Measurement and analysis of shielding materials

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Damping of resonances in screened rooms

It all started with trying to model ferrite tiles in a screened room...
To do this we invented a new way of modelling thin layers in the TLM method.

Damping the resonances helped with EMC measurements by flattening response and reducing sensitivity to position changes.

Meanwhile BAE Systems were trying to model the new Carbon fibre Eurofighter and asked us to look at efficient TLM models for Carbon fibre.


https://commons.wikimedia.org/wiki/File:RAF_Eurofighter_Typhoon.jpg
Shielding of planar sheets

The plane-wave shielding of an infinite sheet depends mostly on the reflection coefficient $\rho$.

The absorption loss through the material dominates at high frequencies $e^{-\gamma d_2}$.
Sample in wall between two chambers

Transmission (SR) through 5mm 30kS/m sheet

This is representative of 5mm thick Carbon fibre composite

E field screening ratio for sphere, conductivity = 10kS/m, radius = 3.1 cm, thickness = 1mm
In order to measure the transmission (SR) and hence SE of a planar sample we may

Put it in a waveguide (as above)

put it a gap between two screened enclosures

Try to measure in free space
The ASTM Coaxial test-jig

Coaxial test samples

CFC Samples

Perforated Brass Samples

Knitted Sample
Knitted Pre-preg with PVD metalisation
Going up in frequency: the reverb chamber
Going up in frequency: the reverb chamber
Anisotropy
Comparison of methods

5/1.5mm Perforated Sheet

- CJI: 2005.12.19
- Aniso300/AC
- Aniso300/GTEM
- Aniso300/GTEM
- Aniso200/GTEM

Shielding Effectiveness (dB) vs. Frequency (MHz)
The problem of surface preparation

• Sample and surface preparation is a difficult and time consuming process
• Samples with non-conducting surfaces present particular problems
The Absorber box method for SE measurement

The Absorber box
The Absorber box with 3D scanner


Scanning fields penetrating the slot panel
Non-woven materials

Nonwoven carbon fibre sheet

12 mm long carbon fibres
7 μm in diameter
\( \sigma = 72 \text{ kS/m} \)
Areal densities 4-75 gm\(^{-2} \)

Nonwoven carbon fibre sheet (SEM)

http://www.tfpglobal.com/products/optiveil/optiveil-for-emi-shielding/

Courtesy of technical fibre products
Shielding Effectiveness of CF Nonwoven

\[ SE = \frac{1 - (\rho e^{-\gamma})^2}{(1 - \rho^2)e^{-\gamma}} \]

\[ SE \approx 1 + \frac{1}{2} \eta_0 G_s \]

Finding the fibre angle distribution

Optical microscope image

Line detection using Hough transform

50 images were analysed each for 4gm\(^{-2}\) and 10gm\(^{-2}\) materials

Heavier materials were too opaque

Lines detecting using Hough transform

Fibre angle PDF is simply related to anisotropy

Anisotropy factor:

\[ \Phi_x = \int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} p(\phi) \cos^2 \phi d\phi \]
Computer Generated Model

Real Material v MC Model and UoY theory

\[ G_s = \frac{1}{G_f \bar{n}_A \Phi_x} + \frac{1}{\frac{k_e N_{cf}}{2} G_c \bar{n}_A \Phi_x} \]

Dawson, J. F.; Austin, A. N.; Flintoft, I. D. & Marvin, A. C., "Shielding Effectiveness and Sheet Conductance of Nonwoven Carbon-fibre Sheets", Accepted for publication in *Electromagnetic Compatibility, IEEE Transactions on*.
FDTD Model of Non-woven

CAD model

FDTD Mesh
FDTD Model of Non-woven - transmission

S-Parameter [Magnitude in dB]

Frequency / GHz

S2,1
FDTD Model of Non-woven

CAD model

FDTD Mesh
FDTD Model of Non-woven - transmission

S-Parameter [Magnitude in dB]

Frequency / GHz

S21
Coax jig - graphene/carbon nanotube samples

New jig under test for small samples up to 20GHz

Copper coated kapton test sample
Questions?

• Shielding enclosure measurements
• Shielding enclosure standards
• Analysis of shielding
• Simple models for designers
• Shielding Materials measurement
• Macro models for TLM and FDTD
• Analysis of material structure
• Effects of slots and joints
• Effect of contents