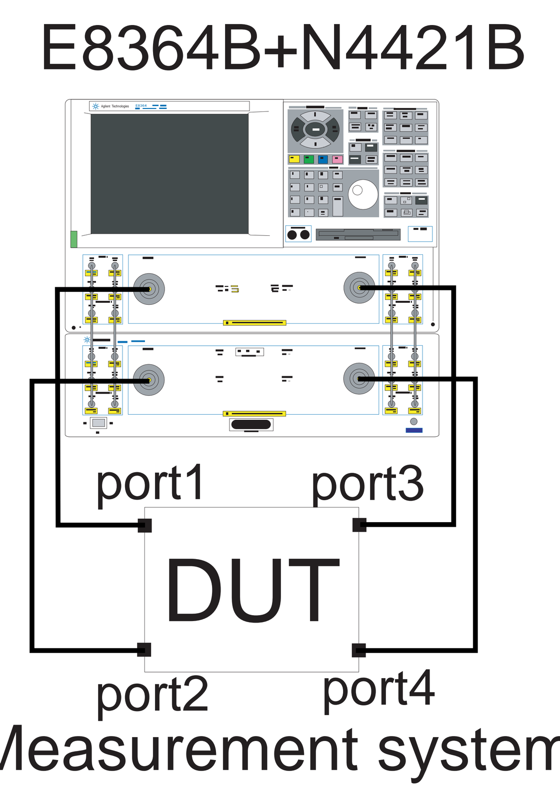
Input : Port 1
Output : Port 3,4
Phase Difference:90°



Chip micrograph

Results

E8364B+N4421B

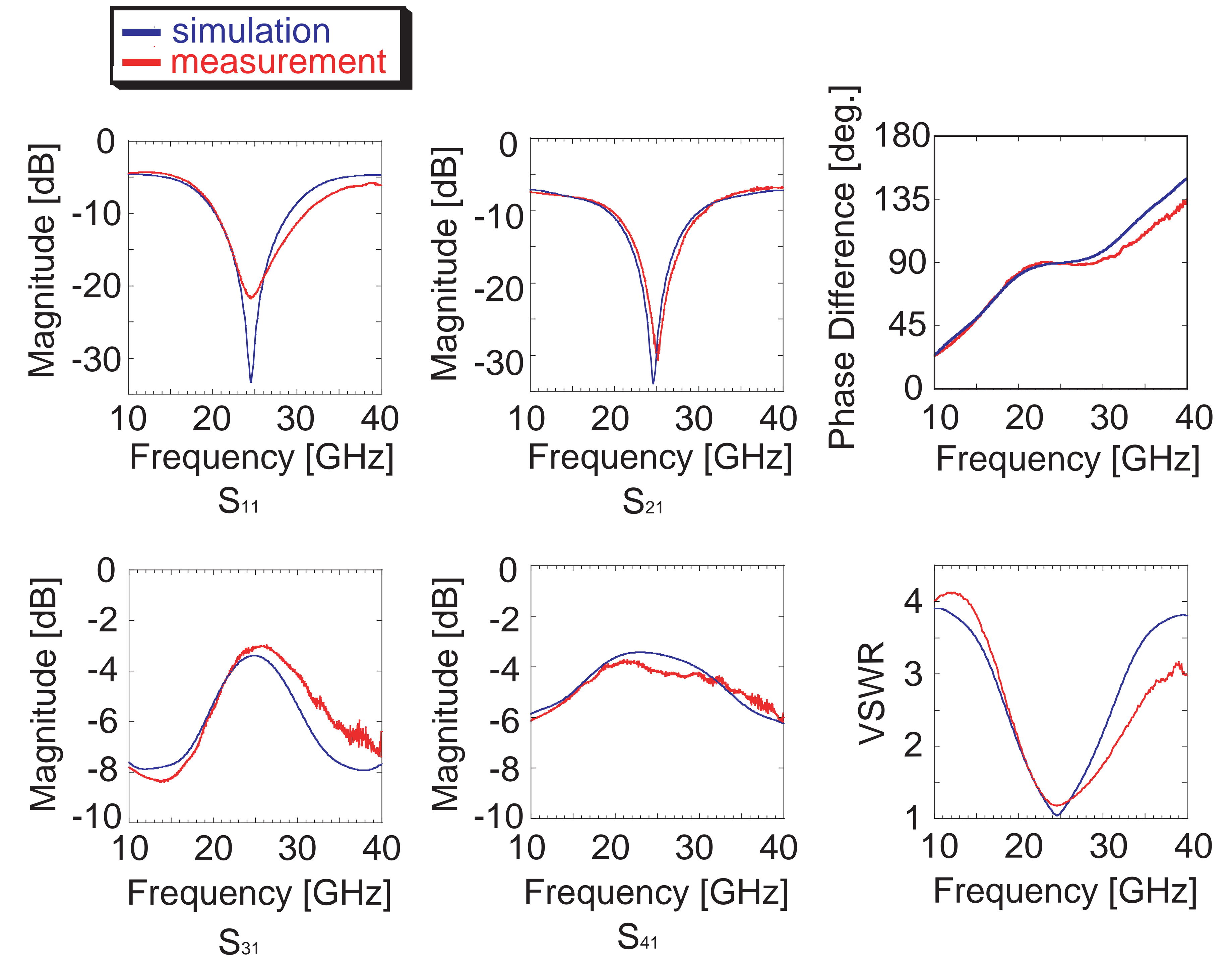


Measurement systems

$$<Insertion\ Loss> = 10\log\frac{P3+P4}{P1}$$

$$<Coupling\ Variation> = 10\log\frac{P3}{P4}$$

$$<Isolation> = 10\log\frac{P2}{P3+P4}$$



The characteristics of directional coupler are examined by the measurement and numerical results from a three-dimensional electromagnetic simulation (CST, MW-Studio).

Simulated results

Insertion loss : -0.4 dB
Coupling variation: 0.1 dB
Isolation : -28.8 dB

Measurement results

Insertion loss : -0.5 dB
Coupling variation: 1.1 dB
Isolation : -29.8 dB

	S_{11}	isolation	coupling variation
measurement	-21	-29.8	1.1
refference[2]	-20	-18	5.5
refference[3]	-40	-38	0.1

The WL-CSP directional coupler has almost the same characteristics as that on GaAs and Al_2O_3 substrates.

Simulated results

VSWR : 1.1
Frequency range :
23.5～26.5 GHz
Fractional band width : 12%

Measurement results

VSWR : 1.2
Frequency range :
21.8～29.4 GHz
Fractional band width : 32%

It is shown that the simulated results are reliable enough to obtain the required value.

[2]S. Banba, et al., IEEE Microwave and Guided Wave Letters, vol. 1, no. 11,pp. 346-347, 1991.
[3] K.W. Eccleston, et al., IEEE Trans. MTT, vol. 51, no. 10, pp. 2119-2125, 2003.

Conclusion

- We propose the use of WL-CSP technology for on-chip passive devices to realize microwave wireless communication circuit.
- The Q factor of the inductor using WL-CSP technology is over ten times higher than that of the inductor using normal Si CMOS process.
- To discuss the performance of distributed constant passive devices using WL-CSP technology, the 3dB90° directional coupler is made and measured by 4-port network analyzer.
- The WL-CSP directional coupler has almost the same characteristics as that on GaAs and Al_2O_3 substrates.
- WL-CSP technology is essential to integrating RF passive devices into Si CMOS chip and to achieve small size and low price RF wireless communication circuits in the future Si CMOS technology.