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Micro-Mechanical Communications In A Complex Protect With Rooted Simulated Microcomputer Device

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Abstract— This paper presents The study of the mechanical interaction among the host, interface, and a device embedded within a laminated composite is important. Embedding micro-sensors in composite laminates produces material discontinuity around the inclusions. This in turn produces stress concentrations at or near the inclusions. Both 2D plane strain and 3D finiteelement models are developed to analyze the stress/strain state surrounding the embedded micro-sensors within a unidirectional composite laminate. The objective of the present numerical effort is to take into account the observed resin-rich areas caused by embedment, and to determine their effects on the local stress field around the embedment and the corresponding potential failure modes.

Keywords: ***Stress/Strain Concentration, Finite Element, Analysis, Matrix Micro-cracking, Composites***

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I. INTRODUCTION

Monitoring functionalities into composites brings out structural integrity concerns about the effect of the inclusions on the load carrying capability, structural life and failure mechanisms. The presence of the embedded devices causes material and geometrical discontinuities which are responsible for unwanted peak values of stress/strain concentration with consequences on the stiffness reduction and the overall material performance. These bring the interest of studying the mechanical interaction among the host, interface, and the embedded devices.

Experimental studies have been conducted on the strength and failure of composite materials with embedded devices such as silicon chips, Lead zirconate titanate (PZT) sensors, or fiber optic sensors, etc. From these references it appears that in cases where the thickness of the inclusion did not alter significantly the through-the-thickness geometry of the host material, the local stress concentration values remained very small thus negligible effects on the material integrity were observed.

However, in cases where the integrated devices were of not negligible size, the reduction of the strength of the embedded material as well as the damage mechanisms had to be quantified and investigated. With regard to the effects on local stress field and failure mechanisms, a number of numerical studies have been performed on embedded optical fiber sensors in composite laminates. Among the few numerical studies on embedded rectangular implants, Chow and Graves investigated the stress and displacement fields near a soft implant inside a laminated composite material. The implant was embedded with cutting several plies of the composites.

Their results indicated that the inter laminar stresses are an order of magnitude lower than the stress representing the applied far field load and the stress concentration factor was dependent on the stacking sequence. The Analyze of inter laminar stress state surrounding an interlaced, active piezo ceramic actuator embedded within a unidirectional composite laminate.

Their finite-element model appeared to be not sensitive to the transition resin layer thickness and the resin- pocket lengths. From analyze concluded that interlacing increases the strength of the composite structures with embedded actuators by redistributing the load around the inclusion and thehost/inclusion interface.

They also stated that the occurrence of delamination within the host is virtually independent of whether or not the inclusion is active. In our study, a rectangular-shaped chip resistor was embedded into a composite laminate as a simulated microsensor. The composite laminate was made from S2/BT250E1LV unidirectional glass-epoxy pre-impregnated. The simulated micro- sensor was placed with its length aligned with the fiber direction (Figure 1).

The present paper investigates the impact on the local stress/strain field under the tensile loading condition of the resin rich area and the fiber distortion due to the embedment of the rectangular-shaped implant. FEM models are developed to analyze the stress/strain state surrounding the embedded micro-sensors. In addition, failure criteria are applied to identify and locate the damage initiation.

II. FINITE-ELEMENTMODEL

The presence of an embedded simulated rectangularshaped sensor in a fiber reinforced composite creates a resin pocket (Figure 2). The sizes and the shapes of the resin pockets were measured, and the dimensions were averaged for our numerical study. 2D model containing composite, resin, and senor areas were set up to study the local stress/strain field (Figure 3). Due to the symmetry of the idealized model, only one quarter of geometry has been considered. A plane strain state has been assumed. A 3D model has also been studied and the results compared with those given by the 2D plane strain modelheredescribedbutnosignificantimprovementhasbeenfo un dintermsofthestressandstrainresults.

Four node quadrilateral plane strain elements are mostly used in this numerical analysis. In addition, three node triangular elements are used to model the tip of the resin pocket. Figure 4 shows the local finite mesh around the resin pocket. It can also be noticed that a finer mesh is used to discrete the domain around the sensor and particularly the resin pocket root, where maximum stresses are expected. The elements shape in these critical areas is carefully chosen to better approximate the ply distortion next to the inclusion due to its embedment within the composite.

Symmetrical boundary conditions are applied to the model with respect the displacement in the x and y directions. A uniaxial tensile load is applied at the end of the model in the form of a uniform displacement in the longitudinal direction. Figure 2: Micro-graph of a section of S-glass/epoxy composite laminate with embedded simulated micro sensor Figure 3: Idealized 2d model Figure 4: Local finite element mesh of 2D FEM model

III. RESULTS ANDDISCUSSION

From the output strain field, it appears that the maximum longitudinal and shear strains occur at the sensor corners within the resin-coating interface (resin rich region). Among the three strain components, the shear strain has the maximum value. Since the neat epoxy resin can carry the least

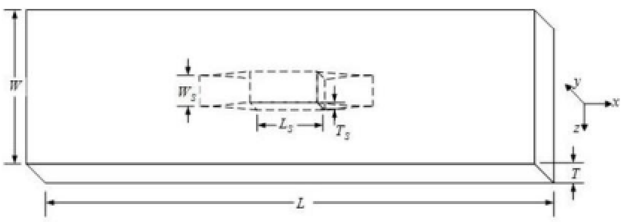

Figure 1: The embedding configuration

IV. FINITE-ELEMENTMODEL

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Figure 2: Micro-graph of a section of S-glass/epoxy composite laminate with embedded simulated micro sensor

y

strain among all the material components in the composite, sheared bonding at the resin sensor coating interface is expected to be the main cause of failure initiation. The three stress components along the resincomposite and resin-sensor coating interfaces generally have the same trend. However, in the latter case, the magnitude of stress is higher. The maximum longitudinal and transverse stresses occur at the sensor corner area. At the end of the resin pocket, the transverse stress increases. However, this small increase is not enough to cause fiber-matrix splitting.

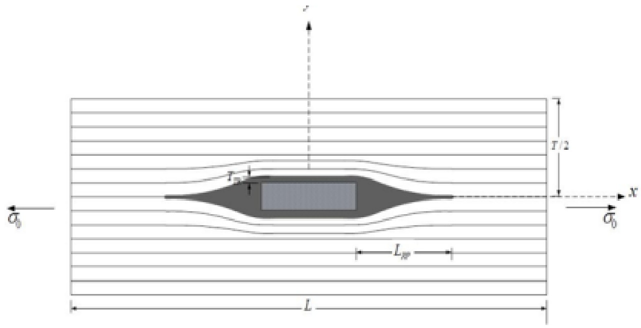

Figure 3: Idealized 2d model

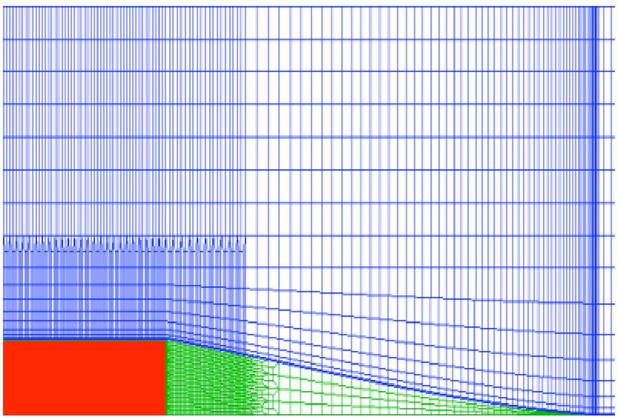

Figure 4: Local finite element mesh of 2D FEM model

The shear stresses along both interfaces show sharp rises at the sensor corners, decreasing monotonically away from the singular point. Based on the stress distribution results from, the values of the stress applied at the far end that cause the initiation of the failure were calculated both for the composite area and the neat resin area separately. For the composite domain, maximum stress criterion is applied. Failure is expected to occur when at least one stress component along one of the principal material axes reach its corresponding strength. The criterion is defined as follows: Here, the subscripts 1 and 2 refer to principal material axes of the composite material. For the neat resin area (including the transition resin layer and the resin pocket), von Mises criterion is applied. Failure is expected to occur when the stress components satisfy the chosen failure criterion.

The von Mises criterion is defined as follows: Using these criteria and the strengths of the considered material, the failure initiation stress is predicted and the site of failure initiation is located. The predicted value shows that micro-cracks may initiate around the embedded sensor at an early stage of the loading process.

Tension failure

$$\sigma_1 = F^c_{1t} \text{ or } \sigma_2 = F^c_{2t} \qquad (1a)$$

Compression failure

$$\sigma_1 = F^c_{1c} \text{ or } \sigma_2 = F^c_{2c} \qquad (1b)$$

Shear failure

$$|\sigma_6| = F^c_6 \qquad (1c)$$

Comparator is a circuit that output is binary information depending upon the comparison of two input voltages here the comparison in between analog voltage and reference voltage. Analog voltage is greater than reference voltage, and then comparator output is logic ‘1’. The comparator output is logic ‘0’, when analog voltage is less than reference voltage. Comparators are effectively used in analog to digital (ADC) converters. In analog to digital conversion process [1], the analog voltage is converted in to samples for getting accuracy. Those samples are given to set of comparators in order to achieve equivalent binary information. The schematic of

$$F_v = (-3J_2')^{1/2} \qquad (2a)$$

$$J_2' = -1/6[(\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_3 - \sigma_1)^2] \qquad (2b)$$

V. RELATED WORKS

In comparator circuits to reduce power consumption the Power gating technique is proposed. In this technique, circuit operates in sleep mode by switching off the current in circuit. Power gating has the benefit that is it measures current (Idd) in the quiescent state. In this paper the different architectures of double tail comparator is presented. The proposed comparator is designed by using power gating technique. Using this technique power and delay is reduced.

VI. CONCLUSION

The presence of the embedded micro-sensors in laminated composites is predicted to initiate premature failure. Complex micro-mechanical interactions occur at the fiber glass/epoxy laminate and the embedded simulated sensor interface. FEM analysis has been conducted to study the effect of the embedded simulated micro sensor on the stress/strain fields and failure mechanisms within the host composite laminate. Under tensile loads, the initial failure is expected to be matrix cracking at the sensor corners in the resin-sensor coating interface. The failure initiation load is predicted using von Misescriterion.

REFERENCES

[1]. P. Nirmala, T. Manimegalai, J. R. Arunkumar, S. Vimala, G. Vinoth Rajkumar, Raja Raju, "A Mechanism for Detecting the Intruder in the Network through a Stacking Dilated CNN Model", Wireless Communications and Mobile Computing, vol. 2022, Article ID 1955009, 13 pages, 2022. https://doi.org/10.1155/2022/1955009.

[2]. D. Sathyanarayanan, T. S. Reddy, A. Sathish, P. Geetha, J. R. Arunkumar and S. P. K. Deepak, "American Sign Language Recognition System for Numerical and Alphabets," 2023 International Conference on Research Methodologies in Knowledge Management, Artificial Intelligence and Telecommunication Engineering (RMKMATE), Chennai, India, 2023, pp. 1-6, doi: 10.1109/RMKMATE59243.2023.10369455.

[3]. J. R. Arunkumar, Tagele berihun Mengist, 2020" Developing Ethiopian Yirgacheffe Coffee Grading Model using a Deep Learning Classifier" International Journal of Innovative Technology and Exploring Engineering (IJITEE) ISSN: 2278-3075, Volume-9 Issue-4, February 2020. DOI: 10.35940/ijitee.D1823.029420.

[4]. Ashwini, S., Arunkumar, J.R., Prabu, R.T. et al. Diagnosis and multi-classification of lung diseases in CXR images using optimized deep convolutional neural network. Soft Comput (2023). https://doi.org/10.1007/s00500-023-09480-3

[5]. J.R.Arunkumar, Dr.E.Muthukumar," A Novel Method to Improve AODV Protocol for WSN" in Journal of Engineering Sciences" ISSN NO: 0377-9254Volume 3, Issue 1, Jul 2012.

[6]. R. K, A. Shameem, P. Biswas, B. T. Geetha, J. R. Arunkumar and P. K. Lakineni, "Supply Chain Management Using Blockchain: Opportunities, Challenges, and Future Directions," 2023 Second International Conference on Informatics (ICI), Noida, India, 2023, pp. 1-6, doi: 10.1109/ICI60088.2023.10421633.

[7]. Arunkumar, J. R. "Study Analysis of Cloud Security Chanllenges and Issues in Cloud Computing Technologies." Journal of Science, Computing and Engineering Research 6.8 (2023): 06-10.

[8]. J. R. Arunkumar, R. Raman, S. Sivakumar and R. Pavithra, "Wearable Devices for Patient Monitoring System using IoT," 2023 8th International Conference on Communication and Electronics Systems (ICCES), Coimbatore, India, 2023, pp. 381-385, doi: 10.1109/ICCES57224.2023.10192741.

[9]. S. Sugumaran, C. Geetha, S. S, P. C. Bharath Kumar, T. D. Subha and J. R. Arunkumar, "Energy Efficient Routing Algorithm with Mobile Sink Assistance in Wireless Sensor Networks," 2023 International Conference on Advances in Computing, Communication and Applied Informatics (ACCAI), Chennai, India, 2023, pp. 1-7, doi: 10.1109/ACCAI58221.2023.10201142.

[10]. R. S. Vignesh, V. Chinnammal, Gururaj.D, A. K. Kumar, K. V. Karthikeyan and J. R. Arunkumar, "Secured Data Access and Control Abilities Management over Cloud Environment using Novel Cryptographic Principles," 2023 International Conference on Advances in Computing, Communication and Applied Informatics (ACCAI), Chennai, India, 2023, pp. 1-8, doi: 10.1109/ACCAI58221.2023.10199616.

[11]. Syamala, M., Anusuya, R., Sonkar, S.K. et al. Big data analytics for dynamic network slicing in 5G and beyond with dynamic user preferences. Opt Quant Electron 56, 61 (2024). https://doi.org/10.1007/s11082-023-05663-2

[12]. Krishna Veni, S. R., and R. Anusuya. "Design and Study Analysis Automated Recognition system of Fake Currency Notes." Journal of Science, Computing and Engineering Research 6.6 (2023): 16-20.

[13]. V. RamKumar, S. Shanthi, K. S. Kumar, S. Kanageswari, S. Mahalakshmi and R. Anusuya, "Internet of Things Assisted Remote Health and Safety Monitoring Scheme Using Intelligent Sensors," 2023 International Conference on Advances in Computing, Communication and Applied Informatics (ACCAI), Chennai, India, 2023, pp. 1-8, doi: 10.1109/ACCAI58221.2023.10199766.

[14]. R. S. Vignesh, R. Sankar, A. Balaji, K. S. Kumar, V. Sharmila Bhargavi and R. Anusuya, "IoT Assisted Drunk and Drive People Identification to Avoid Accidents and Ensure Road Safety Measures," 2023 International Conference on Advances in Computing, Communication and Applied Informatics (ACCAI), Chennai, India, 2023, pp. 1-7, doi: 10.1109/ACCAI58221.2023.10200809.

[15]. I. Chandra, G. Sowmiya, G. Charulatha, S. D, S. Gomathi and R. Anusuya, "An efficient Intelligent Systems for Low-Power Consumption Zigbee-Based Wearable Device for Voice Data Transmission," 2023 International Conference on Artificial Intelligence and Knowledge Discovery in Concurrent Engineering (ICECONF), Chennai, India, 2023, pp. 1-7, doi: 10.1109/ICECONF57129.2023.10083856.

[16]. G. Karthikeyan, D. T. G, R. Anusuya, K. K. G, J. T and R. T. Prabu, "Real-Time Sidewalk Crack Identification and Classification based on Convolutional Neural Network using Thermal Images," 2022 International Conference on Automation, Computing and Renewable Systems (ICACRS), Pudukkottai, India, 2022, pp. 1266-1274, doi: 10.1109/ICACRS55517.2022.10029202.

[17]. R. Meena, T. Kavitha, A. K. S, D. M. Mathew, R. Anusuya and G. Karthik, "Extracting Behavioral Characteristics of College Students Using Data Mining on Big Data," 2023 International Conference on Artificial Intelligence and Knowledge Discovery in Concurrent Engineering

(ICECONF), Chennai, India, 2023, pp. 1-7, doi: 10.1109/ICECONF57129.2023.10084276.

[18]. S. Bharathi, A. Balaji, D. Irene. J, C. Kalaivanan and R. Anusuya, "An Efficient Liver Disease Prediction based on Deep Convolutional Neural Network using Biopsy Images," 2022 3rd International Conference on Smart Electronics and Communication (ICOSEC), Trichy, India, 2022, pp. 1141-1147, doi: 10.1109/ICOSEC54921.2022.9951870.

[19]. I. Chandra, G. Sowmiya, G. Charulatha, S. D, S. Gomathi and R. Anusuya, "An efficient Intelligent Systems for Low-Power Consumption Zigbee-Based Wearable Device for Voice Data Transmission," 2023 International Conference on Artificial Intelligence and Knowledge Discovery in Concurrent Engineering (ICECONF), Chennai, India, 2023, pp. 1-7, doi: 10.1109/ICECONF57129.2023.10083856.

[20]. Revathi, S., et al. "Developing an Infant Monitoring System using IoT (INMOS)." International Scientific Journal of Contemporary Research in Engineering Science and Management 6.1 (2021): 111-115.

[21]. R. K, A. Shameem, P. Biswas, B. T. Geetha, J. R. Arunkumar and P. K. Lakineni, "Supply Chain Management Using Blockchain: Opportunities, Challenges, and Future Directions," 2023 Second International Conference on Informatics (ICI), Noida, India, 2023, pp. 1-6, doi: 10.1109/ICI60088.2023.10421633.

[22]. J.R.Arunkumar. "Comprehensice Analysis of Security Issues in Cloud Computing Technologies", Journal of Science,Computing and Engineering Research, 6(5), 06-10, June 2023.

[23]. S. Sugumaran, C. Geetha, S. S, P. C. Bharath Kumar, T. D. Subha and J. R. Arunkumar, "Energy Efficient Routing Algorithm with Mobile Sink Assistance in Wireless Sensor Networks," 2023 International Conference on Advances in Computing, Communication and Applied Informatics (ACCAI), Chennai, India, 2023, pp. 1-7, doi: 10.1109/ACCAI58221.2023.10201142.

[24]. I. Chandra, K. V. Karthikeyan, R. V, S. K, M. Tamilselvi and J. R. Arunkumar, "A Robust and Efficient Computational Offloading and Task Scheduling Model in Mobile Cloud Computing," 2023 International Conference on Artificial Intelligence and Knowledge Discovery in Concurrent Engineering (ICECONF), Chennai, India, 2023, pp. 1-8, doi: 10.1109/ICECONF57129.2023.10084293.

[25]. R. S. Vignesh, A. Kumar S, T. M. Amirthalakshmi, P. Delphy, J. R. Arunkumar and S. Kamatchi, "An Efficient and Intelligent Systems for Internet of Things Based Health Observance System for Covid 19 Patients," 2023 International Conference on Artificial Intelligence and Knowledge Discovery in Concurrent Engineering (ICECONF), Chennai, India, 2023, pp. 1-8, doi: 10.1109/ICECONF57129.2023.10084066.

[26]. DC Jullie Josephine, J Sudhakar, T Helan Vidhya, R Anusuya, G Ramkumar,"An Improved Multi class Breast cancer classification and Abnormality Detection based on Modified Deep Learning Neural Network Principles", Deep Learning in Biomedical Signal and Medical Imaging, CRC Press, Taylor and Francis, 2024.

[27]. R. Anusuya, Pragya Vashishtha, "Real Automatic Number Plate Image Detection With Yolo Algorithms", Journal of Science, Computing and Engineering Research, 7(7), July 2024.