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Article

Theoretical Insights Manifested by Wave Mechanics Theory of Microwave Absorption—Part 2: A Perspective Based on the Responses from DeepSeek

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Abstract: In Part 1 of this work, it concerns the theoretical foundation of microwave absorption theories that the newly established wave mechanics theory conforms to transmission line theory while the impedance matching theory of microwave absorption originates from the misinterpretation of this fundamental physics law. This Part 2 provides another perspective from a question and its responses from DeepSeek to show the common mis-concepts dominated in the field and that the new wave mechanics theory is rejected by wrong reasons because of these established wrong concepts. The purpose of the work is to draw attention of material scientists to the important issues concerned since the practice of wrong theories continuing in publication with little attention to the newly established wave mechanics theory for microwave absorption. It also shows that artificial intelligence can be a useful tool to identify how the established concepts were behind the scenes to prevent the wave mechanics theory from to be accepted, even though machine intelligence cannot go beyond commonly accepted theory to provide innovations.

Keywords: wave mechanics theory; microwave absorption film; interface; film

1. Introduction

It was confirmed that interfaces between material particles behave differently from those two parallel front and end interfaces in the film. The function of interfaces between material particles is to average the relative permittivity ε and permeability μ [1], while the function of the two parallel interfaces of the film is to make wave superposition possible [2]. The confusion of the material and the device from the material in current theories was identified by as the confusion between the input impedance Z_{in} and the characteristic impedance Z_M [3,4] where Z_{in} characterizes the film or the device and Z_M characterizes the material and the interface. It was further confirmed that the two parallel interfaces in the film behave differently from the interfaces if they were in isolated state. [5] The common errors of the confusion of the film and the interface in current publications were corrected. [6] It was proved that interface does not absorb microwaves even if the related material and film do absorb [7]. A new perspective is concerned in this work that the wrong concepts about the interface have stonewalled the acceptance of the recently established correct wave mechanics theory based on energy conservation [2,8-10] and because of the wrong concepts, the wrong mainstream theories have been insisted on.

Several papers with many downloads have been published to show that the current dominant microwave absorption theories are completely wrong and should be replaced by the new wave mechanics theory established in recent years. However, material scientists still insist on the wrong theories with many publications in various journals without mention the new theory. Only a few published papers [11-14] have mentioned the new theory. To draw their attention to this subject, the

perspectives were provided in Part 1 of this work [15] to show that the new wave mechanics theory of microwave absorption conforms to transmission line theory while the current dominant theories in microwave absorption were developed from the misinterpretation of the transmission line theory, along with the perspectives previously presented from common errors appeared in publications⁶. This Part presents new perspectives of the same subject of Part 1 from a question kindly designed by Dr. Jiqing Zeng of South China Botanical Garden, Chinese Academy of Sciences and the responses offered from DeepSeek. The question and the responses are in Chinese and have been provided in the Supplementary Materials with English translation presented at appropriate positions in this work.

It was a good question since it represents the wrong concepts believed by material scientists and a discussion about the responses offered by DeepSeek helped us to identify why many of the related papers do not mention the opposite theory at all. It also shows that only commonly accepted answers can be expected from AI while the most innovative discoveries are usually difficult to be offered from machine intelligence.

2. The Question and the Responses from DeepSeek

The question for and the responses from DeepSeek demonstrate the wrong concepts hold by material scientists, that is material, film, and interface have been confused.

Question to DeepSeek

“Under what circumstances is microwave absorption only related to the interface of the material and not to the properties of the material itself?”

The correct answer to the question should be when there are front and back interfaces assembling with absorption material to form a device like film, the absorption mechanism of the device will be changed to wave superposition instead of the attenuation power of the material. It should be noted that the film does not absorb microwaves if the material does not absorb even though the absorption mechanisms of the film and the material are different. However, as expected, the responses from DeepSeek were based on the wrong concepts from current theories that confusing film and material, interfaces between material particles and those of the film, and interface of film and in its isolated state.

The response from DeepSeek

Two versions of the response have been provided from DeepSeek and one of it is presented below and the other version is provided in the Supplementary Materials.

“Well, what the user is asking is under what circumstances the absorption of microwaves is only related to the interface of the material, and not to the characteristics of the material itself. This question seems a bit challenging because microwave absorption is often closely related to the electromagnetic parameters of materials such as dielectric constant, magnetic permeability, etc. But users may want to know if there are special circumstances that make interface effects the dominant factor, while the properties of the material itself become less important.

Firstly, I need to recall the fundamental principles of the interaction between microwaves and materials. The absorption of microwaves mainly involves mechanisms such as dielectric loss, magnetic loss, and conductive loss, all of which are related to the inherent properties of materials. But users want to know if there is a situation where interface effects dominate, which may involve reflection, transmission, and interference phenomena. In this case, the design of the interface structure may be more important than the properties of the material itself.

For example, when the material is very thin, such as metamaterials or metasurfaces, the thickness of the material is much smaller than the wavelength of microwaves. Electromagnetic waves mainly interact with interface structures, such as periodic structures or subwavelength structures. The design of these structures can change the reflection and transmission characteristics of electromagnetic waves, while the dielectric constant or magnetic permeability of the material itself may have a smaller impact. In this case, interface effects may become the dominant factor.

In addition, it is also possible to enhance the absorption effect by designing impedance matching different layers in a multi-layer structure, so that the incident wave undergoes multiple reflections and interferences at the interface. At this point, although the material properties of each layer are important, through structural design, the overall absorption effect may depend more on the interactions between interfaces rather than the properties of a single material itself.

Another scenario is surface plasmon resonance, where electromagnetic waves interact with free electrons on the metal surface, exciting surface plasmon polaritons at the interface. In this case, absorption may be closely related to the interface structure, while the internal properties of the material have a relatively small impact.

However, it is necessary to verify whether these situations truly render the properties of the material itself irrelevant. For example, in metasurface design, although structure is crucial, the choice of material (such as metal or dielectrics) still affects the performance of the structure, so it may not be completely unrelated. But the user's question may be whether there are certain extreme situations, such as when the material thickness approaches zero, or when the structural design completely compensates for the material's own characteristics, where interface effects dominate.

It may be necessary to consult some literature or theories to see if such theoretical models exist. For example, in an ideal situation, if the thickness of the material approaches zero, but the interface structure is designed very cleverly, absorption may be mainly determined by the interface structure. Or at certain frequencies, structural design can make the internal losses of the material negligible, while multiple reflections and interferences at the interface lead to absorption.

The concept of impedance matching also needs to be considered. When the impedance of the material is perfectly matched with free space, microwaves will completely enter the material without reflection, and absorption may be determined by internal losses of the material. But if impedance matching is achieved through interface structure and the loss of the material itself is low, then absorption may depend more on the design of the interface structure rather than the loss characteristics of the material itself.

For example, using a multi-layer structure, the thickness and material parameters of each layer are designed to cause destructive interference of the incident wave at the interface of each layer, thereby reducing reflection and increasing absorption. In this case, although material parameters are still important, the overall absorption effect may depend more on structural design, namely the interaction between interfaces, rather than the intrinsic properties of a single material.

In addition, under certain resonance conditions, such as Fabry-Pérot Resonance, electromagnetic waves may form standing waves after multiple reflections inside the material, resulting in strong absorption at specific frequencies. In this case, the position and intensity of the absorption peak may be determined by the thickness of the material and interface reflection, while the loss parameters of the material itself may affect the absorption bandwidth, but the resonance conditions themselves are determined by interface and structural parameters

In summary, possible scenarios include:

1. Ultra-thin materials or metasurface designs are dominated by structural effects.
2. Multilayer interference structure, interface reflection, and phase matching determine absorption.
3. Surface plasmon resonance and interface excitation dominate absorption.
4. Fabry-Pérot resonant cavity, thickness and interface reflection determine the resonance conditions.

Further verification is needed to determine whether these situations truly render the properties of the material itself irrelevant, or whether the coordination of material parameters is still necessary. For example, in metasurface design, although structure is crucial, the choice of material (such as metal or dielectric) still affects performance. However, in some extreme cases, structural design may compensate for changes in material properties, making the absorption effect mainly determined by the interface structure.

In addition, it may be necessary to consider the limit cases in the theoretical model, such as whether absorption may only be caused by interference from interface reflection when material loss approaches zero. For example, in an ideal lossless medium, by designing a multi-layer structure to cancel out reflected waves and restrict transmitted waves, complete absorption can be achieved at a specific frequency. In this case, the absorption mechanism may be independent of the material's own losses and determined only by interface interference.

For example, in Coherent Perfect Absorption, the energy is completely absorbed by the interference of two coherent waves. In this case, the conditions for absorption may only depend on the reflection and transmission characteristics of the interface, but not on the loss parameters of the material. However, this may be a special case and requires specific experimental conditions.

In summary, the possible answer is: when the absorption of microwaves is mainly determined by the reflection, transmission and interference effects at the interface, and the loss inside the material can be neglected, for example, in the case of ultra-thin structure, multi-layer interference design or coherent perfect absorption, microwave absorption may be mainly related to the interface, and has nothing to do with the electromagnetic properties of the material itself (such as dielectric constant, magnetic permeability). In this case, structural design becomes the dominant factor, not the material's intrinsic properties. "

We have checked this question from ChatGPT and DeepSeek with the same question and obtain similar responses. The responses we obtained from DeepSeek also include additional point that material property can be neglected for the perfect impedance matching with the wrong belief that at perfect impedance matching, the incident microwaves did not penetrate the film, and all waves were absorbed by the front interface.

3. Discussions with Respect to the Response from DeepSeek

Reflection loss RL /dB for metal-backed film is always used wrongly in publications to characterize the absorption from material. RL is a parameter for film rather than material [16] and thus it can only be used to characterize film instead of material. The film is a material with a front interface and a back interface. A block of material behaves as film since it has two parallel interfaces [9] and thus RL can be used to characterize a block of material even though it cannot be used to characterize material. Therefore, a block of material can have property not possessed by material. Only parameters such as the relative permittivity ϵ and the permeability μ can be used to characterize material [4]. It should be known that microwave absorption of a material is characterized solely by ϵ and μ of the material even there are other parameters of derivatives of ϵ and μ such as attenuation power constant α and the dielectric and the magnetic loss tangents have the same function.

The interfaces between material particles have often been used to explain the absorption characterized by RL /dB and thus material structure such interfaces between material particles are believed have a dominant effect on material absorption [17,18]. Indeed, there is a clear relationship between RL and the values of ϵ and μ and the values of ϵ and μ are determined by material structure, but there is no clear relationship between RL and material structure or the interface structure of the material. Thus, the research on the relationship between RL and material structure is not scientific. The scientific design of a research program should first determine what values of ϵ and μ are required to achieve the desired value of RL , and how can these values of ϵ and μ by material structure [19]. However, the key research on the relationship between material structure and the values of ϵ and μ has been seldomly done. It should be noted that uniform material with interfaces between material particles is still a single phased material with averaged values of ϵ and μ [1] and the same is true for multi-layered film [10]. The effects of material structure such as split-ring resonators and the Maxwell–Wagner interfacial polarization effect affect the values of ϵ and μ and thus absorption of the film is affected by these effects through ϵ and μ . The sensible research should be down by investigating the relationship between absorption and the effect of split-ring resonators or of the Maxwell–Wagner rather than the relationship between the value of RL and those effects since other device parameters such as film thickness also contribute to the value of RL . These

conclusions demonstrate that the discussions made on the absorption represented by RL/dB and interfaces between material particles make little sense and the material properties of ϵ_r and μ_r is always important for material absorption without exception.

The functions of the two parallel interfaces for film are quite different from those of between material particles for microwave absorption. The interfaces of the film offer wave superposition [2,5,8,20-22] while the interfaces between material particles only provide the average values of ϵ_r and μ_r [1]. It should be noted that interface does not absorb microwaves [7]. The effects of the interfaces between material on absorption are not because interface absorbs microwaves but because the values of ϵ_r and μ_r is affected by material structure. Thus, interface cannot make the effects of ϵ_r and μ_r on absorption becoming minor. There are angular effects on RL/dB for film [2] while material attenuation is of monotonic function [5,21]. Thin film has apparent angular effects on absorption [2,19] and thick film behaves more like material with monotonic attenuation power [19]. However, thin material, metasurfaces, and subwavelength structures were used in these responses related to interfaces within material other than the concepts of thin and thick films. The concepts of thin and thick film were developed to differentiate film and material [19]. The concept of the interface structure of material often neglects the fact that interface does not absorb microwaves [7] and the reflection coefficient of interface is often wrongly used to evaluate absorption from film [6,23-25].

The absorptions of material and film have not been differentiated in DeepSeek's responses representing the common mistake of confusing film with material in current mainstream microwave absorption research. The responses represent the common practice using interface structure within materials to account the absorption peak represented by RL/dB . Such practice has never achieved any valuable conclusions since it has also wrongly attributed the effect of film thickness on RL to the effect of interface structure. The responses also reflect the fact that interfaces of film and interfaces within material have been confused in current theories. The interfaces within material change the average values of ϵ_r and μ_r . The interfaces of inner layers within a multi-layered film function the same as the interfaces within material [10] and multi-layered film have not diminished the effects of ϵ_r and μ_r on absorption. On the other hand, the two parallel interfaces of the film are only responsible for wave superposition rather than changing the values of ϵ_r and μ_r .

The confusion between film and material has led to the establishment of the wrong impedance matching theory which was also involved in the responses. Impedance matching theory is used to explain the absorption peak of film when the input impedance of the film Z_{in} is not equal to the characteristic impedance of free space Z_0 . However, at perfect impedance matching condition that all the incident microwaves enter the film, the front interface of the film disappears and there is no absorption peak at all since the film behaves as material at this circumstance [5,19,21,26,27]. It should be noted that the impedance matching theory in microwave absorption is not the correct and rigorous impedance matching theory in circuit theory.

It should be noted that the Fabry-Pérot Resonance refers to film other than material and the resonance referred by Fabry-Pérot Resonance is in fact the complete wave cancellations rather than real resonance.

The response "in an ideal lossless medium, by designing a multi-layer structure to cancel out reflected waves and restrict transmitted waves, complete absorption can be achieved at a specific frequency" represents a common mistake in the current theory concerning interface structure of material and absorption. When material does not absorb microwaves, the film cannot absorb microwave even if the relevant beams are out of phase by π [2,21,28]. This principle is ensured by energy conservation [7].

Without correct theoretical guidance, experimental data was used to support the wrong theory. A theory that has been repeatedly verified by experiment can still be a false theory. Until the geocentric theory was disproved by the heliocentric theory, all experimental observations were used to support the false geocentric theory; Until the phlogiston theory was disproved by mathematical logic, all experimental results were used to support the phlogiston theory; Until the new wave mechanics theory of microwave absorption is established, all experimental reports were supporting

the erroneous prevailing theory of microwave absorption. By rejecting the correct theory, one fails to recognize the error of the wrong theory. In the past, experimental data was used to support the current wrong theories of microwave absorption because the correct theory was not available. Now, the correct new wave mechanics theory of microwave absorption is rejected, and therefore the mainstream scientists still adhere to the current erroneous mainstream theories.4 Conclusions

In Part 1, it reveals that inconsistency in established theories cannot easily identified without a leaping in theoretical understanding because of the ingrained mis-concepts. AI can do very good jobs under correct theory. Without a correct theory, it is difficult to devise an appropriate question, and it is difficult for AI to sample the correct information overwhelmed by the dominant views although the correct theory has already emerged. The AI modes are trained by common views from current theories, and it cannot be expected that Artificial Intelligence is able to find the inconsistency in current theories. In this Part the responses of DeepSeek from a question are analyzed to clear up the concepts hindering material scientists in appreciating the newly established wave mechanics theory for microwave absorption. Since there are no comments on the new mechanics theory, the responses from DeepSeek represent what the mainstream scientists think. It reveals that the mis-concepts such as using reflection coefficient of interface to characterize microwave absorption, the film with lossless material absorbing microwaves by wave cancellation, are responsible to the fact that material scientists are reluctant to give up the theories that have been proved wrong. Neglecting the fact that the effects of film thickness on absorption have also been mistakenly included as the effects of interface structure of material on absorption has made the research community insist on the unscientific investigation of the fake relationship between interface structure of material and the peak values of RL/dB . Artificial intelligence can be helpful in identifying what mis-concepts have prevented the acceptance of the correct wave mechanics theory but will be difficult to require it to identify problems within current theories.

Wrong is wrong, what is correct is correct, and “doing the right thing is more important than doing the thing right”. [29-32] Wrong theories cannot become correct just because they have survived for a long time and have been supported by majority. The wrong concepts not only have led to wrong theories, they also have made it difficult to recognize the wrongness of the theories as revealed from artificial intelligence. “Yes, error detectors can make research less comfortable — but that discomfort is healthy ... journals need to make clearer and firmer commitments to self-correction.” [33] However, “Scientists are often tardy in fixing basic flaws in their sciences despite the presence of better alternatives” [34] and “A new scientific truth does not triumph by convincing its opponents and making them see the light, but rather because its opponents eventually die, and a new generation grows up that is familiar with it”. [35] That scientists are reluctant to accept new ideas is an unsolved problem repeatedly occurred in history and thus is important to be addressed through concrete examples. It is relevant to conclude with Nobel laureate Ding Zhaozhong’s words: “Every one of my experiments has been opposed by many people, especially the experiments on the space station ... First-rate scientists can look forward and make judgments about the future ... Opposition is not a bad phenomenon, but it is meaningless to solve scientific problems by voting. The progress of science is that the majority obeys the minority. Only when a very small number of people overthrow the views of the majority can science move forward.” [36].

4. Conclusions

The current theories have confused the film with the material. This confusion has led to the wrong absorption mechanism dominated in microwave absorption research. The impedance matching theory is a wrong theory based on a wrong interpretation of transmission line theory. The quarter wavelength theory is a wrong theory, and there are many common mistakes in publications. The experimental data published to support the wrong theory have been proved to disprove the theories. These conclusions are firmly established from the rudiments of physics and can be confirmed by the correct analysis of the data published.

While even the picked experimental data may conform impedance matching theory, the logic of the theory at these is still wrong. The impedance matching theory cannot explain all the absorption peaks from the reported experimental data and cannot offer a logical explanation why almost all the reported absorption peaks do not occur at $Z_{in} = Z_0$. All the absorption peaks reported can be precisely predicted by wave mechanics theory without exception. However, the wrong theories still dominate current publications and thus the issues concerned here are important. Under such solid theoretical results established from the rudiments of physics and the firmly experimental evidence already published in the literature, it will be a laughingstock in history if the corrections of the erroneous theories still need to wait until the next generation.

Supplementary Materials:

Data Availability Statement: Data sharing does not apply to this article as no new data were created or analyzed in this study.

Conflicts of Interest: The authors declare that they have no conflict of interest.

Appendix 1. Backgrounding Information

<https://www.peeref.com/hubs/345>

https://www.growkudos.com/profile/yue_liu_2

<https://www.peeref.com/hubs/219>

<https://www.peeref.com/hubs/218>

A) Why the current theories have confused the film with the material

Yue Liu, Ying Liu, Michael G. B Drew, Wave Mechanics of Microwave Absorption in Films - Distinguishing Film from Material, **Journal of Magnetism and Magnetic Materials**, 2024, 593, 171850
<https://doi.org/10.1016/j.jmmm.2024.171850>

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B) Why the current absorption mechanism for microwave absorption is wrong

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C) Why the impedance matching theory is wrong

Ying Liu, Michael G. B. Drew, Yue Liu, A physics investigation on impedance matching theory in microwave absorption film—Part 2: Problem Analyses, **Journal of Applied Physics**, 2023, 134(4), 045304
<https://doi.org/10.1063/5.0153612>

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D) Why the quarter wavelength theory is wrong (different perspectives)

Liu Y, Liu Y, Drew MGB. A theoretical investigation of the quarter-wavelength model – part 2: verification and extension. **Physica Scripta** **2022**, 97(1) : 015806 <https://doi.org/10.1088/1402-4896/ac1eb1>

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E) Common mistakes in publications

Yue Liu, Ying Liu, Michael G. B. Drew Review: Recognizing problems in publications concerned with microwave absorption film and providing corrections A focused review, **Industrial & Engineering Chemistry Research**, **2025**, <https://doi.org/10.1021/acs.iecr.4c04544>

F) Mathematical foundations

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Ying Liu, Michael G.B. Drew, Yue Liu, Chapter 4: Fundamental Theory of Microwave Absorption for Films of Porous Nanocomposites: Role of Interfaces in Composite-Fillers, in Porous Nanocomposites for Electromagnetic Interference Shielding, Edited by: Sabu Thomas, Claudio Paoloni, Avinash R. Pai, **2024**, Elsevier, [978-0-323-90035-5_B978-0-323-90035-5.00013-1], pp. 59 - 90, <https://doi.org/10.1016/B978-0-323-90035-5.00013-1>

G) Foundation from transmission line theory

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Liu Y, Zhao K, Drew MGB, Liu Y. A theoretical and practical clarification on the calculation of reflection loss for microwave absorbing materials. *AIP Advances* **2018**, 8(1) : 015223.

H) Lessons from history

“A new scientific truth does not triumph by convincing its opponents and making them see the light, but rather because its opponents eventually die, and a new generation grows up that is familiar with it”

M. Planck, *Scientific Autobiography and Other Paper*, William & Norgate, London, 1950, pp. 33 -34.

“Beyond these considerations, the importance of many of the more recent developments cannot be evaluated objectively at this time. The history of mathematics teaches us that many subjects which aroused tremendous enthusiasm and engaged the attention of the best mathematicians ultimately faded into oblivion ... Indeed one of the interesting questions that the history answers is what survives in mathematics. History makes its own and sounder evaluations.”

–Morris Kline, *Mathematical Thought from Ancient to Modern Times*, Oxford University Press, 1972, ISBN 0-19-506136-5

Appendix 2. The Papers Published on This Subject

The number of papers published on the subject by us shows that this is a serious study.

1. Yue Liu, Ying Liu, Michael G. B. Drew **Review**: Recognizing problems in publications concerned with microwave absorption film and providing corrections A focused review, *Industrial & Engineering Chemistry Research*, **2025**, 64(7), 3635–3650, <https://doi.org/10.1021/acs.iecr.4c04544>; Recognizing Problems in Publications Concerned with Microwave Absorption Film and Providing Corrections: A Focused Review, *Qeios*, preprint, 2024-07-01, Supplementary data, Yue Liu, Ying Liu, Drew MGB, [Commentary] Comments on: “A perspective on impedance matching and resonance absorption mechanism for electromagnetic wave absorbing” by Hou et al. [*Carbon* 222 (2024) 118935], *Qeios*, **2024**, Supplementary Yue Liu, Ying Liu, Drew MGB, Corrections of common errors in current theories of microwave absorption caused by confusing film and material, *Qeios*, **2024**/02/10, preprint, <https://doi.org/10.32388/QQ1MFF>; Corrections of Common Errors Associated with the Confusion between Film and Material in Current Theories of Microwave Absorption. Available at SSRN: <https://ssrn.com/abstract=4797207> or <http://dx.doi.org/10.2139/ssrn.4797207>
2. Yue Liu, Ying Liu, Michael G. B. Drew, **Review**: 膜微波吸收研究在波动力学理论方向的新进展, *分子科学学报(英文版, Journal of Molecular Science)*, **2024**, 40(198-04), 300 -305; Review of Wave Mechanics Theory for Microwave Absorption by Film, *Qeios*, Preprint, 2024-07-04, Supplementary data
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