同行专家业内评价意见书编号：20250854461

附件1

浙江工程师学院（浙江大学工程师学院）
同行专家业内评价意见书

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学号： 22260106

申报工程师职称专业类别（领域）： 电子信息

浙江工程师学院（浙江大学工程师学院）制

2025年05月26日

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四、同行专家业内评价意见书编号由工程师学院填写，编号规则为：年份4位＋申报工程师职称专业类别(领域)4位+流水号3位，共11位。

一、个人申报

（一）基本情况【围绕《浙江工程师学院（浙江大学工程师学院）工程类专业学位研究生工程师职称评审参考指标》，结合该专业类别(领域)工程师职称评审相关标准，举例说明】

1.对本专业基础理论知识和专业技术知识掌握情况(不少于200字)

在知识掌握方面，本次项目为我提供了一个重新学习电磁场与微波知识的契机。在基础知识之上，我进一步加深了对电磁理论中高级概念的理解，如阻抗匹配、多重吸收机制和人工电磁结构的设计与工作原理。这些都是现代电磁学研究中非常重要的内容。我通过大量的文献调研，获得了关于高频芯片系统级封装及其辐射抑制方案的全面认识。这个过程中，我不仅掌握了书本上的知识，更是实现了从理论到前沿科研领域的知识升华，这些都为我的后续研究工作打下了坚实的基础。

2.工程实践的经历(不少于200字)

本次项目极大地提高了我在电磁仿真软件CST和HFSS上的使用熟练度。通过大量的仿真试验，我不仅提升了对软件的操作能力，还深入理解了电磁仿真软件的底层工作原理。通过对不同算法优劣的比较，我学会了如何选择合适的模块和软件以优化仿真速度。在文献调研过程中，我的文献检索能力显著提高，对文章主要内容的快速把握能力也得到了提升。此外，作为项目的负责人，我学会了如何更好地把控项目的整体进度，提高了推进项目的能力。这包括制定合理的时间表，确保项目的每个阶段按计划进行。

3.在实际工作中综合运用所学知识解决复杂工程问题的案例（不少于1000字）

在本次项目中，我们在吸波体设计、吸收体测试与反馈优化，以及芯片封装尺寸对吸波影响的研究方面取得了显著成效。这些成就不仅在技术层面上推动了项目的进展，也为我们在学术领域的贡献奠定了坚实基础。以下是具体的成果总结：

1. 吸波体设计

A) 电阻膜FSS方案的理论建模和分析

我们利用多层等效电路模型对电阻膜频率选择表面（FSS）方案进行了深入的理论建模和分析。通过这个模型，我们能够准确地预测吸波体在不同频段的性能表现，尤其是在目标频段的阻抗匹配和衰减系数。我们还从材料的等效电磁参数角度分析了孔隙型有耗介质吸收体的行为，这为我们在设计孔隙结构时提供了重要的理论指导。

B) 样品设计方案

基于理论分析的结果，我们分别为电阻膜FSS和孔隙型有耗介质这两种方案制定了具体的样品设计方案。考虑到工程约束条件，我们在样品设计时确保其在实际应用中的可操作性。设计方案中详细规定了各个样品的结构参数和材料选择，以确保在工程实施过程中具备足够的灵活性。

C) 设计流程的详细说明

为了使设计过程更加透明和易于复现，我们通过流程图和具体实例详细说明了设计流程。这一部分工作为团队成员及后续的研究人员提供了清晰的指导，确保在未来的项目中能够高效地进行类似设计。

D) 结构参数和环境参数对性能的影响

我们进行了多次实验和仿真分析，以揭示结构参数和环境参数对吸收体性能的影响。通过这些分析，我们能够识别出哪些参数对吸波体性能有重大影响，并据此调整设计方案，以优化吸波体的性能。

2. 吸收体测试和反馈优化

A) 测试结果

我们对电阻型吸收体和孔隙型有耗介质吸收体进行了严格的测试。电阻型吸收体在小芯片测试环境中的结果显示吸收水平在-7.4至-11.8dB之间，最差表现出现在20.625GHz。对于孔隙型有耗介质吸收体，材料B的吸收水平在-9.6至-11.7dB之间，而材料A的表现更为优异，整体测试结果在-14dB附近，尤其是在26GHz以上的高频段表现理想。

B) 突破工程约束的优化方案

通过对测试数据的分析，我们提出了突破单个和多个工程边界条件的孔隙型有耗介质优化方案。这些方案不仅在理论上提供了改进的方向，也为实际操作提供了具体指导，使得我们的设计能够更好地适应不同的应用场景和工程需求。

3. 芯片封装尺寸对吸波影响的探究

我们对芯片封装尺寸对吸波性能的影响进行了全面研究。通过一系列实验，我们确定了封装尺寸对吸波体性能的关键影响因素。这项研究帮助我们更好地理解如何在不同封装条件下优化吸波体设计，以确保其在多样化的实际应用中保持优异性能。

在学术方面，我们基于项目研究成果发表了两篇EI（Engineering Index）收录的论文，其中一篇在EMC领域的顶级会议上发表。这些论文的发表不仅展示了我们的研究成果，也在一定程度上提升了我们在电磁兼容性领域的学术影响力。

综上所述，本次项目的成功实施在多个方面取得了显著成效，既推动了吸波体技术的发展，也在学术研究和应用实践中做出了积极贡献。这些成果为未来的研究奠定了坚实的基础，并为行业发展提供了有价值的参考。

（二）取得的业绩（代表作）【限填3项，须提交证明原件（包括发表的论文、出版的著作、专利证书、获奖证书、科技项目立项文件或合同、企业证明等）供核实，并提供复印件一份】					
1. 公开成果代表作【论文发表、专利成果、软件著作权、标准规范与行业工法制定、著作编写、科技成果获奖、学位论文等】					
成果名称	成果类别 [含论文、授权专利（含发明专利申请）、软件著作权、标准、工法、著作、获奖、学位论文等]	发表时间/授权或申请时间等	刊物名称/专利授权或申请号等	本人排名/总人数	备注
Porous Absorber for Electromagnetic Radiation Suppression in Chip-Packages	会议论文	2024年08月06日	2024 IEEE International Symposium on Electromagnetic Compatibility, Signal & Power Integrity (EMC+SIPI), IEEE, 2024	1/6	EI会议收录
A Miniaturized Absorber for Radiation Suppression in the Chip Package	会议论文	2023年10月22日	2023 IEEE 7th International Symposium on Electromagnetic Compatibility (ISEMC), IEEE, 2023.	1/4	EI会议收录

2.其他代表作【主持或参与的课题研究项目、科技成果应用转化推广、企业技术难题解决方案、自主研发设计的产品或样机、技术报告、设计图纸、软课题研究报告、可行性研究报告、规划设计方案、施工或调试报告、工程实验、技术培训教材、推动行业发展中发挥的作用及取得的经济社会效益等】

<table>
<tr><td colspan="2">（三）在校期间课程、专业实践训练及学位论文相关情况</td></tr>
<tr><td>课程成绩情况</td><td>按课程学分核算的平均成绩： 86 分</td></tr>
<tr><td>专业实践训练时间及考核情况(具有三年及以上工作经历的不作要求)</td><td>累计时间： 1.1 年（要求1年及以上）
考核成绩： 89 分</td></tr>
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申报人签名：林超龙</td></tr>
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二、日常表现考核评价及申报材料审核公示结果

日常表现 考核评价	非定向生由德育导师考核评价、定向生由所在工作单位考核评价： ☑优秀　　□良好　　□合格　　□不合格 德育导师/定向生所在工作单位分管领导签字（公章）：　　年　月　日
申报材料 审核公示	根据评审条件，工程师学院已对申报人员进行材料审核（学位课程成绩、专业实践训练时间及考核、学位论文、代表作等情况），并将符合要求的申报材料在学院网站公示不少于5个工作日，具体公示结果如下： □通过　　□不通过（具体原因：　　　　　　） 工程师学院教学管理办公室审核签字（公章）：　　年　月　日

浙 江 大 学 研 究 生 院

攻读硕士学位研究生成绩表

学号：22260106	姓名：林超龙	性别：男	学院：工程师学院	专业：电子信息	学制：2.5年
毕业时最低应获：26.0学分		已获得：28.0学分		入学年月：2022-09	毕业年月：
学位证书号：			毕业证书号：		授予学位：

学习时间	课程名称	备注	学分	成绩	课程性质	学习时间	课程名称	备注	学分	成绩	课程性质
2022-2023学年秋季学期	新时代中国特色社会主义理论与实践		2.0	93	公共学位课	2022-2023学年春季学期	自然辩证法概论		1.0	80	公共学位课
2022-2023学年秋季学期	工程技术创新前沿		1.5	87	专业学位课	2022-2023学年春夏学期	移动互联网智能设备应用设计与实践		3.0	90	专业学位课
2022-2023学年冬季学期	电磁场数值分析		2.0	96	跨专业课	2022-2023学年夏季学期	研究生英语基础技能		1.0	免修	公共学位课
2022-2023学年秋冬学期	电子与信息工程技术管理		2.0	85	专业学位课	2022-2023学年夏季学期	物联网信息安全技术与应用基础		2.0	91	专业学位课
2022-2023学年秋冬学期	工程伦理		2.0	94	公共学位课	2022-2023学年春夏学期	高阶工程认知实践		3.0	84	专业学位课
2022-2023学年秋冬学期	研究生论文写作指导		1.0	73	专业学位课	2022-2023学年夏季学期	研究生英语		2.0	免修	公共学位课
2022-2023学年冬季学期	产业技术发展前沿		1.5	93	专业学位课		硕士生读书报告		2.0	通过	
2022-2023学年春季学期	数学建模		2.0	71	专业选修课						

说明：1.研究生课程按三种方法计分：百分制，两级制（通过、不通过），五级制（优、良、中、及格、不及格）。

2.备注中“*”表示重修课程。

学院成绩校核章：

成绩校核人：张梦依

打印日期：2025-06-03

（60）
成绩校核章

经检索"Engineering Village"，下述论文被《Ei Compendex》收录。（检索时间：2025 年 3 月 26 日）。

<RECORD 1>
Accession number:20240415426948
Title:A Miniaturized Absorber for Radiation Suppression in the Chip Package
Authors:Lin, Chaolong (1); Xing, Jiaqi (1); Li, Da (1); Li, Er-Ping (1)
Author affiliation:(1) Zhejiang University, The Zhejiang Key Lab. of Advanced Micro/Nano Electronic Devices Smart Systems and Applications, Hangzhou, China
Source title:IEEE International Symposium on Electromagnetic Compatibility
Abbreviated source title:IEEE Int. Symp. Electromagn. Compat.
Part number:1 of 1
Issue title:7th International Symposium on Electromagnetic Compatibility, ISEMC 2023 - Proceedings
Issue date:2023
Publication year:2023
Language:English
ISSN:10774076
E-ISSN:21581118
CODEN:IISPDC
ISBN-13:9798350333107
Document type:Conference article (CA)
Conference name:7th IEEE International Symposium on Electromagnetic Compatibility, ISEMC 2023
Conference date:October 20, 2023 - October 23, 2023
Conference location:Hangzhou, China
Conference code:196072
Publisher:Institute of Electrical and Electronics Engineers Inc.
Number of references:13
Main heading:Dielectric materials
Controlled terms:Miniature instruments
Uncontrolled terms:Chip packages - Double layer structure - Leakage suppression - Microwave absorbers - Miniaturisation - Radiation leakages - Radiation suppression - Resistive film - Square rings - Ultra-wide
Classification code:708.1 Dielectric Materials
Numerical data indexing:Decibel -1.00E+01dB, Decibel 1.10E+01dB to 1.00E+01dB, Frequency 2.38E+10Hz to 4.00E+10Hz, Frequency 2.55E+10Hz to 3.95E+10Hz
DOI:10.1109/ISEMC58300.2023.10370448
Funding details: Number: 62027805,62071424,62201499, Acronym: NSFC, Sponsor: National Natural Science Foundation of China;Number: LD21F010002,LQ23F010019, Acronym: ZJNSF, Sponsor: Natural Science Foundation of Zhejiang Province;Number: 226-2022-00145, Acronym: -, Sponsor: Fundamental Research Funds for the Central Universities;
Funding text:This work is supported by the Fundamental Research Funds for the Central Universities under Grant No. 226-2022-00145, National Natural Science Foundation of China under Grant No. 62201499, 62071424 and 62027805, Zhejiang Provincial Natural Science Foundation of China under Grant No. LQ23F010019 and LD21F010002.
Database:Compendex

<RECORD 2>
Accession number:20244517306337
Title:Porous Absorber for Electromagnetic Radiation Suppression in Chip-Packages
Authors:Lin, Chaolong (1); Xing, Jiaqi (1); Li, Da (1); Zhang, Ling (1); Ma, Hanzhi (1); Li, Er-Ping (1)
Author affiliation:(1) Polytechnic Institute of Zhejiang University, College of Information Science & Electronic Engineering, ZJU-UIUC Institute, Zhejiang University, Hangzhou, China
Corresponding author:Lin, Chaolong(chaolonglin@zju.edu.cn)
Source title:IEEE International Symposium on Electromagnetic Compatibility
Abbreviated source title:IEEE Int. Symp. Electromagn. Compat.

Part number:1 of 1
Issue title:2024 IEEE International Symposium on Electromagnetic Compatibility, Signal and Power Integrity, EMC+SIPI 2024
Issue date:2024
Publication year:2024
Pages:348-353
Language:English
ISSN:10774076
E-ISSN:21581118
CODEN:IISPDC
ISBN-13:9798350360394
Document type:Conference article (CA)
Conference name:2024 IEEE International Symposium on Electromagnetic Compatibility, Signal and Power Integrity, EMC+SIPI 2024
Conference date:August 5, 2024 - August 9, 2024
Conference location:Phoenix, AZ, United states
Conference code:203275
Publisher:Institute of Electrical and Electronics Engineers Inc.
Number of references:12
Main heading:Electronics packaging
Controlled terms:Electromagnetic wave emission - Electromagnetic wave propagation - Electromagnetic wave reflection - Reverberation
Uncontrolled terms:Absorber - Absorbing materials - Chip packages - Effective media theory - Electromagnetics - Impedance matchings - In-chip - Low-profile - Matching condition - Radiation suppression
Classification code:711.1 Electromagnetic Waves in Different Media - 715 Electronic Equipment, General Purpose and Industrial - 751.1 Acoustic Waves - 751.3 Architectural Acoustics - 913.4 Manufacturing
Numerical data indexing:Decibel -1.20E+01dB, Decibel -1.40E+01dB, Frequency 2.00E+10Hz to 3.00E+10Hz, Frequency 2.03E+10Hz to 2.98E+10Hz
DOI:10.1109/EMCSIPI49824.2024.10705439
Funding details: Number: 62201499,62071424,62027805, Acronym: NSFC, Sponsor: National Natural Science Foundation of China;Number: -, Acronym: NSFC, Sponsor: National Natural Science Foundation of China;Number: LQ23F010019,LD21F010002,LQ23F010020, Acronym: ZJNSF, Sponsor: Natural Science Foundation of Zhejiang Province;Number: -, Acronym: ZJNSF, Sponsor: Natural Science Foundation of Zhejiang Province;
Funding text:This work was partially sponsored by the National Natural Science Foundation of China under Grant No. 62201499, 62071424, and 62027805 and Zhejiang Provincial Natural Science Foundation under Grant No. LQ23F010019, LQ23F010020, and LD21F010002.
Database:Compendex

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教育部科技查新工作站（Z09）
检索人（签章）：应湘艺
2025年3月26日

A Miniaturized Absorber for Radiation Suppression in the Chip Package

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2023 IEEE 7th International Symposium on Electromagnetic Compatibility (ISEMC) | 979-8-3503-3310-7/23/$31.00 ©2023 IEEE | DOI: 10.1109/ISEMC58300.2023.10370448

***Abstract*-In this page, a miniaturized absorber with ultrawide absorption band is designed and applied for radiation leakage suppression in the chip package. The proposed unit is a double-layer structure with two patterned resistive films of ITO etched on top of the dielectric substrate. The patterned layer is composed of a meandering square ring and a centric circular patch which enhances the coupling within the unit and facilitates the miniaturization of the structure. The size of the unit is $0.08\lambda_L \times 0.08\lambda_L$ (λ_L is the wavelength in the free space of the lowest absorption frequency). When the periodic boundary condition is set in the simulation, it shows a broad absorption band ($S_{11} \leqslant -10$dB) covering 23.8-40 GHz. This unit is then used as a square ring structure for radiation suppression in chip package which demonstrates a -10dB bandwidth within 25.5-39.5 GHz.**

***Index Terms*-Miniaturization, microwave absorber, radiation suppression, chip package**

I. INTRODUCTION

The miniaturization of integrated circuits has significantly improved the quality of people's life. Yet, at the same time, the problem of electromagnetic interference has become more serious, which can deteriorate the performance of electronic instruments and even do harm to human health. Thus, the research of radiation suppression in the chip package has become a topic of substantial importance.

The absorber is a device pervasively applied for the EMI problem. Generally speaking, absorbers can be divided into coating absorbing materials and metamaterial absorbers according to their absorbing principle and form of composition [1]. Coating absorbing materials is the traditional absorber, it achieves electromagnetic absorption by designing the material itself to achieve an ideal balance between impedance matching and electromagnetic losses [2]. This type of absorbers is limited by the properties of natural materials and has less freedom of design.

Metamaterial absorber is a kind of device that incorporates the artificial electromagnetic structure. The earliest artificial absorber called Salisbury Screen achieves a phase difference of 180° at the ground plane based on the transmission line theory for perfect absorption [3]. However, it suffers from fixed thickness and narrow bands. Some absorbers are based on traditional Frequency Selective Surfaces (FSS) [4]. In order to enhance the design flexibility, absorbers based on 3-D and 2.5-D Frequency Selective Surface (FSS) has been proposed [5],[6]. Besides FSS, other artificial electromagnetic structures like SSPP has also been applied in the absorbers [7].
Nevertheless, the absorptive capacity offered by metal-based electromagnetic structures is inherently limited. A great deal of work has been put into solving these problems and the concept of circuit analog (CA) was developed [8]-[11]. This CA absorber is constructed from a periodic resistive-conductive design etched on dielectric substrates, which is frequently ended by a ground plane. In order to obtain greater ohmic loss, we need to seek to increase the impedance of the resistive-conductive layer and two methods were proposed. One of the methods is to mount lumped resistors in the metallic pattern layer [8], [9]. This method is expensive in the fabrication process and not suitable for miniaturization due to the size of lumped resistors. The other way is to replace the original metal of the pattern layer with resistive films [10], [11]. Owing to its high precision, simplicity in manufacturing, and low cost, this technology can be considered a viable option.

In this paper, a low-profile miniaturized absorber and used for radiation suppression in the chip package. The suggested

2024 IEEE International Symposium on Electromagnetic Compatibility, Signal & Power Integrity (EMC+SIPI) | 979-8-3503-6039-4/24/$31.00 ©2024 IEEE | DOI: 10.1109/EMCSIPI49824.2024.10705439

Porous Absorber for Electromagnetic Radiation Suppression in Chip-Packages

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***Abstract*—In this paper, a low profile absorber for suppressing the electromagnetic radiation in the chip packages is proposed. The incorporation of porosity reduces the dielectric constant of the absorbing material which makes it easier to meet the impedance matching condition. Additionally, the porosity causes incident electromagnetic waves to undergo multiple reflections within the pores, effectively lengthening their propagation path within the absorber and enhancing the absorption capability. The simulated results in the chip-package model demonstrate an effective absorption of -14 dB within 20.3-29.8 GHz by adding the proposed absorber into the package. The detailed working mechanism of this structure is explained through the effective medium theory. Finally, the porous absorber is fabricated and experimental measured within a real chip-package inside a reverberation chamber, where the measured results bring out a -12 dB absorption effect covering 20-30 GHz.**

Keywords—Absorber, chip-package, effective medium theory, electromagnetic radiation.

I. INTRODUCTION

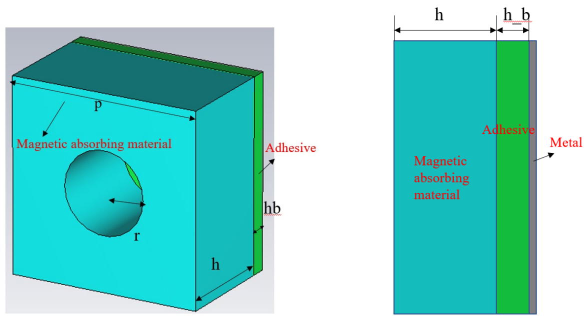
The increment of the chips' operating frequency not only enhances the information processing speed of chips but also poses greater challenges to the electromagnetic compatibility of the entire electronic system. For example, if the electromagnetic radiation generated by the device is not effectively suppressed, it may affect the operation of other devices, and even endanger people's health. Therefore, the research of electromagnetic radiation suppression for chip-packages especially for high frequency chips is of great importance.

In order to mitigate EMC challenges in chip-packages, the common solution is to attach an absorber to the bottom of the heat sink to absorb electromagnetic radiation emitted from the chip packaging. Microwave absorbers are widely used in both military and civilian fields, such as stealth technology, antenna radomes, and more. Generally speaking, absorbers can be categorized into metamaterial absorbers, typically represented by FSS (Frequency Selective Surfaces), and conventional coating absorbing materials. The metamaterial absorber is a device that integrates an artificial electromagnetic structure. In the design of metamaterial absorbers, the most critical aspect is the design of the FSS structure, for which there has already been considerable work aimed at enhancing FSS performance[1]-[2]. However, the electromagnetic losses introduced are insufficient when FSS structures are directly applied to absorbers, to enhance Ohmic losses, strategies such as incorporating lumped resistors into the structure and replacing metal patterns with resistive films have been proposed[3]-[5]. Besides FSS-based absorber, other electromagnetic absorptive structures, such as SSPP-based absorbing structures have also been applied to the package scenarios[6]. However, these structures typically have larger dimensions, and their absorption bandwidth is inadequate, making them limited for applications in chip packaging scenarios. The coating-absorbing materials absorb electromagnetic waves through the magnetic loss or dielectric loss based on the inherent properties of the materials[7]. In order to enhance the absorption performance of traditional absorbing materials, one method is to improve impedance matching conditions by attaching a layer of dielectric with a lower dielectric constant onto the surface of absorbing materials with a higher dielectric constant[8]. Nevertheless, the absorption depth of the coating materials is still not ideal enough.

In order to further improve the radiation suppression in the chip-packages, in the following sections, the specific structure of a porous absorber is firstly discussed in detail, which is followed by a comprehensive analysis of the working mechanism of this structure, employing the effective medium theory combined with attenuation coefficient and impedance matching conditions. Finally, the absorber is placed within a chip-package model for simulation and experimental verification. The measured results demonstrate that the absorber can achieve a -12 dB absorption band in the 20-30 GHz range within the chip-package model.

II. ABSORBER DESIGN

A. Structure Design Details



(a) (b)

Fig. 1. The proposed absorber: (a) 3D view; (b) side view

TABLE I
PARAMETERS OF THE ABSORBER UNIT

Parameters	p	r	h	hb
Values (mm,)	2.33	0.5	1.3	0.2