Graphene and shielding

SiO Graphene project

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Content

• Project scope
• Shielding challenge
  • New material
• SE measurement technique
• The future
Participants

- Institute
  - RISE IVF, Mölndal
  - RISE, Linköping
  - RISE, Borås
- EMC technology
  - EMC Services

- Manufacturers, products
  - Atlas Copco Industrial Technique
  - Megger Sweden

- Manufacturers, material
  - Graphmatech
  - Biofiber Tech Sweden
  - Meva Energy
Project scope

- Shielding for EMC design
  - Main interest for manufacturers: 30 – 1000 MHz
- Replacement of existing Ni-plating material
  - Environmental issue
- Replacement of metal enclosure
  - Cost and weight issue
- Graphene inclusion in polyimide with kept performance
  - How much is needed?
  - Mechanical performance
- Will be demonstrated in actual products from Atlas Copco Industrial Technique and Megger Sweden
- How to measure – today focus
Shielding definition – traditional theoretical approach

Theoretical approach infinitely large plate
The multiple reflection parameter, M, is often neglected

\[ SE = \frac{E_2^2}{E_1^2} \] or \[ SE = R + A \] [dB]
(shielding effectiveness)

\[ R = \text{Reflection loss} \]
\[ A = \text{Absorption loss} \]
\[ R = f \text{ (wave impedance, material, frequency)} \]
\[ A = f \text{ (material, thickness, frequency)} \]
Shielding – theoretical calculation example

- Only provides material influence
  - Conclusion from graph: the material is normally not a big issue
  - Not a valid assumption for Graphene?
- Matching interfaces not included
- Results at low frequency not valid
  - Geometry parameters needed
  - Often lower values for magnetic shielding

Ref.: HW Ott

oh1061e
Shielding leakage - the dominant aspect
Coated parts – design challenge

Compatibility between
- 2 shielding parts
- Other mating surfaces
- Shielding connectors
- Filter connection (for external filtered interface)
Measurement technique

- 3 levels
  - Material level – survey method
  - Material level – test fixture
  - Product level
    - Standardized method – compare EUTs with CISPR 16 emission method
      - What do we find from this
    - Reference method with internal generator?
      - Tailored test object?
- Resistance measurement methods
  - Material level – LF measurement of resistance
  - Suitable for quick selection and evaluation
Material level test – survey method

- Test setup using loop antennas
  - 1 – 1000 MHz OK
- Quick simple method
  - Near field measurement
  - Impact on antenna factor?
  - Edge leakage?
  - Antenna distance not so critical
First results #1 – survey method (loops)

- Test setup using loop antennas
  - 20 kHz – 8 GHz
- Comparison with reference Cu plate
- Some resonances
  - Mainly at > 1 GHz – loop behavior
  - Below 1 GHz – setup resonances?
- Material XG-1
  - ca 20 dB difference from Cu
  - Resonance at 100 MHz
First results #2 – survey method (loops)

- Test setup using loop antennas
  - 20 kHz – 8 GHz
- Comparison with reference Cu plate
- Much smaller probe
  - Poor resolution < 100 MHz
  - Less resonances
    - Less coupling loop-mtrl?
    - Less edge leakage?
    - Mainly at > 3 GHz – loop behavior
- Material XG-2
  - Approx. same as Cu
  - Resolution probably limited
Material level test – Mode Stirred Chamber (MSC)

- Test setup using mode-stirred chamber
- High quality method
  - Far field measurement
  - but only useable for approx. $f > 500$ MHz
- Complex setup, special equipment
  - IEC 61726 (passive component test)
  - MIL STD-285 and MIL-DTL 83528 are only using fixed antenna
- Example showing gasket measurement
  - Source: KI report 2004:2E “Ageing of shielding joints” (Lena Sjögren)
Material level test – small test fixture

Gasket measurement

Source: “RF shielding performance of thin flexible graphene nanoplatelets-based papers“ (Tamburrano et al), IEEE 2014
Test fixture aspects

- Test setup using small test fixture
  - FCSH = Flanged Coaxial Sample Holder
- Higher quality method
  - Near field measurement
  - Low resolution < 100 MHz
  - E or H-field probes?
- Relatively simple equipment
- Standard ASTM D4935-18 (intended for gaskets) can be used as reference
Shielding test method, product level

- Approach:
  - Measure the attenuation through the enclosure

- Alternatives:
  - Figure: Standard IEEE 299 for radiated cabinet measurement
  - CISPR25 method for conducted measurements (transfer methods)
  - Many IEC standards for cables and connectors
    - Not relevant

- Cons for IEEE 299:
  - 30-300 MHz not covered for enclosures
  - Interfaces of connectors and cables may be missed in IEEE method
  - Electronic HW influence not included
Product level EMC testing, EN standard

Radiated emission  Conducted emission

EUT placed on specified height from GRP – tabletop or floor standing
Handling resonances in measurement

Smoothing of result may be made in 3 domains

• Geometry domain: mode stirring
  • Averaging of angle of incidence by changing the chamber

• Frequency domain
  • Smoothing by averaging over a frequency bandwidth

• Antenna domain
  • Averaging by turning the object
Future projects

• SiO Graphene program welcomes new initiatives
• In particular with focus on electronics
• Ideas?
Response from audience

• Tips från coacherna?