On-Chip Wireless Signal Transmission using Silicon Integrated Antennas
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Background
Realization of 3D packaging of ULSI circuits for high integration and higher-speed operation.

Issue
Development of interconnect technology between chips.

Solution
Wireless interconnect using on-chip integrated dipole antennas.

Advantages
High speed data transmission by EM wave propagation.
Multiple access by use of UWB communication.
Fabrication by conventional LSI process.
Close range communication.

Si Integrated Antenna
Objective
1. Transmission characteristics of integrated dipole antennas for stacked Si chips.
2. Interference and suppression by 5.2 GHz WLAN for UWB communication using integrated antennae.
3. Equivalent circuit model of Si integrated antennae.

Signal Transmission through Stacked Si Chips

Transmission Characteristics in Frequency Domain
Reflected coefficient (S11)
Transmission coefficient (S21)
Sinusoidal wave (f=20 GHz)
Gaussian monocycle pulse

Transmission and Received Waveform of UWB Signal
Transmitted waveform
Received waveform

Dependences of Gain and Vpp on Number of Stacked Si Chips
Sinusoidal wave (f=20 GHz)
Gaussian monocycle pulse

Integrated Notch Filter
Device parameter
L = 3.06 cm
L' = 1.8 cm
L'' = 0.62 cm
G = 2.95·10^8 S/cm
G' = 20 [F]

Transmission Characteristics of Integrated Notch Filter
Measurement data showed good corresponding to the simulation results. It was found that a notch was observed at 5.2 GHz and separation was approximately 45 dB.

Comparison Simulation Results of Equivalent Circuit with Measurement
S-parameter
Received waveform

Conclusions
1. Gaussian monocycle pulse was transmitted and received successfully through 10 stacked Si chips with 0.4 mV peak-to-peak voltage. The attenuation was improved by insertion of high resistivity Si chip.
2. Interference of WLAN at 5.2 GHz on UWB data transmission was investigated and suppressed by use of the designed notch filter integrated on Si chip.
3. Equivalent circuit model was developed for Si on-chip integrated antennae. Using the equivalent circuit model and extracted RLC parameters, received waveform could be reproduced by HSPICE simulator successfully.

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Motivation

Signal Transmission through
Stacked Si Chips

Equivalent Circuit Model of Si Integrated Antenna
Transmitting antenna
Channel
Receiving antenna

Parameter

The simulation results using the equivalent circuit model fitted well with the measurement data of S11 and S21, respectively.

Using extracted RLC parameters and equivalent circuit model, received waveform of Gaussian monocycle pulse was simulated by HSPICE circuit simulator.

The simulation result could be reproduce the measurement data.