10-20-2017

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Recommended Citation

Matthew Robertson, Justin Christensen, Greg Wilson and JR Dennison, "Electron Yield of a Carbon-composite Nanodielectric," American Physical Society Four Corners Meeting, Colorado State University, Fort Collins, CO, October 20-21, 2017.

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ABSTRACT

Electron irradiation experiments were conducted to investigate the electron transport, charging, discharging, and emission properties epoxy/carbon-fiber composite material. We discuss how these results are influenced by the nanoscale structure of the conducting carbon fibers embedded in the dielectric epoxy matrix. Electron yield measurements were made in an ultrahigh vacuum electron emission test chamber, with electron beam energies ranging from 15 eV to 5000 eV. Related structural and charging priorities have also been measured by scanning electron microscopy, energy dispersive x-ray analysis, cathodoluminescence, electron-induced arcing, and conductivity. The emission properties of the composite material are considered, in regard to models which combined the two component base material emission properties.

BACKGROUND

Electron yield is defined as the average number of electrons out of a material vs the number of incident electrons in. This property is highly energy dependent and is useful in understanding how a material will charge up in a given environment. One application of electron yield is in understanding the charging properties of a spacecraft such as a satellite. Because materials charge differently from one another, huge potential differences can develop between adjacent spacecraft components. This can lead to electrostatic discharge (ESD) which can damage sensitive electronics, optics, and mechanical components vital to the proper functionality of the satellite

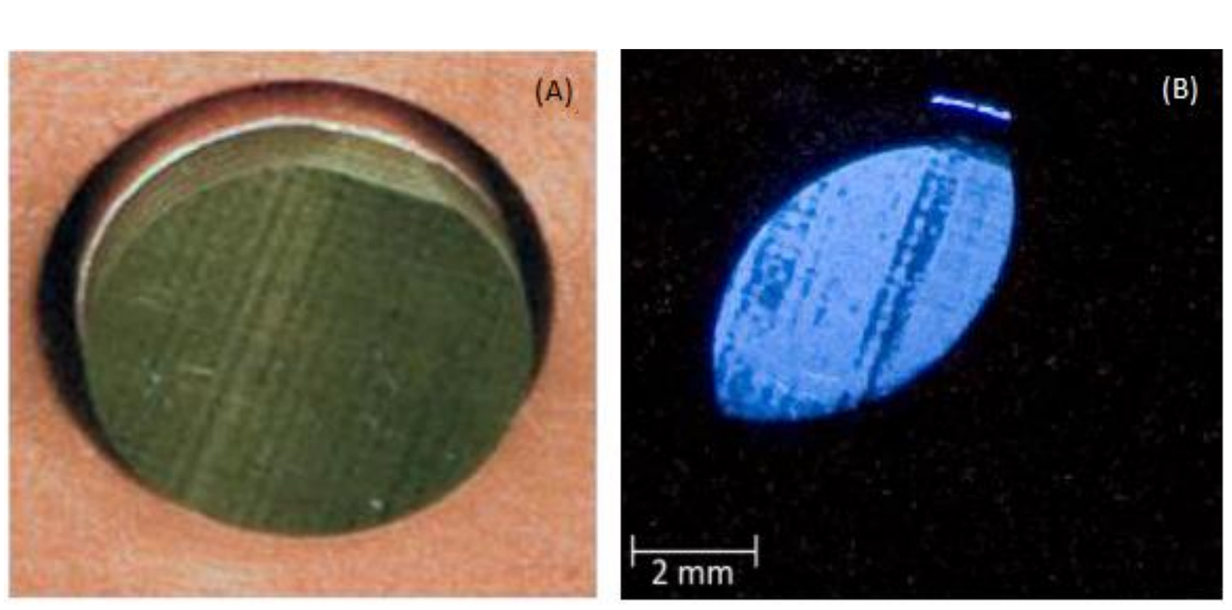

Figure 1. (a) 1 cm diameter sample of a epoxy/carbon-fiber composite material. (b) The sample glows when charged with the electron beam. Note the carbon fiber weave structure.

MODELLING COMPOSITE MATERIALS

Modelling composite materials is more complex than then a simple bulk material. A simple example of a composite material would be a thin film layered over another material. In the example below we have a carbon contaminate layer growing over a gold sample over time, figure 2 (b).

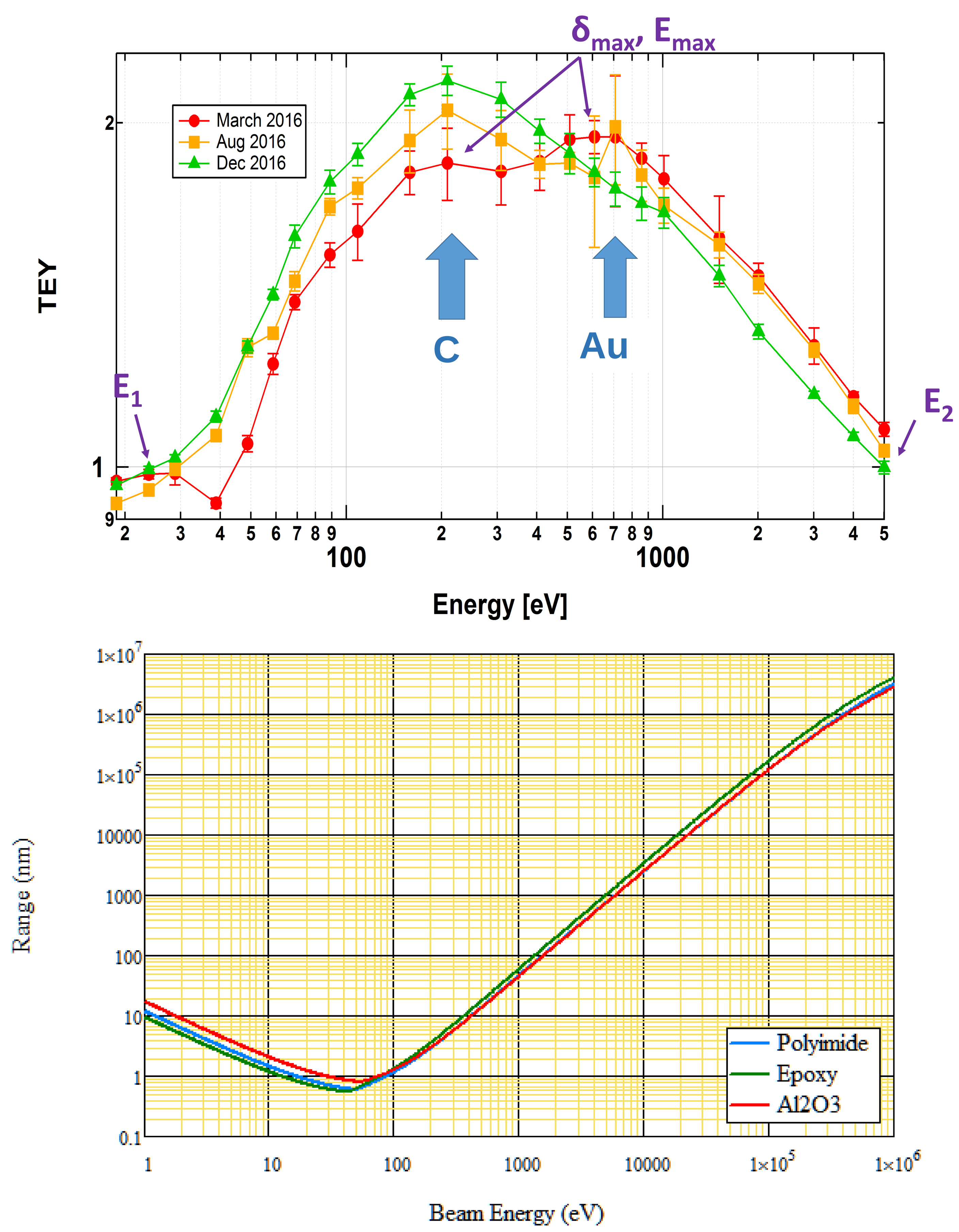

Figure 2. (a) Electron yield curve for a gold sample with a carbon contaminate layer. (b) graph of range of electron vs beam energy. Typical beam energies for measuring electron yield are between 15eV to 5000eV.

Modeling behavior becomes more complex when using insulating materials or when the structure is more complex. Such is the case with carbon fiber, a Carbon-composite Nanodielectric. Our results for a carbon fiber material are shown in figure 3.

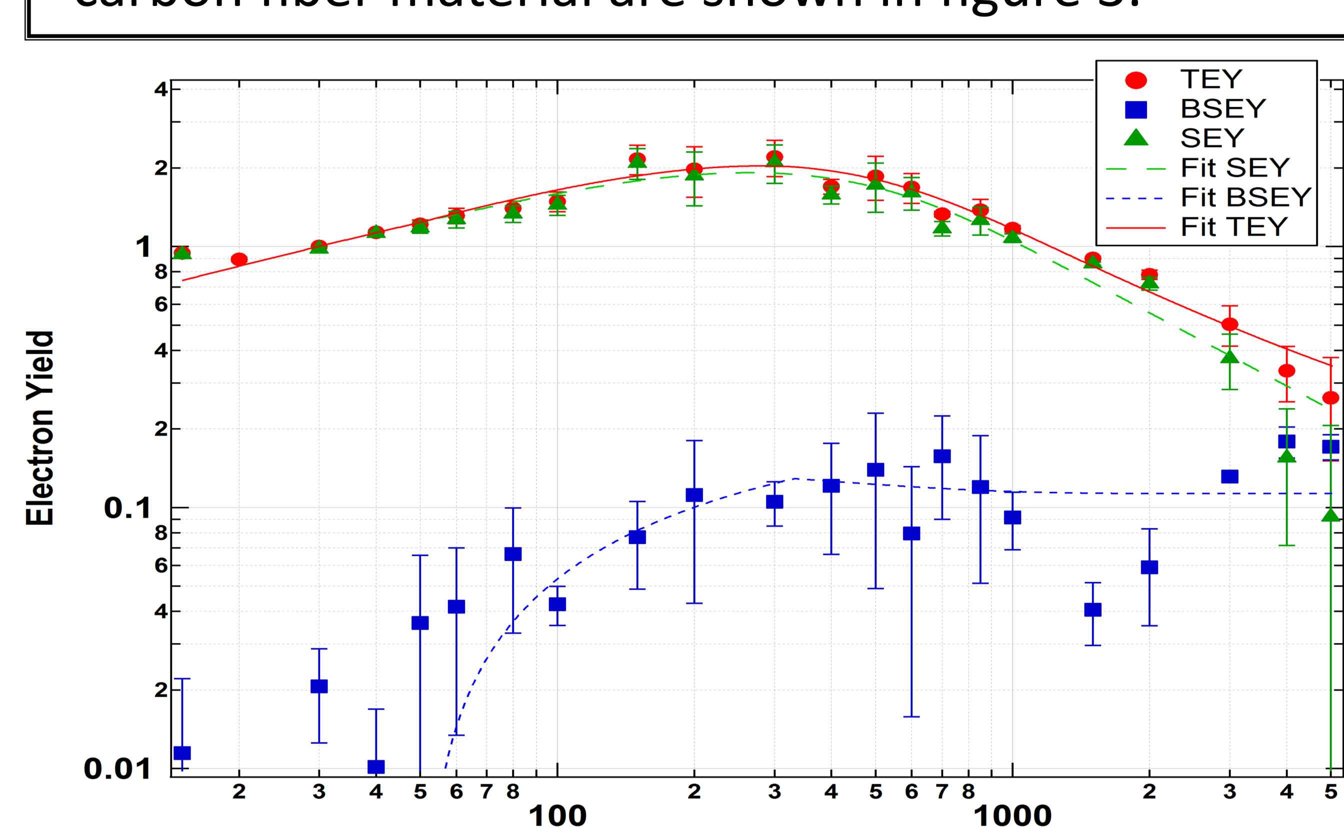

Figure 3. electron yield curve of a carbon fiber material

POTENTIAL MODELS

There are two simple models for composite materials, Vertical and Horizontal. In the vertical case the model is a linear combination of the two materials. In the horizontal case the model is a weighted combination of the two materials. An example of both cases are given below

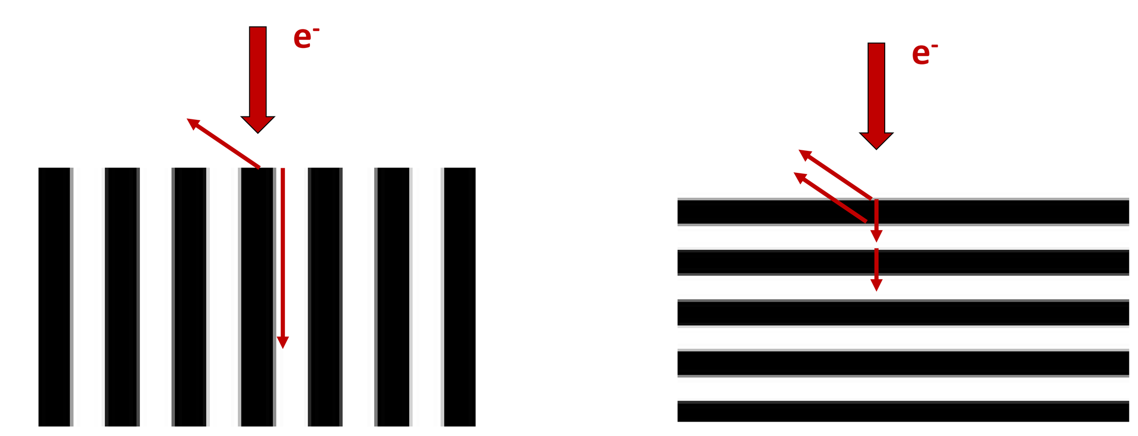

Figure 4. (a) Vertical model diagram. (b) horizontal model diagram.

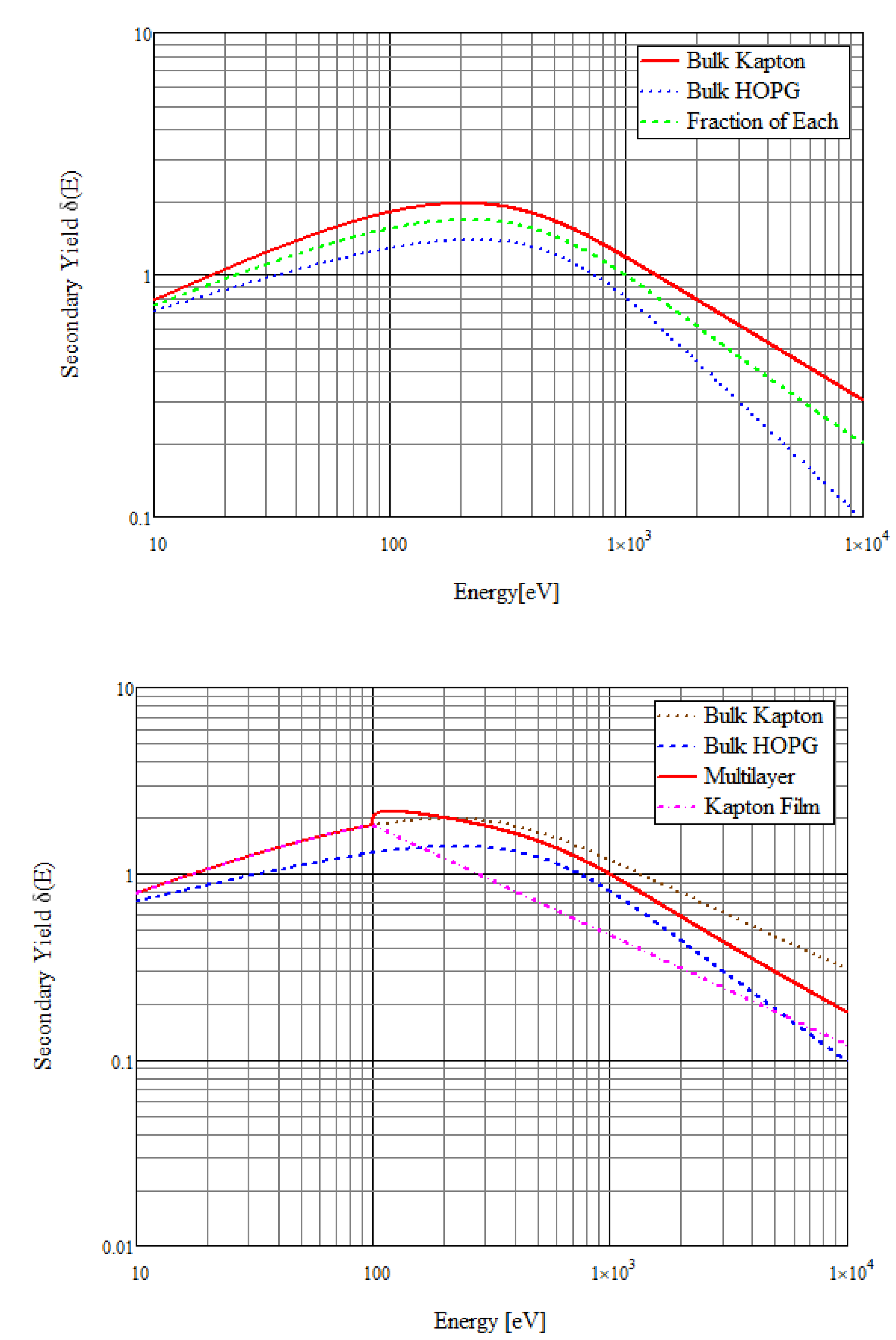

Figure 5. (a) example of vertical model with kapton and carbon. (b) example of horizontal model with kapton and carbon

CONCLUSIONS/FURTHER STUDY

Carbon fiber is a complex composite material to model. We hypothesize the model for carbon fiber would be some hybrid of the two simple models suggested above, due to it having traits of both models. The next step is to run some tests on The epoxy by itself.