Summary from Materials Breakout Session

The Materials and Shielding breakout session consisted of 14 attendees with a variety of background and technical interests. The attendance sheet is attached to this summary. We began the breakout session with general introductions and moved into a brainstorming activity. I asked the group to brainstorm on topics pertaining to flight validation for materials needs and technology that requires flight validation, with the commonality that these flight opportunities must be influenced by solar variability. The group agreed that, in general, materials degrade in the “solar” environment and that solar variability is not a major factor. Material performance in the “solar” environment is the driver. The exception to this is the obvious influence of solar variability on the Atomic Oxygen density in LEO.

Consideration was given to future missions, that will use ultralightweight materials (i.e. inflatables, solar sails, sunshades,……etc). We envision the SET as a perfect testbed to qualify new materials for these future missions.

The group brainstorming session resulted in 26 topics for review. These topics are, in no particular order:

1. Deep dielectric charging
2. New materials for radiation shielding for biological systems
3. New materials (optimized) for electronic shielding
4. New materials for charge dissipation
5. Composites
6. Thin Films for charge dissipation
7. Materials degradation with ground verification
8. Understanding latch-up from materials point-of-view
9. Coatings, both optical and Thermal
10. Fiber optic radiation shielding
11. Inflatable materials, perform either and actual inflation test, or place materials in tension, simulating inflation
12. Radiation Tolerant electronics (i.e. SiC)
13. Fly biological samples
14. Plasma measurement and plasma effects on thin films
15. Optimize self-healing materials, recover samples after exposure
16. Nano-technology – carbon nano-tube applications
17. Thin films to measure accumulated dose, annealable
18. Contamination model verification
19. Environment sensors to monitor toxic emission inside spacecraft
20. New, Improved MEMS
21. Strain sensors
22. Smart materials
23. CAD/CAE Interface
24. Low energy electron interaction cross sections and transport algorithms
25. Real time Atomic oxygen measurement
26. Electron spectroscopy of in-space surfaces

From this list, we divided these topics into 4 categories. Those categories were:

1. Materials degradation / Performance
2. Radiation Shielding – Electronics
3. Radiation Shielding – Biological Systems
4. Predictive Tools.

The afternoon session was occupied with each topic being assigned to a specific individual to fill out a "Breakout Session worksheet" on his/her assigned topic. We then voted, to set a priority on High, Medium, or Low ranking, on each of the topics. I presented the topics that the group voted as high priority. Below are the topics and a brief rationale description, in no particular order.

1. <u>CAD/CAE Interface</u>   Predictive tool to input CAD drawings directly into dose predictive software (i.e. shell dose)./ Current procedure is to design spacecraft configurations in the dose prediction software using very basic geometry. This is a ground-based activity.

2. <u>Low energy electron interaction cross-sections and transport algorithms</u>.   Enhance existing transport algorithms by including electron interaction cross sections for low energy electrons. With the current emphasis on material development focusing on ultralightweight, low energy electron interaction will dominate damage mechanism. Understanding of the dose deposition will improve models for life prediction.

3. <u>Electron/Positron data and transport in the plasma environment</u>.   Once again, understanding low energy charged particle interaction with material and transport of these particles that originate primarily in the plasma environment is necessary to perform accurate ground based modeling for material/system life prediction.

4. <u>Contamination Model Verification</u>.   Numerous particulate redistribution models exist with little to no flight verification of these models. QCM flight with pre-flight modeling will provide validation of existing models and yield credibility and lower risk error for future missions.

5.<u>Reusable space deployable and retrievable lightweight solar shielding for temporary and emergency protection of spacecrafts and astronauts.</u>   This utilizes smart material technology and demonstrates shape memory technology. This technology can be used for deployment schemes for sails, sunshades, inflatable structures and temporary crew shelters.

6. <u>Real time atomic oxygen measurement</u>.   Needed for highly accurate AO quantitative measurement. AO density varies with solar variability. AO interaction with contamination has been demonstrated to enhance some types of contamination deposition. AO erodes materials, with erosion rates being higher with increased AO density. Accurate AO density measurement will improve accuracy of ground-based testing.

7. Development of Engineering Tools and Models from Human Risk Assessment and their Validation. This topic seeks to validate current prediction tools and detectors by performing ground based modeling of absorbed dose and incorporating optimized shielding materials to reduce predicted dose levels to, or below, current NCRP limits. Flight validation of ground-based predictions will be accomplished using existing, or newly developed detectors systems.

8. Bare Die Shielding of Micro Spring Electronics. Flight validation of micro-electronics radiation shielding.

9. Radiation Tolerant Microelectronics. Partnering required to continue development and eventual flight validation of new, radiation tolerant microelectronics (i.e. SiC) substrates.

10. Flight Validation of Ground Test Protocol Using Conductive, Charge Mitigating Material. This topic seeks to verify ground test protocol, using established ground-based Space Environmental Effects testing procedures (i.e. ISO standard CD 15856 – Simulation for radiation tests of materials). Combined with this topic is the flight qualification of charge mitigating materials, thin films, composites…etc. Several types of charge mitigating material have been developed and require flight qualification for use on future spacecraft. This topic would accomplish this requirement.

11. Space Curable Resins for Inflatable and Composite Materials. Inflatable structures are being considered for low-mass spacecraft. Rigidization of the inflatable structures is a desirable quality. Using the natural space environment (i.e. charged particles, UV…etc) to cure resign that rigidize structures is feasible. Also, manufacturing composite structures, in-space, using resins that are applied in the space environment is desirable. Once again, space curable resin systems, for composites, can be validated.

12. Materials Property Monitor. This topic will allow a multitude of coupon-sized samples to be exposed to the solar environment and active data will be obtained to track material property performance in the solar environment. Material properties such as thermo-optical properties, mechanical properties, and conductivity can be measured real time. Environmental monitoring can be combined with the Materials Property Monitor to measure the natural, and induced, space environment.

13. Optical and Thermal Coatings. New optical and thermal control coatings are continuously being developed. These new coatings offer increased performance for specific mission applications. Flight validation of performance qualifies these coatings for future use on spacecraft and offers verification of ground-based testing protocol.

14. New Inorganic Strain Gage Material. Construction of new stain gages offers a non-adhesive bonding technique that reduces / eliminates adhesive outgassing from strain gage application. These new strain gages need flight validation in the solar environment.

15. Optimized Encapsulating Shields for COTS electronics devices. With most rad-hard electronics parts being difficult to impossible to obtain, radiation shielding of COTS parts becomes essential. New encapsulating techniques are being developed and require flight validation to qualify for future missions and reduce risk.

The data sheets are included with this summary. The details for Flight requirements are either left blank (indicating unknown) or a best guess is provided. My recommendation is to contact the name given on the data sheet for more detailed information regarding flight requirements or general clarification.

David L. Edwards
Mail Stop ED31
MSFC, AL 35812
256-544-4081 (office)
256-544-5103 (fax)
david.Edwards@msfc.nasa.gov