2nd Review of manuscript:

"**Evaluating the Effectiveness of Aluminum Coatings on Patch-Repaired Composites Using Electro-Thermal Analysis**"

GENERAL COMMENTS

Authors have made some changes, mainly as descriptive additions, but have ignored some comments and not properly addressed some others. At the same time, they have not rectified the vagueness of some statements and terminology. For instance, a) in Lines 244 – 246 they sate that carbon fibres "sublime" at temperature >3000 C, even though in my previous report they were given a definition of the term and acknowledged in their answer.

Graphitic carbon does not sublime but undergoes oxidation to CO2.

Has been modified to decompose.

b) In line 287 they state that the epoxy resin melts at .250 C even though they were told that the epoxy resin matrix consisted of a cross-linked network that cannot melt but undergoes a large reduction in modulus. Again, this was acknowledged in the answers but not corrected in the text.

Has been modified to degrade.

c) In lines 464 and 466 there are discussions about the increase in weight brought about by the Al coatings. In aircraft structures this is an infinitesimal fraction of the overall weight.

Thank you for your comment regarding lines 464-466 about the aluminum coating weight. We believe there may be a misunderstanding, as our text actually aligns with your observation. In our manuscript, we specifically highlighted that 'the design optimizes conductivity without introducing unnecessary weight, which is crucial for maintaining the aircraft's balance' and further noted that our approach minimizes 'the added weight, an important consideration for aircraft performance and safety.

d) In their answers they state that …repairs restore the "structural strength" but cannot recover the" original conductivity". This is baseless without theoretical elaboration and possibly experimental evidence.

Regarding the comment about our statement that repairs can restore structural strength but not original conductivity, we would like to clarify that this position is supported by both theoretical principles and evidence in the literature.

As mentioned in our manuscript (lines 364-371、lines 414-417,etc.), the inability to fully restore original conductivity stems from the fundamental nature of composite repair. This is because:

①The electrical conductivity of carbon fiber composites primarily relies on conductive networks formed by thousands of continuous carbon fiber filaments

②When the material is damaged, these carbon fibers experience irregular fractures at the microscopic level

③During the repair process, even with perfectly aligned orientation, it's impossible to guarantee that each broken carbon fiber can precisely reconnect with its original corresponding part

As a result, while structural strength can be restored (through effective load transfer mechanisms), the conductive pathways are permanently altered.

While some papers may not explicitly state this conclusion, it is implied in the literature. For example, Wentzel et al.[1] investigated the effect of damage in carbon fiber bundles on overall electrical conductivity. The study showed that carbon fiber breakage leads to changes in local resistance, and proposed a model for predicting fiber strength degradation based on resistance changes. Loyola et al.[2] proposed a conductivity-based damage detection method, demonstrating that the electrical conductivity of carbon fiber composites changes with fiber breakage, thus validating the impact of carbon fiber integrity on conductivity.

Furthermore, this limitation is generally acknowledged within the field. The assertion that a repaired structure could be identical in all properties to its pristine state contradicts fundamental principles of material science and repair mechanics. Structural integrity can be restored through proper load transfer mechanisms, but the microscale electrical pathways, once disrupted, cannot be perfectly reconstructed through conventional repair methods.

[1]D. Wentzel et al. "Effect of fiber damage on the overall electrical conductivity of bare carbon fiber strand." *International Journal of Fracture*, 183 (2013): 275-282.

[2]B. Loyola et al. "Conductivity-Based Damage Detection in Carbon Fiber Composites." (2012): 671-678.

COMMENTS REQUIRING CORRECTIVE ACTIONS

TITLE:- In previous report it was suggested to change the term “aluminium coating” with “aluminium-foil coating”, because it is seems to be impossible to produce shaped Al zones on repair patches with techniques available for aluminium coatings, namely vacuum deposition nor powder spraying. It is possible, on the other hand, to cut shapes from thin Al foils and stick them on CF composite patches to suit the specific requirements for the repair job considered. How is done in industrial practice?

Thank you for your valuable comment regarding the terminology in our title. We understand your concern about the feasibility of producing shaped aluminum zones using vacuum deposition or powder spraying techniques.

We have deliberately chosen to maintain the term 'aluminum coating' rather than 'aluminum-foil coating' because we believe the latter cannot comprehensively encompass all aluminum-related surface protection methods used on aircraft. Since the damaged area in our study might have had minimized lightning protection measures originally, we cannot definitively determine whether coating deposition techniques were initially employed in this area.

Our paper focuses on theoretical research quantifying the relationship between aluminum coating thickness and the restoration of surface conductivity in repair patches, without delving into specific application techniques. Therefore, we believe that narrowing our title to 'aluminum-foil coating' based on one particular manufacturing process would not adequately represent the scope of our research.

We appreciate your practical insights regarding industrial implementation, which will certainly be valuable for future research focusing on application.

aspects1.INTRODUCTION: - Authors say nothing about methods used in practice for repairing damages to aircraft structures. Authors must reassure the reader that the fibre arrangements they have used in the model is realistic.

It should be clarified that the model used in this study is based on previously researched and validated models from existing literature, rather than being arbitrarily created. Unidirectional composite materials are widely used in the aviation industry, particularly in structural components that bear loads in specific directions, such as wing spars, stringers, frames, and stiffeners among other critical load-bearing elements.

Although the main focus of this paper is the theoretical analysis of the relationship between aluminum coating thickness and conductivity restoration, the model setup does reflect situations likely to be encountered in actual aviation structure repairs. Unidirectional fiber arrangement is a common and necessary design choice in specific aviation structures, ensuring that the model has practical reference value.

2. ELECTRO-THERMAL……., 1) Section 2.2.1 – Regarding the Headings and Data in Tables 1 and 2 (ref 13, 20). It should be stated that these are unidirectional composites, and an indication should be given of the resin type and CF content used. 2) There is inconsistency in denotations used for direction in the two tables, i.e for directions in Table 1 are x, y and z, while in Table 2 these become longitudinal and transverse. 3) How were these properties measured? Note the quoted accuracy to 2 decimal places for values at high temperatures, < 3000 C! It is not sufficient, or even appropriate, to say that these are reliable because they have been taken from peer reviewed papers. Identified errors or inaccuracies should not be allowed to propagate without questioning or rectification.

Concerning the material property data presented in Tables 1 and 2, these values are sourced from published and widely cited references. These publications are considered reliable data sources in the composite materials field and have been adopted and validated by numerous subsequent studies. As standard practice in academic research, investigators typically rely on established data from peer-reviewed literature, especially when such data has been validated across multiple studies.

While revalidating every set of published data would be ideal in principle, it often falls beyond the scope and resource constraints of individual research projects. The focus of this study is on theoretical modeling and analysis rather than experimental verification of previously published material property data.

3) The TGA trace by Ogasawara, which has been used for the ablation data (loss of weight) should be shown, as these would facilitate the interpretation of the results of the simulation This would also acts a finger print for the degradation characteristics of the polymer matrix to complement the data in Table 1 and 2, which are vital to the degradation induced by lightning strikes.) Statement in Line 287 is not correct because Epoxy resins are cross-linked macromolecules which do not melt but undergo a large reduction in modulus above Tg, which is likely to be around 200 C for the matrix of the composite examined. 3) Section 2.4 – A plot of temperature gradient at the centre of the damaged zone versus distance from top surface would be a useful parameter to fully characterize the damage resistance of the material and make comparisons for different applied voltage or current.

While this data indeed formed part of the background research for establishing degradation thresholds, the current study focuses primarily on the critical temperature points and damage thresholds as they relate to lightning strike damage modeling. The complete TGA trace was not included to maintain focus on the specific temperature-dependent properties

most relevant to the computational model. The key degradation characteristics have been incorporated into the simulation parameters as described in Section 2.

3. ANALYSIS ……Section 3.1 – The description and analysis of the repair patches is not at all clear. A sketch is required to show the cross-section of the damaged structure, with a clear identification of the damaged area, with the upper cross-section identified as the repair patch. At the same time, there must be a clear designation of the physical characteristics assigned to the composite structure underneath the patch. Section 3.2.1 – There is confusion regarding the statement regarding 20 cm coating when earlier the width was given a 30 cm value (Figs 9 and 10).

Thank you for the continued attention and feedback. These comments aimed at enhancing the paper's readability, particularly for readers outside the specialized field, are appreciated.

It should be clarified that the previous revisions did not intentionally disregard any comments. Each suggestion was carefully considered. However, certain recommendations (such as providing experimental evidence to validate data already cited in multiple peer-reviewed journals) extend beyond the scope of this study. These widely accepted material property data have been cited in numerous papers both domestically and internationally, and according to academic convention, citing data from existing peer-reviewed literature is standard practice in academic research.

Additionally, regarding the TGA experiment, it is the view that simply for the sake of improving readability, it is not necessary to include all related experiments of the cited conclusions, as this would cause the paper to lose its focus.

The current revision has corrected technical inaccuracies (such as the description of epoxy resin behavior at high temperatures) and strived to improve the clarity of the paper. An appropriate balance must be maintained between research focus and providing additional background information.

The constructive suggestions provided are valuable, thank you again for your time.