New Approach to Reduce Radiated Emissions from Semiconductor by Using Absorbent Materials

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Abstract

Semiconductors performing digital clocking are a main source of radiated emission noise. Therefore, the most secure method of reducing emission noise is to reduce emission radiated from semiconductors; an application of an absorber to the surface of semiconductors is one of these methods, too. However, in reality, it is difficult to achieve as much effect of noise reduction as expected by using only absorber. It is confirmed by experiment in this paper that a loop area within chip has no correlation with radiated emission noise and it is clarified why the existing absorber fails to achieve a satisfactory effect of emission noise reduction. Besides, a new type of chip coating absorber has been developed which can cover up to semiconductor out lead by using ferrite coating material of ferrite/epoxy acrylate substance using only permeability loss out of electromagnetic wave reduction characteristics of materials. As a result of evaluating radiated emission noise by applying this coating absorber to semiconductor device, it could be confirmed that emission noise decreased from about 3dB up to 20dB depending on frequency.

Ⅰ. Introduction

Advances in digital technology and semiconductor have made the size of electronic equipment smaller and their structure more complex while the increasing number of circuits places interconnection in a narrow space with a large integration, thereby causing serious problems of electromagnetic emission due to SSN (Simultaneous Switching Noise) or ground bouncing, etc. Besides, the emission noise radiated from the majority of electronic equipment varies according to each equipment; it is not the noise of specific frequency, but the noise of broad band, which makes it actually difficult to find a solution to the problem.

In an effort to solve this problem, many set makers apply EMI solution at the system level based on empirical data, but the trend of larger integration for semiconductor package makes it impossible not only to identify noise source, but also to obtain a perfect EMI solution unless the noise characteristics of semiconductor are accurately analyzed.

For the most secure method to solve this problem of emission noise, design of EMI at the time of semiconductor chip design is believed to be the most economical method, but up to now there are actually a lot of technological constraints and limitations.

The method of applying an absorber as one of the methods to reduce the noise radiated from semiconductors is often adopted recently, but its effect is, in fact, not so satisfactory as expected.

In this paper, the new method of applying a chip coating absorber which can cover up to semiconductor lead frame by using ferrite coating material of ferrite/epoxy acrylate substance was applied to examine the ways of curbing the emission noise radiated from semiconductors.

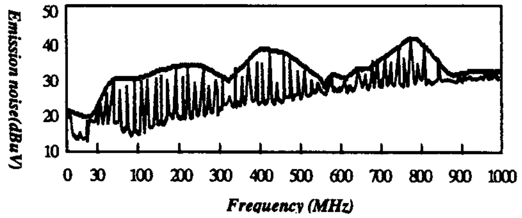
Ⅱ. Development of Absorber Material

The method of applying an absorber is often adopted as one of the methods for reducing noise radiated from semiconductors is often adopted.

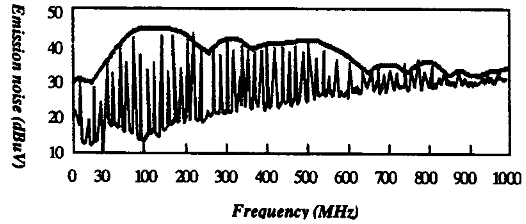
The noise created around semiconductors which is a source of emission noise source is, in large part, divided into 3 types of noise as follows:

1. Radiated noise caused by signal propagation through the semiconductor metallization and package lead frame
2. Radiated noise caused by propagation of semiconductor emitted signals through the trace pattern on a board
3. Radiated noise caused by supply current flowing through the PCB power supply and ground layers.

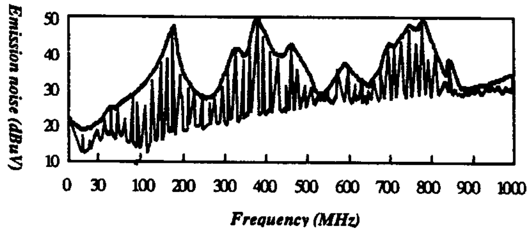
Out of the above radiated noises, only the noise No. 1 can show the effect of using an absorber and for the remaining noises, the effect of an absorber can not be expected. However, the magnitude of radiated noise No. 3 is the largest and then No. 2 and No. 1 in that order. Therefore, it is in fact difficult to expect the significant effect from the existing absorber reducing only the noise No. 1.



1) semiconductor metallization and package lead frame



2) trace pattern on a board

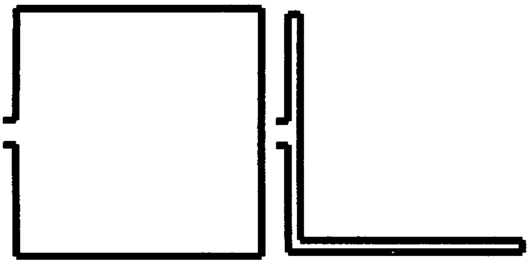


3) PCB power supply and ground layers

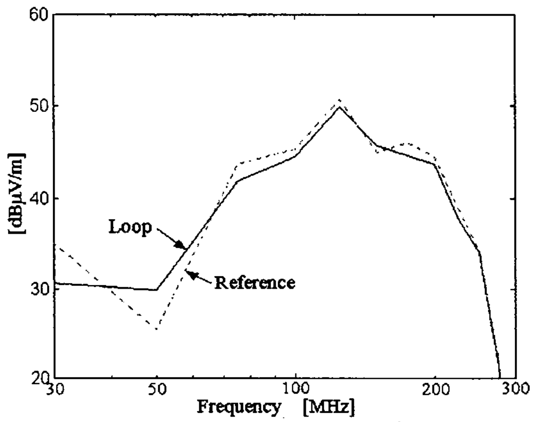
[Fig. 1] Radiated noise created around semiconductor.

Actually, it was confirmed by the experiment that a loop area within chip has no correlation with radiated emission noise. [Fig. 2], [Fig. 3] show the result of experimenting loop area within chip and radiated emission noise.

In the final analysis, the conclusion is drawn that it is difficult to achieve a satisfactory result by



[Fig. 2] Test loop and reference loop within chip (loop area: 3,000 μm × 3,000 μm).



[Fig. 3] Experiments of on-chip differential mode radiation(input frequency = 100 MHz).

covering only package surface as is done now in order to reduce radiated noise and at least up to package out lead must be covered for the more effective function of an absorber.

However, two problems had to be solved in order to cover package out lead.

1. It must be electrically insulated to avoid short between package out leads.
2. It must be easily workabe to be applied to various package types.

In an effort to satisfy the above requirements, a new type of chip coating absorber has been developed which can cover up to semiconductor lead frame by using ferrite coating material of ferrite/epoxy acrylate substance using only permeability loss out of electromagnetic wave reduction characteristics of materials.

The basic principle of electromagnetic wave absorber out of electromagnetic wave reduction characteristics of materials is to match the incident wave with the impedance of materials under incidence and thus to induce an entry of incident wave into the inside of materials and reduce it inside materials. Accordingly, the impedance of materials is an important factor of the electromagnetic wave absorbing capability; the impedance is represented by complex permeability, complex permittivity and thickness. In this regard, it is noteworthy that the permittivity loss and permeability loss of materials are used.

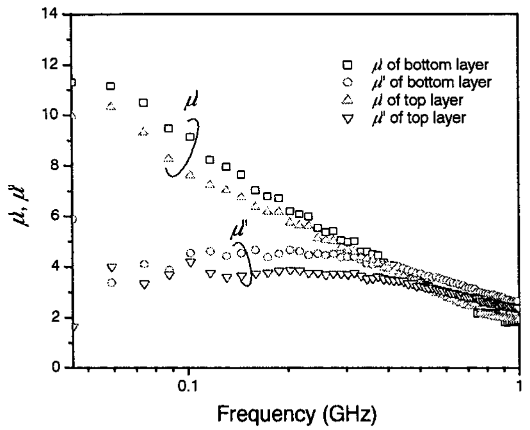
For an electromagnetic wave absorber, a multiple layer type instead of a single layer type was applied to make the absorbing band wider.

[Fig. 4], [Fig. 5] show the complex permeability and complex permittivity characteristics of the developed absorber respectively.

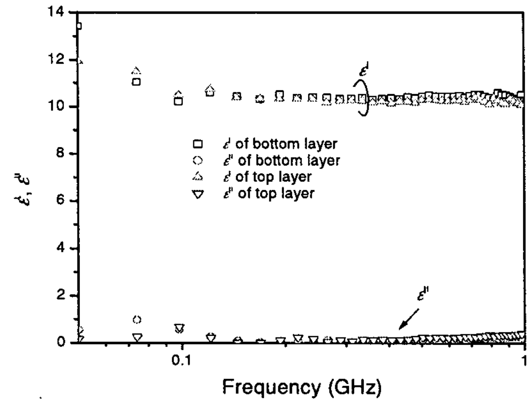
As is shown in the diagram, the real number of permeability gradually decreases while the imaginary number reaches the peak at about 200MHz band and then gradually decreases.

Ⅲ. Evaluation of EMI Reduction Characteristics

A study has been conducted to examine the effect of applying chip coating absorber to ATAPI decoder



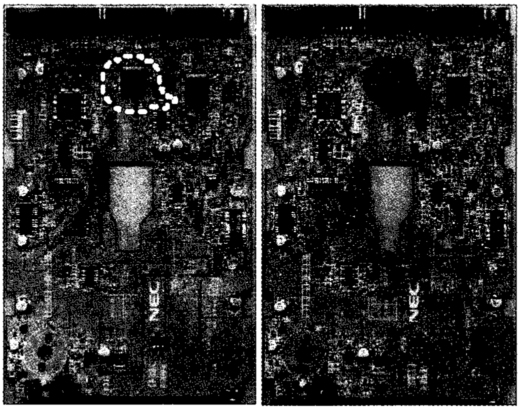
[Fig. 4] Complex permeability(μ) of the developed absorber.



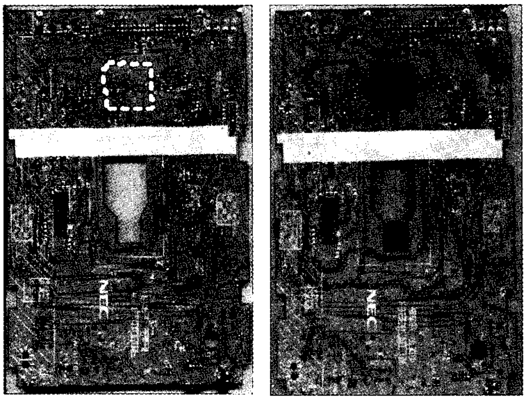
[Fig. 5] Complex permittivity(ε) of the developed absorber.

chip within CDROM board. The ATAPI decoder chip represents IML1401 ASIC device in which logic part of 0.5 μm design rule and 1MDRAM memory are merged and its speed is the fastest within the board having 50 MHz operating frequency. This device has 4 poly 3 metal topology and its package type is 100 TQFP(Thin Quad Flat Package).

GTEM cell was used to evaluate radiated emission noise and initial board state exceeded FCC limit at the band of 100 MHz, 200 MHz, 400 MHz, 500 MHz, 600 MHz representing harmonic frequency of 50 MHz. It was confirmed that ATPI decoder ASIC device was a main source of these noises and in an effort to improve this, chip coating absorber was coated up to problematic ASIC device out lead.

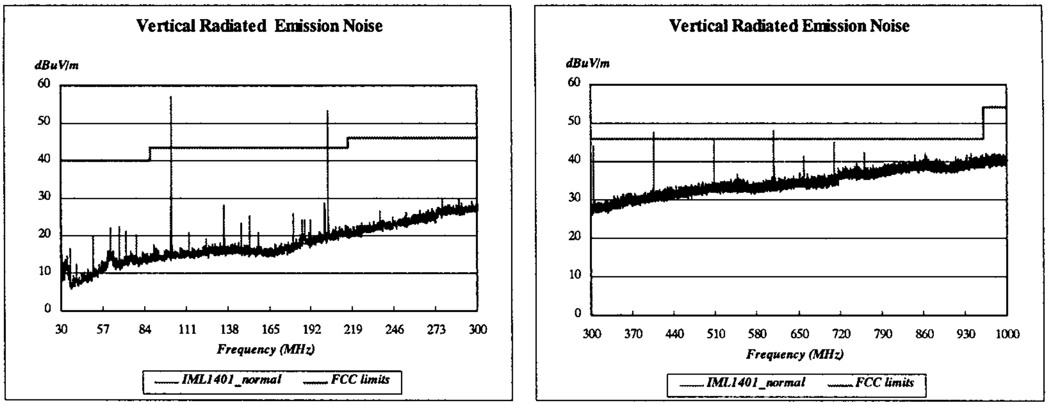


[Fig. 6] Photo of board before & after coating(front-side of board).

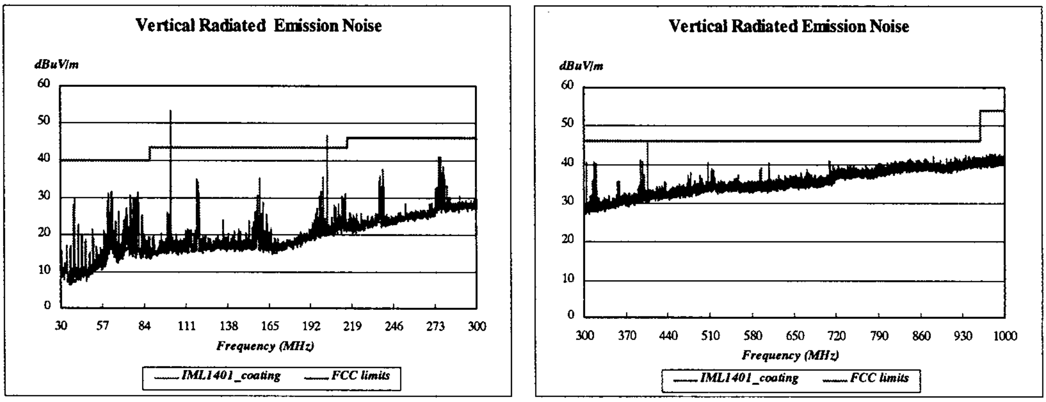


[Fig. 7] Photo of board before & after coating(back-side of board).

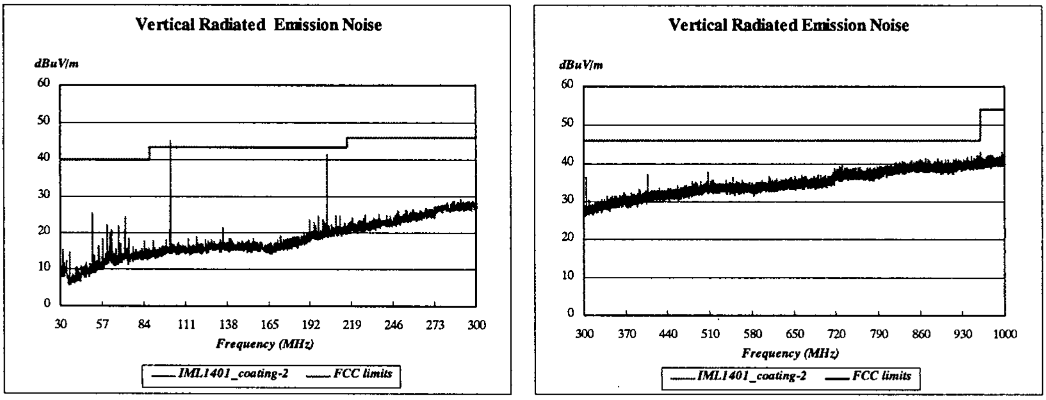
Especially, an area in which ASIC device on the back side of CDROM board is located is not covered



a) before coating (normal)

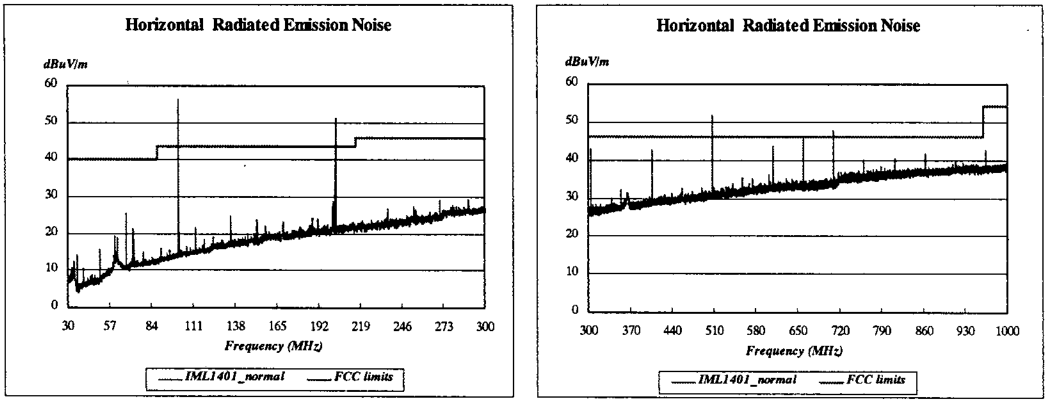


b) after package coating

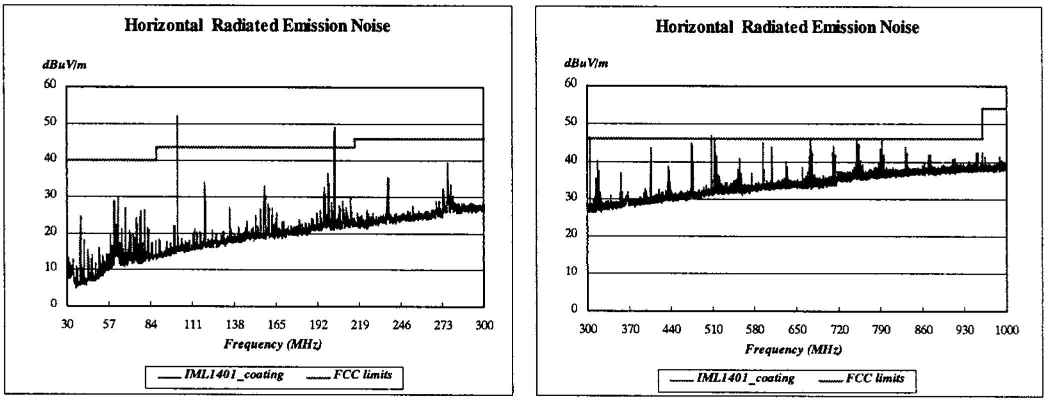


c) after package & back side of board coating

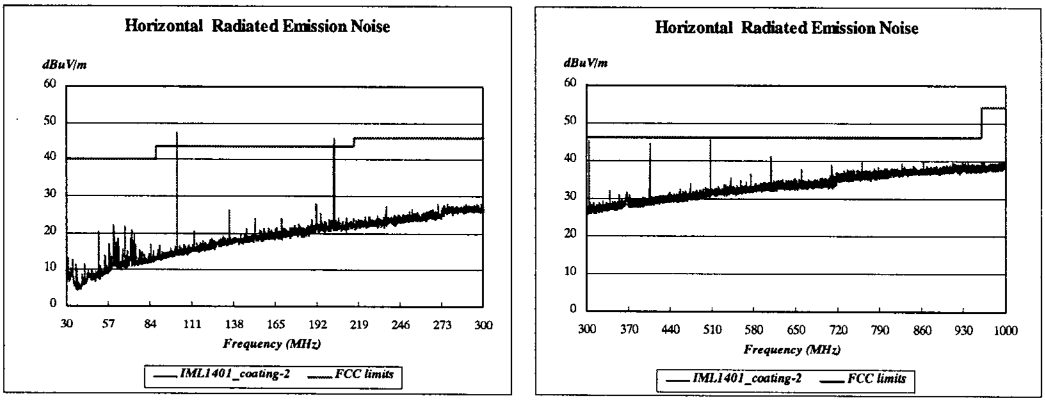
[Fig. 8] Vertical radiated emission noise.



a) before coating (normal)



b) after package coating



c) after package & back side of board coating

[Fig. 9] Horizontal radiated emission noise.

by ground, but completely exposed. In order to improve this weakness, coating is applied also to the back side of board.

[Fig. 6], [Fig. 7] show photos of the board before and after coating absorber is applied.

[Fig. 8] and [Fig. 9] show the result of evaluating vertical, horizontal radiated emission noise respectively before and after application of chip coating absorber.

It could be confirmed from the result of evaluating radiated emission noise of board after coating that the noise decreased from 3 dB to 20 dB as a whole. Especially, the performance of reducing most peak noises was shown at the band of 300 MHz or higher.

Especially, the effect of EMI reduction proved greater when coating was applied up to the back side of board than it was applied only to the semiconductor package, showing that the scope of applying the coating absorber studied in this paper can be extended to the coating of semiconductor products and section with a large loop antenna area inside the board as well.

Ⅳ. Conclusion

However, in reality, it is difficult to achieve as much effect of noise reduction as expected by using only absorber. It is confirmed by experiment in this paper that an area within chip loop has no correlation with radiated emission noise and it is clarified why the existing absorber fails to achieve a satisfactory effect of emission noise reduction.

Besides, a new type of chip coating absorber has been developed which can cover up to semiconductor lead frame by using ferrite coating material of ferrite/epoxy acrylate substance using only permeability loss out of electromagnetic wave reduction characteristics of materials. As a result of evaluating radiated emission noise by applying this coating absorber to semiconductor device, it could be confirmed that emission noise decreased from about 3dB up to 20 dB depending on frequency.

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When this chip coating absorber is applied, it is judged that the problem of emission noise can be solved swiftly and the noise source can be interpreted exactly.

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