SPE COMPOSITES

MAY / JUNE 2019

Composites Connection™

Official Newsletter of the SPE Composites Division
Reaching Over 1,000 Composites Professionals
In All Industries

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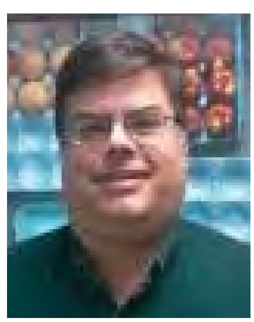

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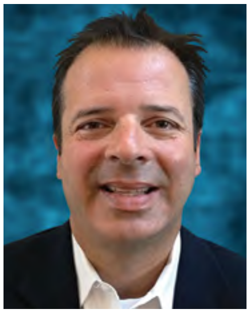

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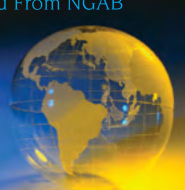

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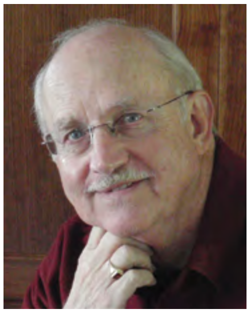

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SPE Composites Board of Directors meeting together for the first 2019 BOD meeting at ANTEC 2019.

Board Meeting Minutes Dec 19, 2018

By: John P. Busel

Wednesday, December 19, 2018
11:00 AM – 12:30 PM Eastern US
Conference Call

1. Welcome

- Ray Boeman called the meeting to order at 11:07 am.
- John Busel conducted Roll Call of the attendees.

2. Administrative

- Ray Boeman reviewed the last meeting minutes of September 4, 2018. It was moved and seconded to approve the last meeting minutes as written. Motion passed.
- Ray Boeman reviewed the action items. A new line item was added in the budget by the treasurer.
- Ray Boeman reported that changes to the Policy Manual was distributed prior to the meeting.
- Ray Boeman reported that D&O insurance was secured for the ComDiv as required by SPE HQ.

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Board Meeting Minutes continued...

- Ray Boeman reported that Antoine Rios was appointed Chair of the Finance committee. The other members of the committee are the COMDIV Chair, Ray Boeman, and Treasurer, Tim Johnson, in accordance with the Policy Manual
- Ray Boeman reported that Antoine Rios and Creig Bowland have been appointed to the Auditing Committee. The Chair-Elect - Ian Swentek, chairs the committee.

3. Treasurers Report

- Ray Boeman reported Tim Johnson was unable to present his report. John Busel read the treasurers' report provided by Tim Johnson. No comments or discussion.

4. ComDiv Policy Manual Update

- Ray Boeman reviewed the changes to the Policy Manual. He received several comments from the BOD members that included grammar, spelling, and other more changes.
- Ray Boeman reviewed the comments from each member. Discussion was on section B.5 last paragraph on quorum. The group agreed that paragraph was not clearly stated. It was pointed out that quorum in Section V has a different definition. Antoine Rios moved to change the wording in B.5, paragraph 4 – "For the transaction of business at any meeting of the board a quorum should be met. A quorum is defined as 1/3 of the full board members with at least 2 executive board members. For changes to the Policy Manual refer to Section V.2." Jim Griffing seconded. Motion passed.

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Board Meeting Minutes continued...

- Ray Boeman reviewed the comments from Jim Griffing on Section C. Jim Griffing pointed out inconsistencies in the manual regarding the Councilor being identified as an Officer. Jim Griffing moved Section C.1 to add Councilor to read "…Past Chair, Secretary, Councilor, and Treasurer, and in Section C.2. Ian Swentek pointed out that SPE policy indicates Councilor cannot be an Officer. The group discussed options. Motion did not pass. Jim Griffing then moved to delete the following words "with the exception of the COMDIV Councilor whose term coincides with SPE Headquarters term of office" from the last sentence of the first paragraph of section C.2, and to delete "OFFICERS –" in the title of Section I. Motion seconded. Motion passed. The Board concluded that the approved changes adequately addresses the inconsistencies.
- Ray Boeman reviewed the comments provided by John Busel for Section F - Secretary.
  o Antoine Rios moved to remove section F.4.b. Motion seconded. Motion passed.
  o John Busel moved to remove the words "and calendar" from section F.7.a. Motion seconded. Motion passed.
  o John Busel moved to remove Section F.8.a & b. Motion seconded. Motion passed.
  o John Busel moved to remove the second sentence in F.5.a because it includes "nominating committee" which was voted by the Board at the last meeting to eliminate this committee. Motion seconded. Motion passed.
- Jim Griffing moved to delete F.1.c "and sends a copy to the SPE Executive Office" and add this section "and sends a copy to the SPE Executive Office" to the end of Section F.1.e. Motion seconded. Motion passed.
- Jim Griffingmoved to accept all other changes to the policy manual as presented. Motion seconded. Motion passed.

5. Committee Reports

- Tech Conference - ANTEC 2019 – Rich Caruso reported there are 2 sections on Monday and Tuesday of the conference for composites. There are 20 technical papers and 2 keynotes. We need volunteers to moderate 4 sessions. There is no discounted registration rate for moderating. The question was raised as to the best time to present awards. It was suggested to have awards presented after the keynotes. The group agreed to have the awards presentation on Tuesday after the keynote.

6. New Business

- There was no new business to discuss.

7. Wrap Up

- Ian Swentek reported that the next meeting is tentatively scheduled for March 18, 2019 from 12:00 – 2:00 pm. He is waiting for confirmation from the hotel and will advise the Board when this happens.

8. Adjourn

- There was no further business to discuss. He thanked the members for their patience on the policy manual discussion. Ray Boeman adjourned the meeting at 12:30 pm.

Respectfully Submitted,
John P. Busel, Secretary

Attendees

Officers:
Ray Boeman, Chair
Ian Swentek, Chair-Elect
John P. Busel, Secretary
Dale Brosius, Councilor

Director Members:

Creig Bowland	Rich Caruso
John Gillespie	Jim Griffing
Dale Grove	Enamul Haque
Alex Kravchenko	Nipanni Rao
Andy Rich	Antoine Rios
Uday Vaidya	Mingfu Zhang

This Issue:

Education Report

By: Uday Vaidya

The overall activities of the education within the SPE Composites Division are going well. Below is a summary of activities in the last quarter.

The ACCE 2019 student poster competition

will be held as in the past. The topics covered include a broad spectrum of biocomposites, nanocomposites, design/manufacturing and application development topics related to automotive and transportation. We are expecting a very enthusiastic poster session this time. We are targeting between 45-50 student participants and the final list will be compiled by July 31, 2019.

Education Funding For 2019

We will run the education funding call for the 2019 period to receive proposals by May 31, 2019. We are looking at receiving at least 8-10 quality proposals. The draft "Call for Proposals" for this is attached – it is similar to that shared before. (See Appendix A)The history of the 2018 funding is attached as Appendix B to this report.

We continue to compile the Universities most engaged with SPE Composites and responsive to SPE activities

(Updated March 2019)

This list is based on about 10 years of engagement with these institutions and those that tend to respond/participate in SPE Composites activities.

Please review this list and append to it based on your interactions and if you see any missing.

1) Aachen University, Germany
2) Auburn University
3) Baylor University
4) Clemson University
5) Colorado State University
6) Fraunhofer ICT
7) Georgia Institute of Technology
8) Iowa State University
9) Louisiana State University
10) Michigan Area High Schools
11) Michigan State University
12) Mississippi State University
13) North Dakota State University
14) Oakland University
15) Oklahoma State University
16) Old Dominion University
17) Purdue University
18) San Diego State University
19) Tuskegee University
20) University of Alabama, Tuscaloosa
21) Univ. of Alabama at Birmingham
22) University of Dayton
23) University of Delaware
24) University of Guelph, Canada
25) University of Kentucky
26) Univ of Massachusetts, Amherst
27) Univ of Massachusetts, Lowell
28) University of Maine
29) University of Michigan, Dearborn
30) University of Mississippi
31) University of Southern California
32) University of Southern Mississippi
33) University of Tennessee, Knoxville
34) University of Texas, El Paso
35) University of Texas, Marcos
36) University of Waterloo, Canada
37) University of Wisconsin, Madison
38) University of Wisconsin, Stout
39) Vanderbilt University
40) Wayne State University
41) Washington State University
42) Western University, Canada
43) Western Washington University
44) Winona State University

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This Issue:

Education Report continued...

The SPE Plastivan events

and coordination at three sites is being discussed for the 2019 period. We will update the list of events shortly as they are being formalized. One is expected to take place in Michigan, one in the Southeast and one in the Southwest.

In the Fall 2018 and Jan 2019 period

we had three events at the University of Tennessee engaging 18 and 24 students respectively in hands-on activity of building glass and carbon fiber snow sled using vacuum infusin molding. The students learned about fabric preparation, layup, vacuum bagging and resin mixing and handling. On March 14, 2019 the UT SPE chapter along with the UT Fibers and Composites Manufacturing Facility hosted 32 architecture students for the plastics and composites in architecture demos and interactive videos.

Other suggestions are most welcome.

Respectfully submitted by Uday Vaidya, PhD
SPE Composites Education Chair

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Education Report continued...

APPENDIX A

The call for proposal for the Education Funding for the 2019 period is given below.

Call For Proposals

SPE Composites Division Education Funding

Due: May 31, 2019

Background:

The use of advanced composites is rapidly growing in a number of sectors including automotive, sporting goods, infrastructure, defense and industrial applications. The next generation work force and employers seek talent with comprehensive experience in the design, modeling, manufacturing and characterization of advanced composite materials and products.

The SPE Composites Division is making significant efforts to expand the pool of trained work force with relevant training and experience in composite applications that aligns with the needs of the industry.

The SPE Composites Division invites applications to fund the purchase / procurement of equipment or software that will enhance undergraduate and graduate student involvement in any aspect of advanced composites science and technology. The proposal must demonstrate high level of student involvement and make the case for how the proposed acquisition/activity will benefit the program. Examples of such request may include, but not limited to-

Equipment for composites processing / manufacturing (for example- molds/ tooling, resin/fiber processing equipment, 3D printing etc.)

Design, modeling and product development (solid modeling, finite element analysis, process modeling software)

Unique educational activity (targeted workshops, develop training/education modules)

Who is Eligible:

A four-year institution/university or a 2-year community college that offers courses and/or training in engineering and technology with course offerings in Introduction to Materials, Fibers, Polymers, Composites, Manufacturing. Demonstrated involvement from Freshmen to Senior to Graduate level students and K-12 outreach students in composites activities is encouraged.

Level of Funding:

SPE Composites Division will provide <u>up to</u> $5000 (for each approved proposal) with an institutional cost share requirement of 1:1. For e.g. if the value of the equipment/software/activity is $10,000, SPE will contribute $5000 towards the purchase. The institution will be responsible to provide $5000. Indirect costs *are not* allowed.

Application Process:

The application should be organized as follows:-

Cover Page: Name of the Project, Point of Contact, Institution Name and Contact Details, Date of Submission

Body of the Application (3-5 pages max):

1) Background of the Lab/Center/Department/Unit/Institution
2) Anticipated number of users and how the equipment/software/activity will impact- undergraduates, graduates, staff, post-docs, and other users

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Education Report continued...

3) Description of the processing equipment/software/activity – need and plans for use
4) Budget breakdown including cost share details and justification
5) Letter of commitment for the cost share from the Dean, Department Head or other Institutional authority (authorized to sign on behalf of the institution)
6) Quote or evidence of cost based on correspondence with the vendor

Review and Selection Process:

Each application will be reviewed by a team of industry and academic experts and funding will be released based on their recommendation and approval of the SPE Composites Board. Based on the quality of the proposals received the Board may award 1 to 3 awards in this funding cycle.

Expectations if awarded:

Recipients are expected to:

Participate in one of the SPE meetings (SPE ACCE, ANTEC etc) to report on educational impact of the funding. The information can be in a poster or presentation format.

Provide a brief summary/highlights at the end of the year that could be included in the SPE Composites Division newsletter.

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Education Report continued...

Deadline / Submission of Application: <u>May 31, 2019</u>.

The submission is limited to one application per institution per year.

Applications should be e-mailed to (with the Subject Line – SPE Education Fund Application:

Uday Vaidya, PhD; SPE Education Chair, uvaidya@utk.edu; Phone: 205-410-2898

Other Information:

Notification of awards will be made in the July-early August 2018 time frame. The awards will be made at the annual SPE ACCE meeting to be held in Novi, Michigan in September 4-6, 2019. The awardee institution will receive the funding, a certificate and plaque. The award notifications will be made in SPE media, website and news releases.

Thank you for your time and interest. We look forward to hearing from you. Please contact us for additional details.

APPENDIX B : History of SPE Education Funding recipients from 2018.

Proposal recommended for funding (2018 history)

Proposal	University	SPE Funds requested and recommended	Total project
Aero @ Auburn Makerspace – 3D Printing Lab	Auburn University	$4945	$9890
Acquisition of a High Temperature Composite Filament Extruder for 3D Printing	University of Alabama, Tuscaloosa	$5000	$10000
Educational Tools for Vacuum Infusion of Composite Structures	University of Southern California	$5000	$10000
Selective Laser Sintering for Investigation of Anisotropic Failure Criteria	University of Wisconsin, Madison	$4712	$9424

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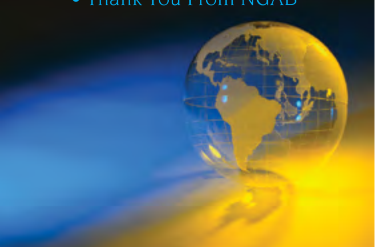

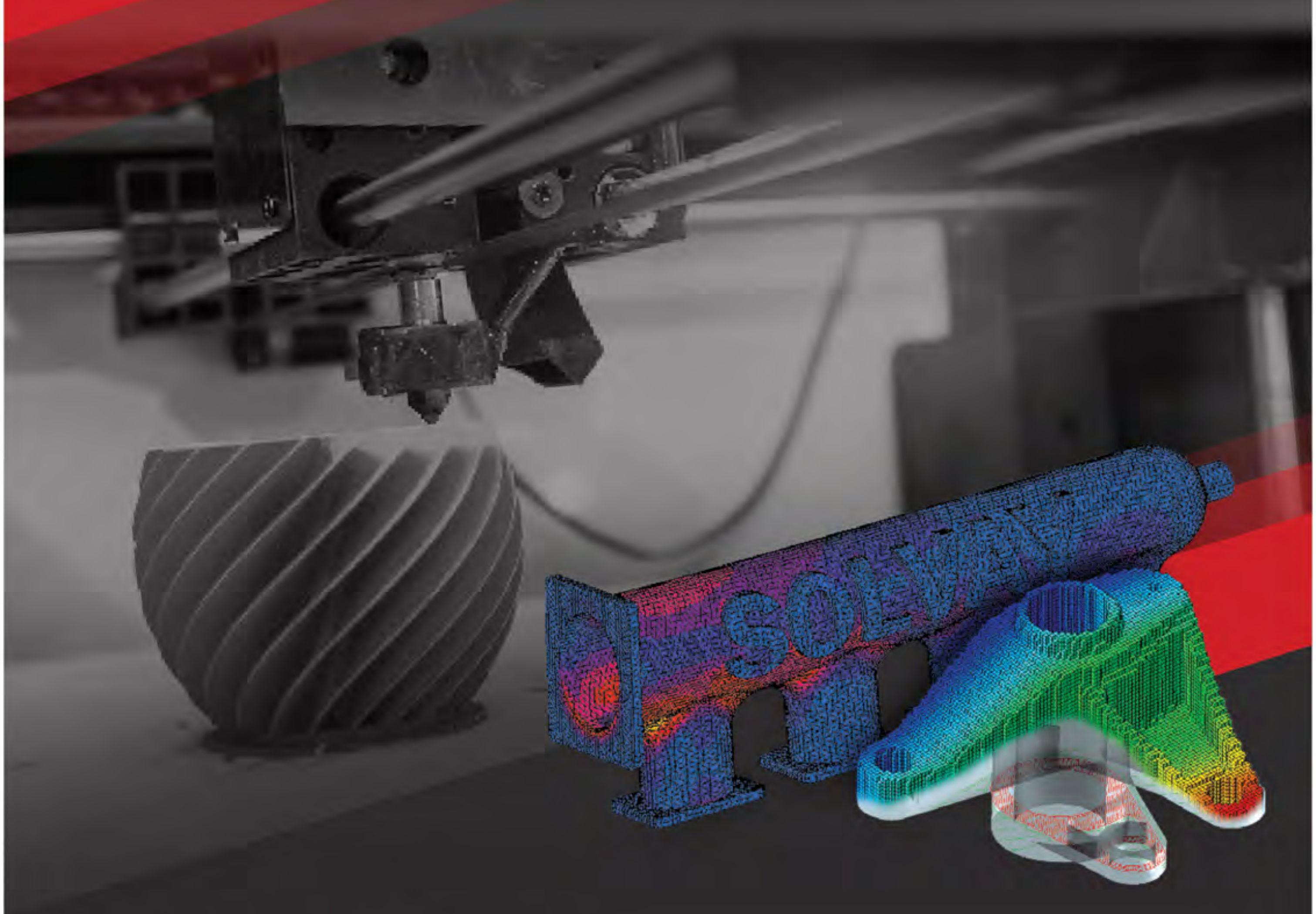
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Secretary Report

By: John P. Bussel

Election of Board of Directors

It is time for the SPE Composites Division membership to elect members to open seats on the Division's Board of Directors. Each individual elected to the Board serves a three-year term. You are asked to vote for eight Board candidates to fill the 3-year open terms for 2019–2022. Write-in candidates are also eligible for election to the Board, remember you are allowed to only vote once.

Procedure for voting:

- Review the candidates' biographical sketches.
- Enter your name and your primary email address (to allow the Nominating Committee to validate the ballot).
- Vote for eight persons for Board of Directors by checking the box by the candidate's name, OR check the box next to "Write-in Candidate" and fill in the appropriate contact information.
- Complete the "Volunteer" and "Suggestions" sections.
- Click "Done" to submit your online ballot.

Please note: Ballots received after February 15, 2019 will not be counted.

Candidates for Board of Directors for the SPE Composites Division (Vote for 8) *

1. Rich Caruso, CEO, INTER/COMP, LLC
2. Michael Connolly, Ph.D., Technology Leader - Urethane Composites, Huntsman Polyurethanes
3. Pritam Das, Technical Manager, Toray Composite Materials America, Inc.
4. Fred Deans, President, Allied Composite Technologies, LLC
5. Jim Griffing, (retired), Technical Fellow, Boeing Research & Technology
6. Enamul Haque Ph.D. Vice President and General Manager, Research & New Product Development, Cooley/Group
7. Antoine Rios, Ph.D., The Madison Group
8. Uday Vaidya, Ph.D., UT/ORNL Governor's Chair in Advanced Composites Manufacturing, Chief Technology Officer, IACMI, University of Tennessee and The Composites Institute

Results

- All candidates for Directors were approved.

SPE Staff Observations

- Kathy - I don't believe having a longer election period would net a larger participation as most who will vote do so in the first 24 hours. You will see on your reporting that only one vote was cast outside the first 24 hours.

This Issue:

ANTEC TPC Report 2019

By: Rich Caruso and Shankar Srinivasan

SPE's Annual Technical Conference 2019- Summary

1) ANTEC has two sections this year

a. ANTEC INSPIRE 2019 (March 18 - 20) - Technical sessions and exhibition

b. ANTEC INSIGHT 2019 (MARCH 20 - 21) - Industry Insights, Trends and exhibition

2) ANTEC 2019 By the numbers-

We, the composites division have a total of

a. 4 - technical paper sessions at ANTEC 2019

i. 2 - sessions each on Monday March 18th and Tuesday March 19th

b. 22 - talks over 4 sessions

i. 2 Keynotes - 1hr each (Alan Taub, U Michigan and Mark Voss, GM)

ii. 20 Technical papers 30min each

3) Contributors- We would like thank all our board members for their time and commitment to the review process and a special thanks to John Busel and Alex Kravchenko for being our key support members with the ANTEC review process and TPC activities.

FUTURE

ANTEC submissions to our division have gradually reduce over the last 3 years but this has been a trend with other divisions as well. Though the submission numbers have dropped, we as the composites division have maintained a steady 2nd and this year we have dropped to 3rd position for the most number of ANTEC submissions received.

Proposed /Suggested Actions to Improve Participation/Submissions-

1) Personalized email invites- In the past, personalized email invites have resulted in higher submission numbers (in 2016-17 we received 65 approx.) We plan to formalize this process.

Request to Board Members - The success of this effort requires us to keep our email invite list up to date with the latest emails of our division's patrons. We need your help in augmenting the list with potential new participants by June 2019 so we can prepare for 2020.

2) Cross Marketing - It would be an effective strategy to have dedicated resources/ people/ board members leverage relations to cross market our division's ANTEC session at other events such as ACCE, JEC or even at CAMX and extend the offer vice versa (we know to some of us this approach could be unorthodox, but it is important that we try new approaches or give it some consideration)

Request to Board Members - We look forward to your inputs, thoughts, suggestions an if possible your help as well.

3) Unique Platform (Moon shot) - Beside our traditional Technical paper sessions, we as a division or whole of SPE even, should consider providing a unique platform for both our academia and industry contributors to feature their mature research and new licensable technologies. This could benefit both our patrons and our contributors by accelerating communication and potentially tech transfer.

Request to Board Members - We look forward to your inputs, thoughts, suggestions an if possible your help as well.

This Issue:

SPE Council Summary

March 16 - 17, 2019 • Detroit, MI

The SPE Council meetings were held prior to ANTEC 2019 in Detroit, Michigan. At the beginning of proceedings, President Brian Grady called for a moment of silence to honor the passing of several distinguished SPE members, including Dr. Vicki Flaris, Thoi Ho, Dennis Hvam, and Richard G. Johnson.

All presentations and data discussed during Council meetings are available on The Chain in the Council Committee of the Whole (CCOW). We encourage everyone to take the time to review this information to get a full understanding of the Society.

Financial Review

For 2018, SPE had a net positive operational result, but showed an overall deficit due to lower than expected investment results. SPE management meets on a quarterly basis with investment advisors. January 2019 results were better than budget. SPE is projecting a loss for 2019. Complete details on the 2019 budget are available on The Chain. A summary of the 2018 budget vs. actual report is available below:

		2018 Budget		2018 Actual
REVENUES				
Membership/HQ	$	2,062,001	$	2,076,477
Foundation	$	463,500	$	366,397
HQ Events	$	888,500	$	805,372
Supported Events	$	348,500	$	396,510
Total Revenues	**$**	**3,762,501**	**$**	**3,644,756**
EXPENSES				
Membership/HQ	$	2,916,161	$	2,612,042
Foundation	$	589,495	$	456,673
HQ Events	$	715,781	$	559,365
Supported Events	$	22,600	$	10,135
Total Expenses	**$**	**4,244,037**	**$**	**3,638,215**
RESULTS				
Operational Result	**$**	**(481,536)**	**$**	**6,541**
Investment / Interst	**$**	**401,000**	**$**	**(290,420)**
Total Result	**$**	**(80,536)**	**$**	**(283,879)**

SPE Official Business

Councilor Bruce Mulholland presented several proposed changes to bylaws and policies related to the budget review process and Fellows/HSM ratification procedures. Council approved both motions. All changes can be found in the official minutes.

At the end of Council I, President Grady thanked the Executive Board for their service. He also thanked Past President Al-Zubi who is now leaving the Executive Board. President-Elect Landes president the ceremonial pin to Grady and delivered the traditional "Whereas" tribute to Grady.

Incoming President's Remarks

Dr. Brian Landes of Dow Chemical begins his tenure as President of SPE (2019 – 2020). Dr. Landes delivered an inspiring talk that encouraged all SPE members to reflect upon why they joined the society and what they can do to ensure the society remains relevant and important in a changing world. His presentation included a summary of the SPE Strategic Plan that focuses on twin pillars of knowledge and networking. If SPE is to be vibrant for future generations of plastics professionals, it must make difficult decisions about resource allocation and member engagement. In keeping with the plastics zeitgeist, Landes ended his talk with a short video from The Alliance to End Plastic Waste, a global group that recently dedicated $1.5bn to fight plastics pollution. SPE is uniquely positioned to contribute to this discussion because our strategic plan aligns with what is needed among the broader public audiences where scientific knowledge of polymer materials is lacking. This is the first step in a long journey, Landes concluded.

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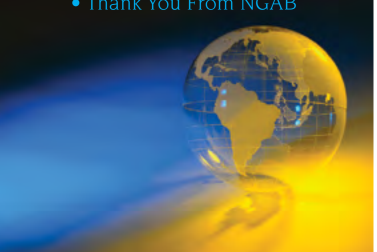


SPE Council Summary continued...

SPE Foundation

Foundation Director, Eve Vitale, presented a summary of her team's work over the past year. 21,371 students experienced the PlastiVan in 2018. $88,250 was awarded in scholarships in 2018, with 33 recipients at 21 universities. A scholarship marketing campaign was established in 2018 to increase awareness of the available scholarships in an effort to increase the number of applicants. $64,645 in grants were awarded in 2018, some at events that were not SPE-centric, thereby increasing awareness. "Giving Tuesday" (Tuesday after Black Friday) was a success, raising $8,985 so that 1200 new students can experience the PlastiVan.

Strategic Commentary

ANTEC

The 2018 event, at the time of writing, was projected to achieve ~$300k in profit for SPE. ANTEC 2020 will be in San Antonio, TX with Council starting on the 28th of March and the actual program lasting from March 30-April 2. CSE Farrey announced that ANTEC 2021 will be held in Denver, CO from March 22-25. The public announcement included discussion of the rationale for not co-locating with NPE. Both organizations, SPE and PLASTICS, have achieved a level of success with their respective events that co-location is no longer the optimal arrangement for either group.

SPE Services to Chapters

Sandra McClelland of the SPE Finance Committee presented findings from an in-depth review of SPE staff resource allocation and chapter support requirements. As summarized by CSE Farrey, HQ provides a vast array and quantity of services that consumes a significant portion of HQ staff time and resources. The current fee model (under which some Chapters pay for services and others don't) is inequitable and unsustainable. Everyone would be better served with a clearer understanding of the services provided and the cost structure. It was decided that a small task group would be assembled to review the issue and bring a recommended revised model forward for consideration. Complete details are available on Leadership Lane.

SPE Sales & Marketing

SPE Business Development Manager, Stephanie Clark, reported on the advertising revenue generated in 2018. In 2019, 79 exhibitors on the floor and 37 are brand new to ANTEC. The total revenue generated from this is $249,000. There are also 6 sponsors generating $75,000. In total, $360,000 was raised against an aggressive budget of $331,990. 26 chapters and organizations have supported student activities in 2018. In 2017, there were $270,087 of advertising sales but since that time, the total has increased to $556,600 in just 1.5 years.

Additional Reports

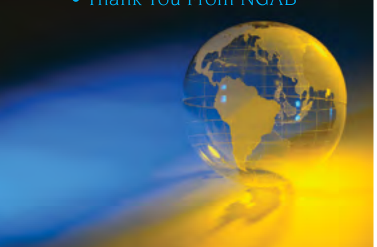
4 new student chapters have been chartered and approved by Council:

- National Textile University
- University of Oklahoma
- Ontario Institute of Technology
- UC Berkeley

The next Council meeting is tentatively scheduled for November 14-15. Further details will be made available on The Chain.

Respectfully submitted,
Conor P. Carlin
VP Marketing & Communications

This Issue:



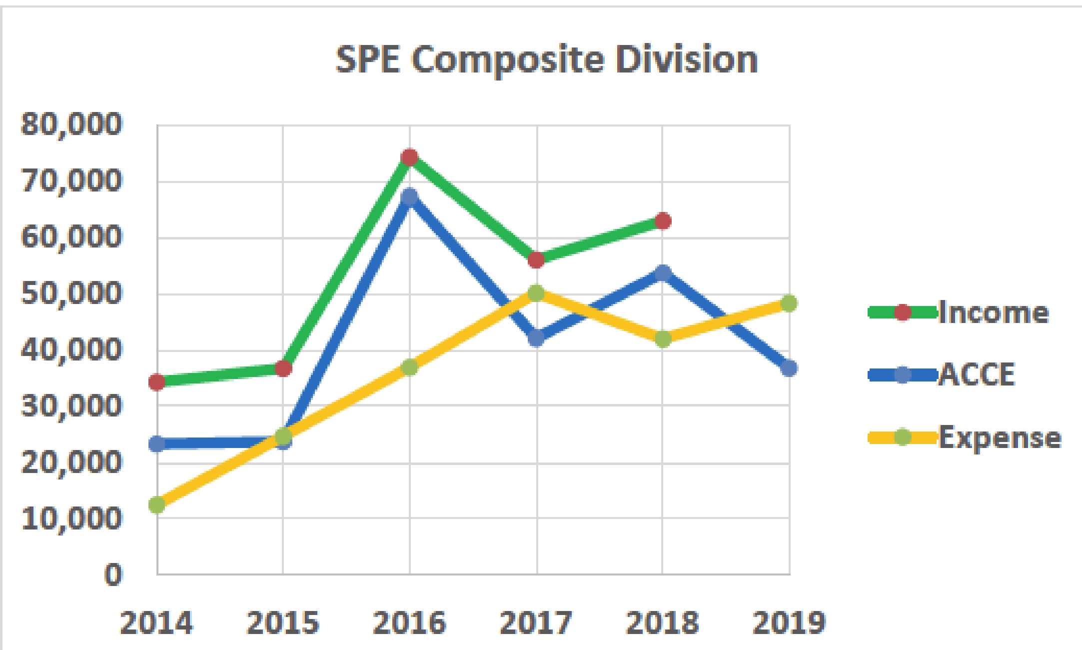
Treasurer's Report

By: Tim Johnson SPE Composites Division Treasurer

Currently the Division has cash on the order of $84.8K and $77.0K in investment. This follows distribution of profits from the ACCE, of $36.8K, the overall balance for the division account projects to be $161.8K.

All major scholarship awards and education grants have been distributed, and only expenses associated with ANTEC are anticipated for the remainder of the fiscal year, while income from Newsletter Sponsorship is expected through the spring.

I have attached a chart with some historical perspective.



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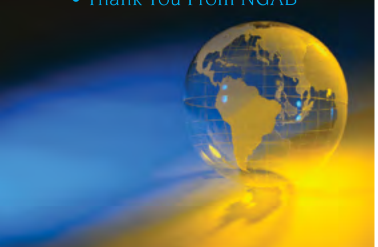

Communications Report

By: Andy Rich

The Main Site

The Microsite has finally been moved over to our main site, so there are no longer 2 separate sites. There is also no longer any linking page, the SPE site links directly to our home page.

Pedro has given me access to the Word-Press editing site, so that I can now do almost any changes that need to be made. If there is something that I cannot do myself, he is still able to help me.

For instance, we have a new Educator of the Year announcement. Once I have that text, I can make that addition.

I would like everyone to please take a look at the website and submit all suggested changes to me as soon as you can. The more we make changes to the account, the better it is for our site.

Twitter

Christophe Kuhn is doing a very good job of posting to the twitter account. I hope everyone in our group is "Following" our Twitter account. There are several reasons to Follow us on Twitter:

1. Keep up to date with the Composites Division
2. The more followers we have, the better it is for our account and its visibility.
3. You have the opportunity to Re-Tweet our posts, which helps boost the account.

Like the main site, Twitter rewards activity, so gather the followers, read the tweets, and re-post as many as possible.

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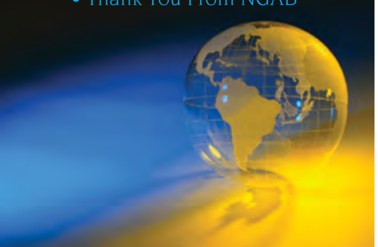


Awards Committee

By: Dale Grove

Dr. Jan Anders Mansson successfully became a SPE Fellow due to the strong sponsor letters of Jim Griffing and Dale Brosius.

Despite advertising, students did not applied for the Composite Division Travel Award. We advertised through our newsletter, website, a full SPE News Blast, and direct correspondence with student chapters. None of this worked, and I have, in the past, sent the information across our entire membership via a BCC announcement, leading to some complaints. (This was disappointing to say the least.)

Dr. Pilla from Clemson University won the Educator of the Year award. His award will be presented Monday morning after the Keynote speaker. Ray, I need your signature pronto, so I can send the completed form and plague to Shankar—check earlier emails.

Because of the timing of ANTEC versus the Foundation scholarship awards, we will not know the winners of these scholarships until later in the year. The winners of the Harold Giles Award will have to be announced during the ACCE conference.

If another board member wants to step up and take the reins of the Awards Committee, I am more than willing to step down.

This Issue:

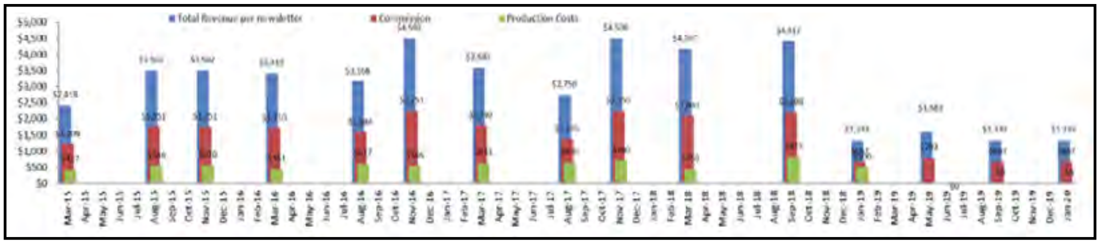
Educator of the Year Award

Dr. Srikanth Phila (left in picture from Clemson University won the Composite Division' s Educator of the Year Award. The award was presented to Dr. Pilla at Antec 2019 by Composites Board members Shankar Srinivasan(right) and Rich Caruso (not in picture).

Newsletter Report

By: Pritam Das

Financial analysis for the SPE Composites newsletter:



- Sponsorship (May) slightly higher than last round (Jan) but expected to pick up more than sponshorship shown below for 2019. 2019 sponsorship still expected to be lower than 2018.

- Teri hiring new help to get more sponsroship (Kim Hoodin - media rep for Composites World and Plastics Technology Magazine)

Newsletter:

- 1st newsletter (36 page) for 2019 published in Jan/Feb.

- Newsletter uploaded on SPE website.

- eblast sent to SPE composites members.

- LinkedIn posts sent out for the newsletter.

- Planning to release the next newsletter (May/Jun) by 1st week of May.

- Please support in providing articles to me by early April.

Request:

Please take a picture of the BOD at ANTEC 2019. Few moments from the BOD meeting would be great.

Thanks,
Pritam Das

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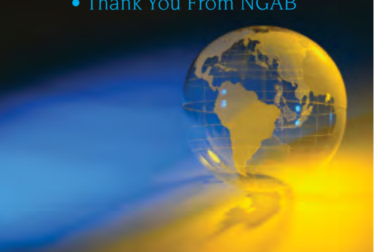

Award Winning Paper

Determination Of Mode II Traction Separation Law For S-2 Glass/Epoxy Interface Under Different Loading Rates Using A Microdroplet Test Method

Sandeep Tamrakar[1, 3*], Raja Ganesh[1, 4],
Subramani Sockalingam[1,4,5], John W. Gillespie Jr.[1, 2, 3, 4]
[1] Center for Composite Materials (UD-CCM), [2] Department of Materials Science & Engineering
[3] Department of Civil & Environmental Engineering
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[5] Current address: Department of Mechanical Engineering, University of South Carolina, Columbia SC 29201

ABSTRACT

This paper presents a methodology to extract the rate dependent traction separation law for composite interface through iterative method by simulating all the physically observed mechanisms in a microdroplet experiment. Experimentally obtained rate dependent interfacial shear strength (1 µm/s to 1 m/s), large strain resin properties (0.001/s to 12,000/s) and information on crack initiation at the interface obtained from carbon nanotube sensors are used as model input. Through simulation of microdroplet experiments, unique set of traction separation laws were determined for a given loading rate by narrowing down the range based on IFSS prediction for different droplet sizes and the associated failure modes Both traction law parameters, i.e. peak traction and the fracture energy increase with the increase in the rate of loading. Partitioning of energy absorption contribution by the constituents suggests resin plasticity and strain energy stored in the fiber play an important role up to failure.

Keywords: traction law, composite interface, microdroplet, S-2 glass/epoxy

1. Introduction

In the automotive industry, there is a demand for lightweight composite structure with enhanced energy dissipation capability during an event of crash or impact. Under dynamic loading, energy is dissipated through various mechanism such as delamination, matrix cracking at higher length scale and fiber matrix debonding, frictional sliding and fiber breakage at lower length scale. Studies have shown that the damage mechanisms pertaining to lower length scales absorb more energy [xx]. The interaction between fiber and matrix at the interface determines the overall energy absorption capability of the fiber reinforced composite material [1]. A coating on the surface of the fiber called sizing, which is in the nanometer length scale, consists of film former and silane coupling agents [2,3]. The chemical formulation of the sizing and its compatibility with the resin significantly affects the degree of adhesion between fiber and matrix and ultimately the energy absorbing capability of the composite [4,5]. This opens an opportunity to maximize the composite properties by studying the energy dissipation and failure mechanisms during interface debonding and design lightweight automotive parts. An ideal case for maximum energy absorption would be to have resin deform plastically near the

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interface with the ultimate failure occurring along the interface. Since this is a dynamic event, it become important to consider the rate dependent properties of the matrix as well as the interface.

One approach to optimize the interaction between constituents for maximum energy absorption is by studying a model composite through finite element simulation (FEA). This requires accurate rate dependent properties for fiber, resin and interface. In FEA simulation, cohesive zone models are generally used to simulate the interface between two dissimilar materials. Dependence of traction law parameters on the rate of loading has been reported in the literature [6–8]. For instance, traction law obtained through direct approach for steel adherends bonded with polyurea exhibited strong dependence on the rate of loading [8]. Rahulkumar et al. [9] modeled fracture in viscoelastic materials by combining viscoelastic adhesive model with a rate independent cohesive zone model. Xu et al. [10] modeled rate dependent failure behavior of adhesive bonds by introducing a Maxwell element to a rate independent cohesive zone model. Model parameters were determined by simulating DCB tests conducted at different strain rates. Wang et al. [11] employed spring and dashpots to introduce viscoelastic factor in the cohesive zone model and simulated DCB tests with metal adhesive (elastic) and rubber adhesive (hyperelastic) structure. Marzi et al. [12] used a rate dependent extension of bilinear cohesive model and implemented in commercial FE code LSDYNA via a user-defined subroutine. Butt joint and tapered DCB tests were conducted at velocities ranging from 10-2 mm/s to 102 mm/s to determine the Mode I model parameters. Gowrishankar et al. [7] adopted an iterative approach in which the toughness of silicon/epoxy interface was estimated by comparing the crack length in a DCB specimen, and then the peak traction was adjusted to match the experimental results. These parameters were in good agreement with the ones extracted directly.

In this study, traction law parameters are iteratively determined by accurately simulating and matching the experiments [13,14]. This route, in conjunction with the novel test methods developed for characterization of rate dependent interface and resin properties in our previous studies [15,16] and in-situ sensing of crack initiation, is the approach used.

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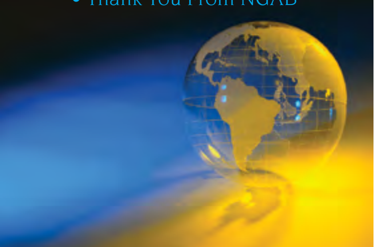

2. Microdroplet test

S-2 glass fibers with (3-glycidoxypropyl) trimethoxy silane coupling agent and epoxy film former sizing obtained from Owens Corning Corporation were used. Epoxy resin DER 353 (Dow Chemical Company) was mixed with bis (p-aminocyclohexyl) methane (PACM-20) curing agent (Air Products and Chemicals, Inc.) at stoichiometric ratio of 100:28 (weight ratio) to form the droplets which is then allowed to gel at room temperature for 5 h, followed by curing at 80 and 150 °C for 2 h each. At least 10 valid microdroplet tests were used for each loading rate. The nominal diameter of the S-2 glass fibers considered in this study was 10 µm. The embedded length of the droplet ranged from 70 to 200 µm. Fiber gauge lengths (top of drop to load cell) between 1 mm and 2 mm were maintained. Tests were conducted at 1 um/s, 0.1 mm/s and 1 m/s [17]. A modified tensile Hopkinson bar was used for 1 m/s loading rate. Details on this test setup can be found in [15].

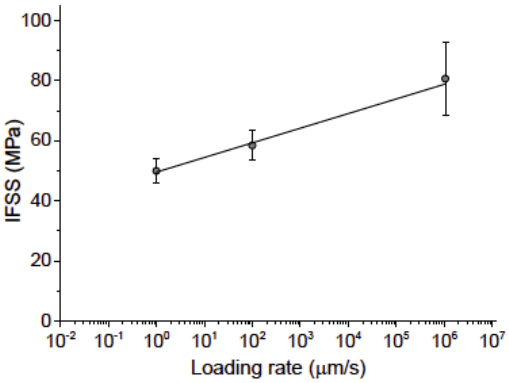

Figure 1 Average IFSS vs. loading rate for microdroplet specimens with embedded length ranging from 70 µm to 125 µm show a linear increase when plotted on a log scale

Experimental results exhibited size effects showing lower IFSS for higher embedded length, which are accounted for in the simulation. The average IFSS increased by a factor of 1.6 when the displacement rate was increased from 1 µm/s to 1 m/s (See Figure 1 and Table 1). Resin plasticity in the droplet is observed at the location of knife edge contact. Finite element simulation of the microdroplet experiments incorporates accurate rate dependent resin properties to partition the resin and interface energy contributions.

3. Proposed methodology for the determination of traction separation law

Our proposed methodology to determine rate dependent traction separation law for composite interfaces includes characterizing the rate dependent response of fiber, matrix and interface separately. Then, by accu-

Table 1 Rate dependent IFSS and specific energy up to debond

Loading Rate	IFSS (MPa)	Specific energy debond (J/m2)
1 µm/s	49.9 ± 4.7	670 ± 220
0.1 mm/s	58.4 ± 4.9	880 ± 350
1 m/s	80.6 + 12.1	1950 + 860

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rately simulating all the physically observed mechanisms in the specimen, unique traction law can be determined. Parametric studies on a bilinear traction law conducted by Tamrakar et al. [24] demonstrated a non-unique nature of the traction law where there are more than one combinations of peak traction and relative displacement for crack separation traction law parameters that accurately predict the maximum load. Two different combinations of peak traction and fracture energy resulted in very similar force displacement response. However, the point at which crack initiation occurs varies. For the traction law with 160 J/m2 and 120 MPa peak traction, the crack initiates at around 88% of the peak load, whereas for the one with 200 J/ m2 and 75 MPa, crack initiation occurs right after reaching the peak load. These parametric studies suggest that additional experimental information such as load at the initiation of debonding along the interface is important to establish uniqueness. For this purpose, the authors developed CNT sensors at submicron length scale to monitor the onset of crack initiation at the interface, where the CNT sensors act as on/off switch [17]. Measurements on change in electrical resistance during microdroplet test showed that the crack initiation occurs at the peak load and becomes unstable and failure occurs. Information on crack onset and its corresponding load level is used as an input in the FE simulation to extract traction separation law.

Resin plasticity is another factor that that must be accounted for in simulations of the microdroplet experiments for accurate traction law determination. During the experiments, large plastic deformation has been observed at the tip of the droplet where knife edge comes in contact. When only the elastic response of the resin is considered, interface debonding is assumed to be the only energy absorption mechanism. However, when resin yield stress is exceeded additional energy absorption occurs through resin plasticity. Rate dependent yield stress and stress strain response for DER 353 epoxy resin serve as input in the model [17].

The first step is to conduct the microdroplet experiments under different loading rates (Figure 2). During the experiment, cured specimens are placed on a specimen holder, which is attached to a load cell. Knife edges induce compression in the resin droplet resulting in large local deformation. This force is transferred to the fiber through shearing shear of the resin of and the interface, which results in the fiber being loaded in tension and is measured by the load cell.

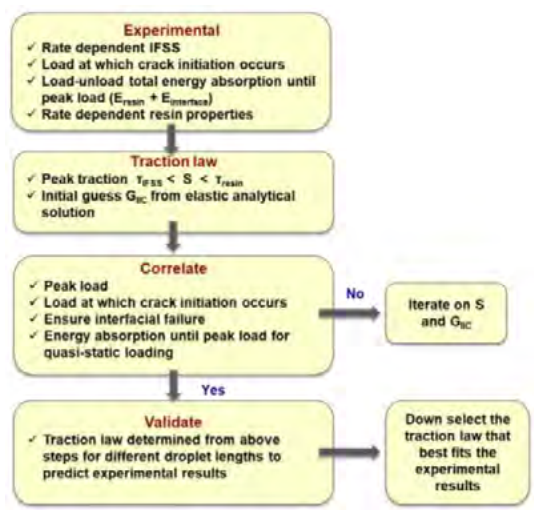

Figure 2 Methodology for determination of traction separation law for composite interface

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Award Winning Paper continued...

In our methodology, we create specimens with a minimum of three embedded lengths (75 μm, 100 μm and 125 μm). We ensure that the failure mode is along the interface and not within the resin. Our study using CNT sensors indicate that the interface debonding occurs at the maximum load in our S glass/epoxy specimens [17]. The IFSS data for each embedded length is used to correlate with the numerical predictions.

A bilinear traction separation law is assumed for the interface under Mode II loading. The key parameters associated with the traction law are the peak shear stress (S) and the critical energy release rate, GIIc (the critical shear displacement is calculated using the other parameters). It is important to note that the IFSS is an average value and that there is significant gradients along the droplet interface (highest near the knife-edge loading surface). Hence, IFSS is much lower than the peak shear stress defined in the traction law.

The simulation based iteration process using known properties of the fiber and epoxy resin begins by choosing a value for peak traction that is equal or higher than the average interfacial shear strength. Since the failure mode is confirmed experimentally to debond within the interphase, the peak stress should also not significantly exceed the yield stress of the resin (otherwise failure will occur in the resin and not be consistent with interfacial failure mode). Initial estimates for the critical energy release rate is calculated by using the critical opening displacement from the previous studies by Sockalingam et al. [13] assuming an elastic resin response for the same S glass (GPS sized)/epoxy constituents.

Simulations with different combinations of peak traction and critical energy release rate within this range are carried out for a 75 μm droplet. Combinations that cannot reach the

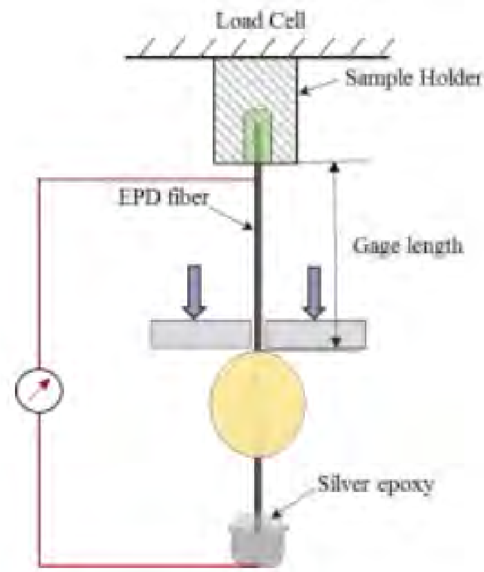

Figure 3 Quasi-static microdroplet test setup

maximum load are eliminated. Those combinations that match the peak experimental load are then checked for failure mode (interfacial or resin). Resin failure modes (extensive resin plasticity near the interface) and the associated traction law parameters are also eliminated. This sequence significantly narrows the range of admissible parameters.

This range of acceptable traction law parameters are then used to predict the IFSS for the next larger droplet sizes (100 μm and then 125 μm). This sequence is repeated and further narrowing of the range is achieved. Three drop sizes provide convergence of the traction law parameters that provides the correct failure mode and failure loads for all embedded lengths. The simulation results also allow the partitioning of energy absorbing mechanisms (interface and resin plasticity) and prediction of cohesive zone sizes for all loading rates. Incorporating resin plastic-

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This Issue:

ity ensures energy absorption of the interface softening is accurate. Assuming elastic response (for a resin with extensive resin plasticity) will result in an overestimation of the interfacial energy absorption.

This procedure also works well for droplets tested at higher rates of loading, where only the maximum load can be measured accurately. This methodology provides a unique critical peak shear stress and energy absorption parameters for the Mode II traction law as a function of loading rate that can be used in other micromechanical simulations [18].

4. Finite element model

A quarter-symmetric FE Model was used to simulate the microdroplet experiment. S glass fiber (10 μm diameter), steel knife blade and epoxy resin droplet (with spherical shape) were modeled using 8-noded linear reduced-integration 3D Brick elements (C3D8R in ABAQUS), with enhanced hourglass control. Zero-thickness 3D cohesive elements (COH3D8) represent the fiber-matrix interface. The thermal preload during the curing of the droplet was modeled as an initial quasi-static step [13], while the subsequent knife edge loading was simulated as a dynamic explicit load step and solved using the double-precision ABAQUS Explicit solver.

The fiber is modeled as isotropic linear elastic material. The matrix is modeled isotropic linear elastic up to yield. Rate dependent post yield behavior of the epoxy resin obtained from compression experiments serves as model input. The resin exhibits post yield softening, plastic flow followed by strain hardening at large strain. Element deletion occurs at the failure strain of 70%. Input properties of fiber and matrix can be found in [17]. Post yield stress strain curve for 0.001/s strain rate is used. For higher strain rates, the entire curve is shifted vertically using the strain rate dependent yield stress. Details on curve fitting and yield stress prediction using Eyring equation are presented in our previous work [16]. Details regarding meshing and boundary conditions in the model can be found elsewhere [17].

Table 2 Properties of fiber and matrix

Property	S-glass fiber	Epoxy resin DER 353
Young's modulus (GPa)	90.0	3.2
Poisson's ratio	0.17	0.36
CTE (ppm/°C)	3.4	70.0

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5. Determination of traction separation law

5.1. High rate loading

For high loading rate of 1 m/s, the average IFSS for a 75 µm droplet was 88 MPa. So, a peak traction greater than 88 MPa was chosen based on our methodology. A series of parametric studies were conducted for a droplet with 75 µm embedded length to generate a family of IFSS vs. peak traction and fracture energy curves (Figure 4). In general, simulations with lower peak tractions showed delayed crack initiation at interface and higher peak traction showed resin failure. This trend is consistent with all the loading rates used in this study.

For 1 m/s, peak tractions ranging from 110 MPa to 150 MPa match the experimental IFSS and failure modes are carried forward to predict the IFSS for different droplet sizes as part of the procedure. Traction parameters that do not predict the experimental peak loads or failure modes are eliminated.

Traction laws (120 MPa-300 J/m2 and 130 MPa-270 J/m2) exhibited correct failure modes for both 100 µm and 125 µm droplets. Size effects on the interfacial shear strength was also observed from simulation results (consistent with experimental observations), where larger droplet sizes showed lower IFSS. The traction law 120 MPa -300 J/m2 results in less error compared to the line fit to the experimental results. Hence this combination is chosen as the unique parameters for the loading rate of 1 m/s. It should be noted that our methodology to determine unique traction separation law is limited by the variability in experimental data.

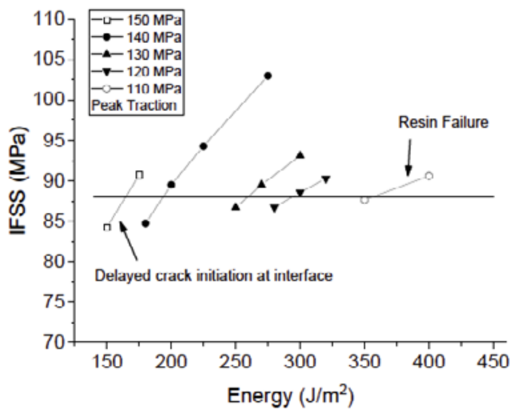

Figure 4 Parametric study on peak traction and fracture energy for the determination of traction separation law for 75 µm droplet at 1 m/s loading rate. Traction laws with peak shear stress of 110 MPa and 150 MPa are eliminated

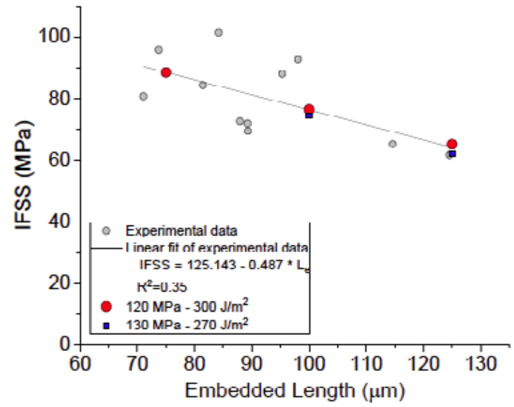

Figure 5 Average interfacial shear strength from microdroplet experiments and FE model showing size effects for 1 m/s loading rate

Table 3 Goodness of fit for the predicted IFSS at 1 m/s

Traction law	Error*
120 MPa and 300 J/m2	0.54 %
130 MPa and 270 J/m2	1.95 %

$*Error = \left| \frac{IFSSexp - IFSSmodel}{IFSSexp} \right| \times 100\%$

continued on page 33...

5.2. Intermediate loading rate

For the intermediate loading rate of 100 μm/s microdroplet tests, the IFSS was 61 MPa for a nominal 75 μm droplet. Following the methodology, results from a parametric study done with peak traction ranging from 70 MPa to 90 MPa with a wide range of fracture energies are shown in Figure 6. For peak traction between 75 MPa and 85 MPa, failure occurred along the interface and the traction laws 75 MPa –120 J/m2, 75 MPa –150 J/m2, 80 MPa –100 J/m2, 80 MPa –120 J/m2 and 85 MPa and 90 J/m2 predicted IFSS within the experimental error. However, when the peak traction of 70 MPa and 90 MPa exhibited delayed crack initiation at the interface and resin failure, respectively. Following our methodology, the traction law was narrowed down to 75 MPa –150 J/m2, which showed interfacial failure for both 75 μm and 125 μm droplets. Comparison of the simulation with the linear fit to the experimental results show an excellent correlation including size effect with an average absolute relative error of 5.9%.

5.3. Quasi-static loading rates

For quasi-static loadingrate of 1 μm/s, the averageIFSSfora75 μm droplet was 54 MPa. Traction laws with peak traction 60 MPa did not reach the experimental IFSS (Figure 7). The ones that matched the experimental IFSS (65 MPa -100 J/m2 and 70 MPa –80 J/m2) are carried forward and used to predict the IFSS for different droplet sizes.

Simulations run with 70 MPa traction law exhibited delayed crack growth at the interface for droplet size of 125 μm and consequently was eliminated from further analysis. The FE predictions using the downselected traction law 65 MPa –100 J/m2 are within 2.9% of the line fit to the experimental data (Table 4).

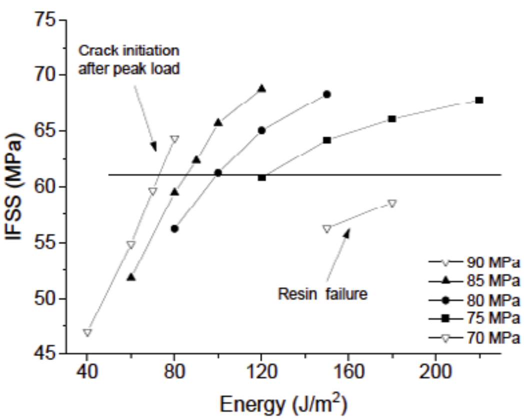

Figure 6 Parametric study on peak traction and fracture energy for the determination of traction separation law for 75 μm droplet at 100 μm/s loading rate

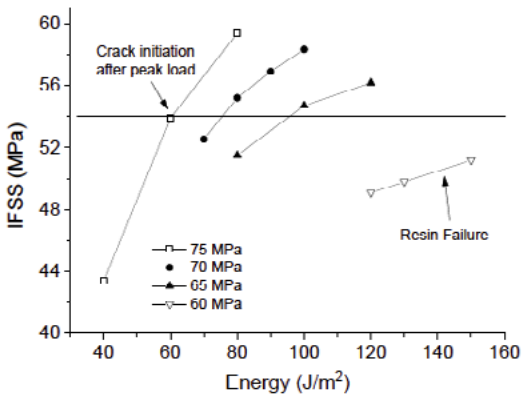

Figure 7 Parametric study on peak traction and fracture energy for the determination of traction separation law for 75 μm droplet at 1 μm/s loading rate. Traction laws with peak traction 60 MPa and 75 MPa are eliminated from further study

Table 4 Goodness of fit for the predicted IFSS at 1 μm/s

Traction law	Error
65 MPa and 100 J/m2	2.9 %
70 MPa and 80 J/m2	5.1 %

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Award Winning Paper continued...

6. Conclusions

A methodology has been developed to extract the rate dependent traction separation law for composite interface through iterative method by simulating microdroplet experiment. Experimental results show the interfacial properties are dependent on rate of loading and on the geometry of the specimen. Rate dependent inelastic resin properties were considered, which is critical for accurate determination of traction law. Use of only elastic properties for resin droplet tend to overestimate the traction law parameters of the interface. Crack initiation occurs at peak load, which correlates well with the experimental results obtained from CNT sensors. A range of traction separation laws were determined for different loading rates by simulating the microdroplet experiments with a certain embedded length. Then, unique rate dependent traction laws were determined by narrowing down the range by simulating microdroplets with different droplet sizes. The simulations showed a general trend where a lower peak traction exhibited resin failure and higher peak traction showed a brittle failure. These failure modes are associated with the crack opening displacements assumed in the traction law. These results showed the overall energy absorption capability and failure modes depend on the rate dependent peak traction stress and resin yield stress. Interfacial traction separation laws (both peak traction and the fracture energy) were found to be dependent on the rate of loading (Figure 8 and Table 5). The range of shear strain rates presented in Table 5 have been calculated by assuming interface thickness of 10 –100 nm. Peak traction and fracture energy exhibit a fairly linear relation with shear strain rate when plotted on a semi log scale (Figure 9).

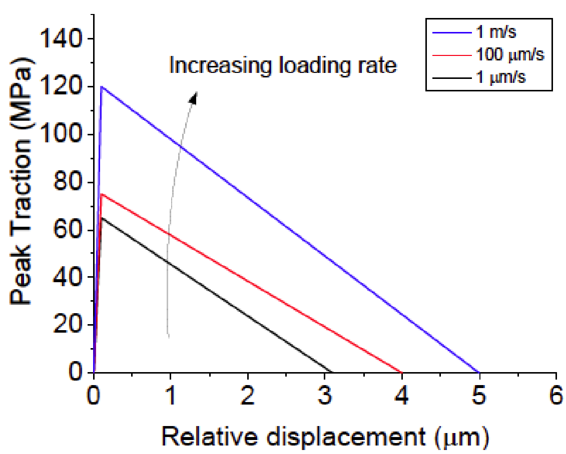

Figure 8 Traction separation law for different loading rates

Table 5 Rate dependent traction separation laws

Loading rate	Relative nodal velocity	Shear strain rate range	Peak traction	Fracture energy	Relative displacement
1 μm/s	0.9 μm/s	9/s –90 /s	65 MPa	100 J/m^2	3.1 μm
100 μm/s	90 μm/s	900/s –9000/s	75 MPa	150 J/m^2	4.0 μm
1 m/s	1 m/s	10^7/s -10^8/s	120 MPa	300 J/m^2	5.0 μm

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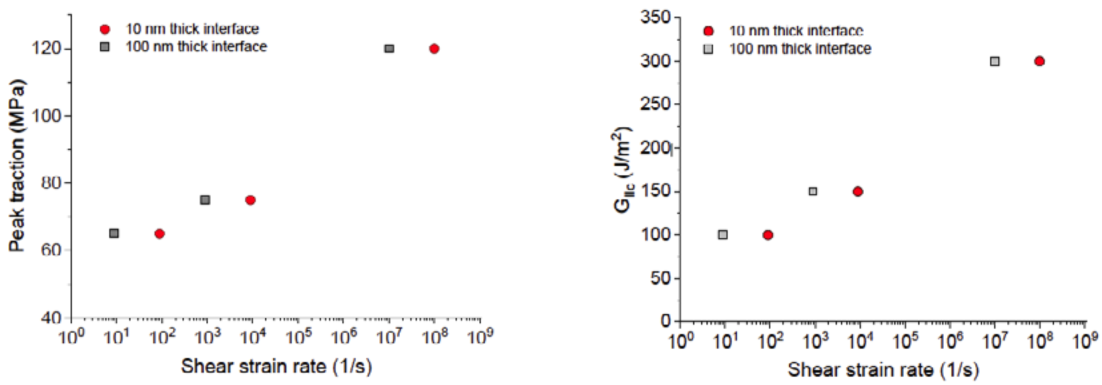

Figure 9 (a) Peak traction and (b) fracture energy as a function of shear strain rate for interface with 10 nm and 100 nm thickness

7. Acknowledgements

Research was sponsored by the Army Research Laboratory and was accomplished under Cooperative Agreement Number W911NF-12-2-0022. The views and conclusions contained in this document are those of the authors and should not be interpreted as representing the official policies, either expressed or implied, of the Army Research Laboratory or the U.S. Government. The U.S. Government is authorized to reproduce and distribute reprints for Government purposes notwithstanding any copyright notation herein.

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Thank You from NGAB

SPE Composites BOD is invested in supporting future generations of SPE. Following is a thank you note from the Next Generation Advisory Board Team.

Dear Composites Division Board,

Thank you so much for having us as guests during your board meeting at ANTEC. It was wonderful discussing NGAB and the opportunities for us to work together. We are excited to collaborate with you on attracting young professionals to ACCE!

Your generous donation and support is incredibly appreciated! Thank you for investing in future generations and making it possible for NGAB to meet in person to make great things happen. Your donation fully funded our Winter Planning Meeting, where 8 members determined our succession plan, got the reigns on our social media, developed an elevator pitch, developed task forces to target key challenges for SPE, and finalized ANTEC event agendas.

Please let us know what you need from us for support! Please keep us informed on your next steps for ACCE planning and we will find the best young professionals to work with you!

Thank you so much!
The Next Generation Advisory Board team

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