GRAPHENE FOAM/PDMS COMPOSITES FOR LIGHTWEIGHT, FLEXIBLE EMI SHIELDING

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Introduction

Electromagnetic interference (EMI) is a prevalent problem in modern electronics. When devices are improperly shielded, EMI can enter the system and effect circuit reliability.

EMI is attenuated in primarily three ways: reflection, absorption, and multiple reflection (Figure 1).

High intrinsic absorption is needed for use in the most effective EMI shielding.

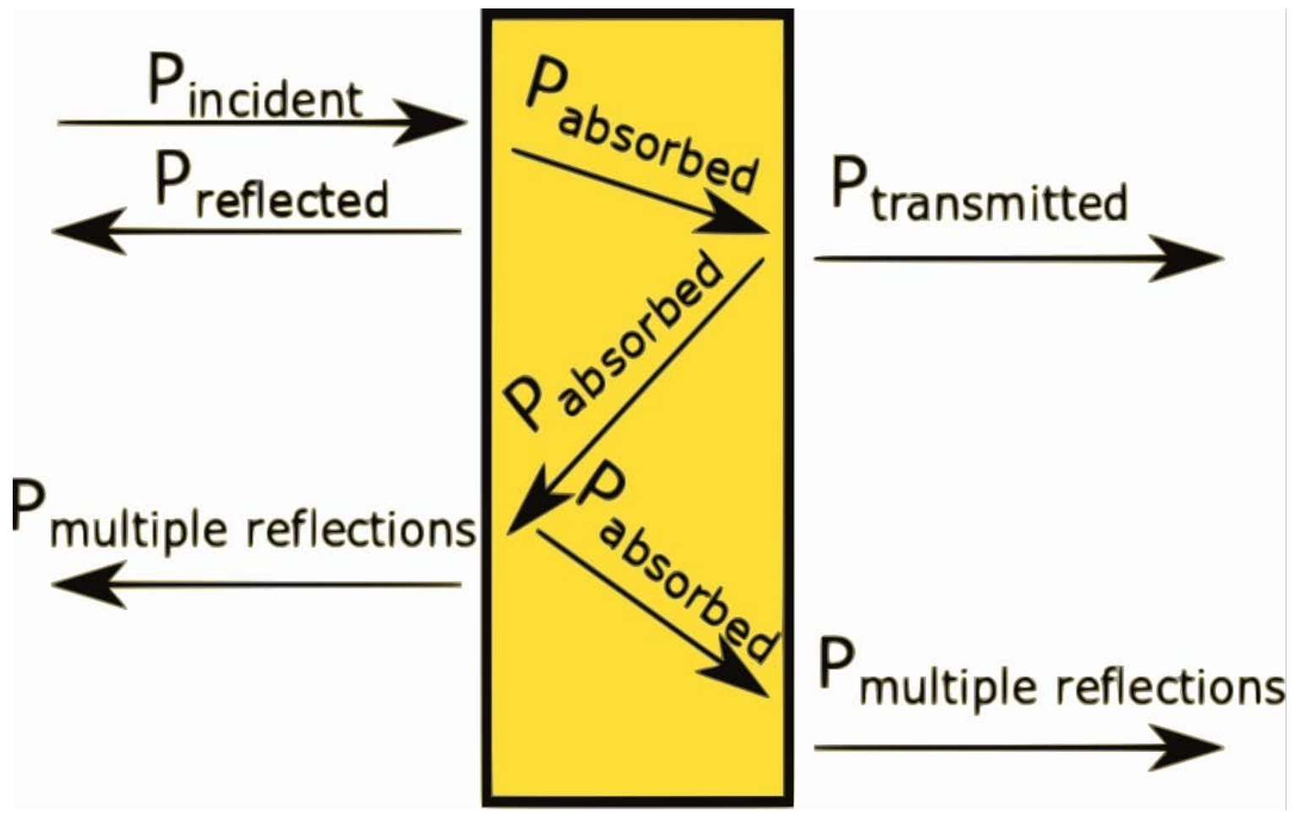


Figure 1: Shielding mechanisms

Background & Motivation

- Current shielding methods use metals which have high shielding effectiveness (SE), but are highly reflective due to impedance mismatch.
- Graphene has inherently high absorption (2.3% for single layer), and large aspect ratio, making it an effective conductive filler in composites.
- Creating graphene foams produces highly conductive networks which result in high absorption and SE.
- Filling these foams with polymer makes them flexible and stretchable with wider military and commercial use.

Methods

- Graphene ink is made by use of microfluidization.
- Directional freezing effects are tested by two moulds (Figure 2, 3)
- The effects of two different binders, CMC and Teflon, are tested.
- Ink is injected into moulds and freeze dried at -80 ºC followed by 10 mbar and 65 ºC under vacuum.
- PDMS is drop-coated onto foams and cured at 100 ºC.
- Composite SE is measured using VNA waveguides at 8.2-12.4 GHz.

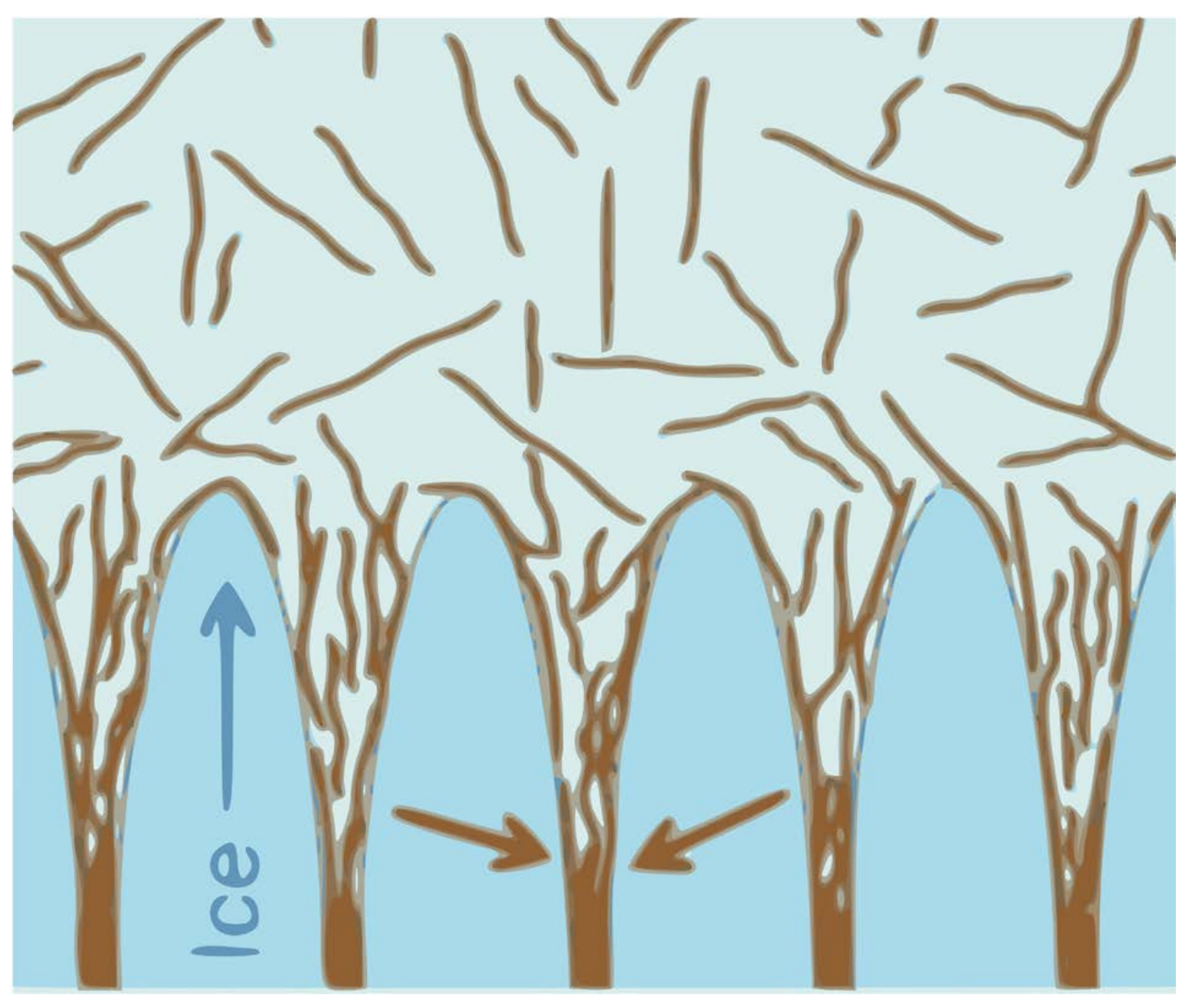
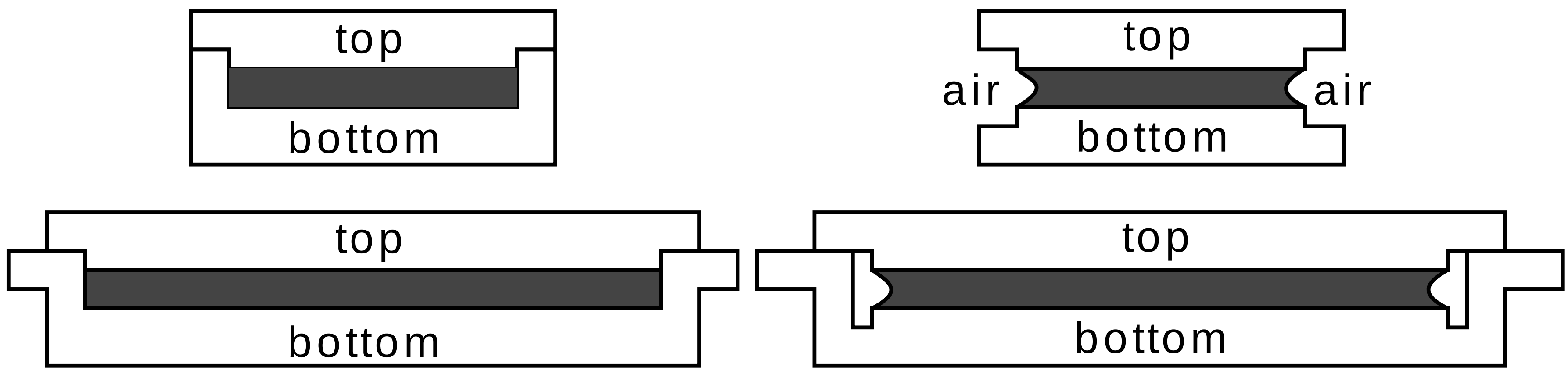


Figure 2: *Directional freezing effects on foam formation. Flakes are forced between crystals.[3]*



Closed Form

Open Form

Figure 3: *Mould design cross-sections*

Results & Discussion

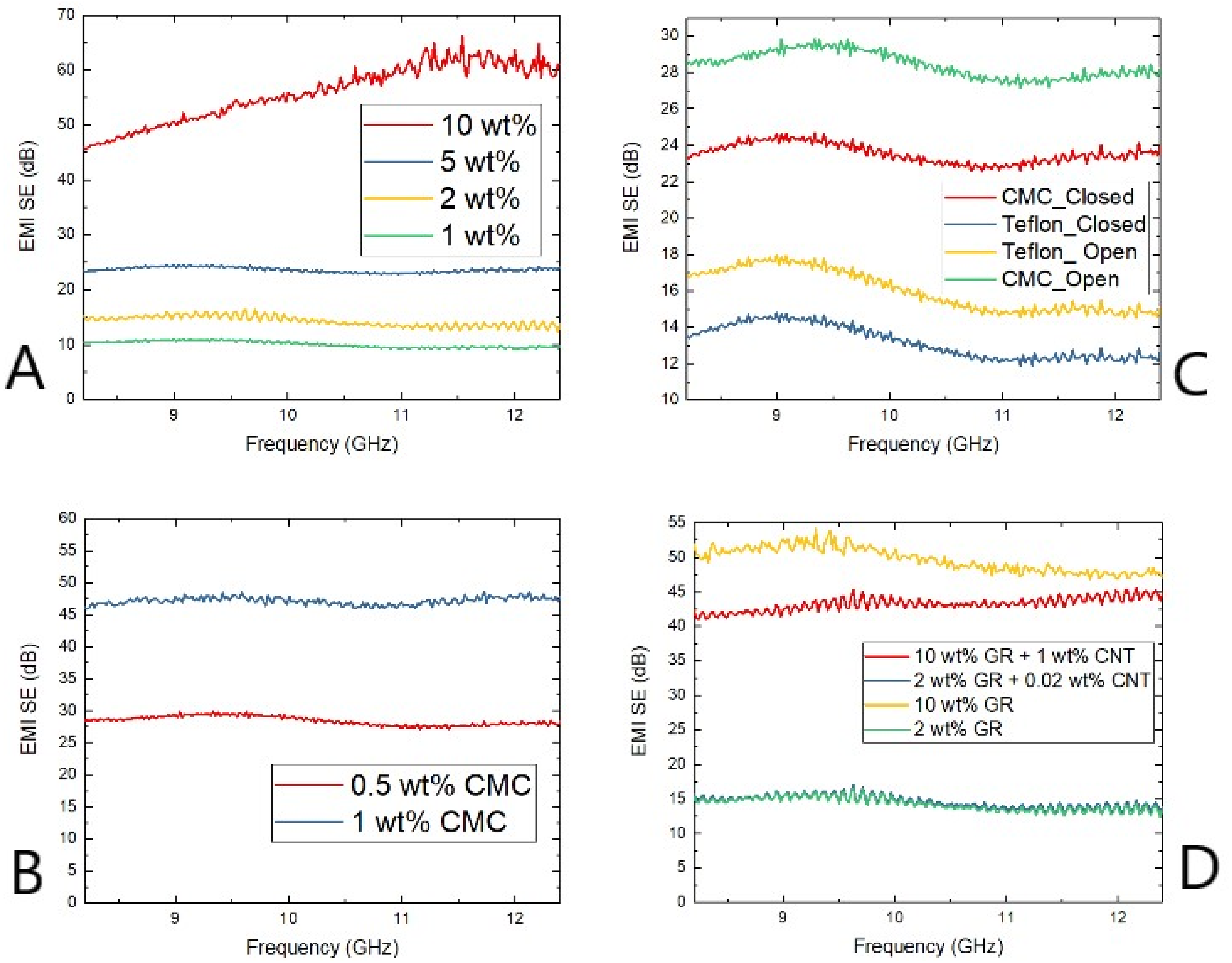


Figure 4: *EMI SE for varying: A) Foam density, B) Binder loading, C) binder/mould type, D) Carbon nanotube additive.*

A non-linear relationship between foam density and total EMI SE is observed (Figure 4 A). An increase in EMI SE of 19 dB is observed when the CMC concentration is doubled from 0.5% to 1.0% (Figure 4 B). This characteristic suggests increased foam network connectivity and conductivity. The comparison of Teflon and CMC as binders reveal that CMC yields greater desired effects, increasing the EMI SE by as much as 10 dB over Teflon (Figure 4 C). Additionally, EMI SE is also increased by incorporation of directional freezing (open mould). To further increase EMI SE carbon nanotubes (CNTs) are added, however, the opposite effect is observed (Figure 4 D). Instead of increased properties, a substantial drop in SE occurs. A possible reason for this reaction is that the CNTs were broken upon microfluidization rendering them useless and/or destructive to the foam formation.

Conclusions

We tested different binders, densities, nanotube addition, and mould configuration to evaluate graphene foam composites for EMI shielding. Our study shows EMI SE as high as 70 dB, foam density as low as 10 mg/cm^3, and EMI absorption greater than 90% showing their viability as low cost, high performance EMI shielding.

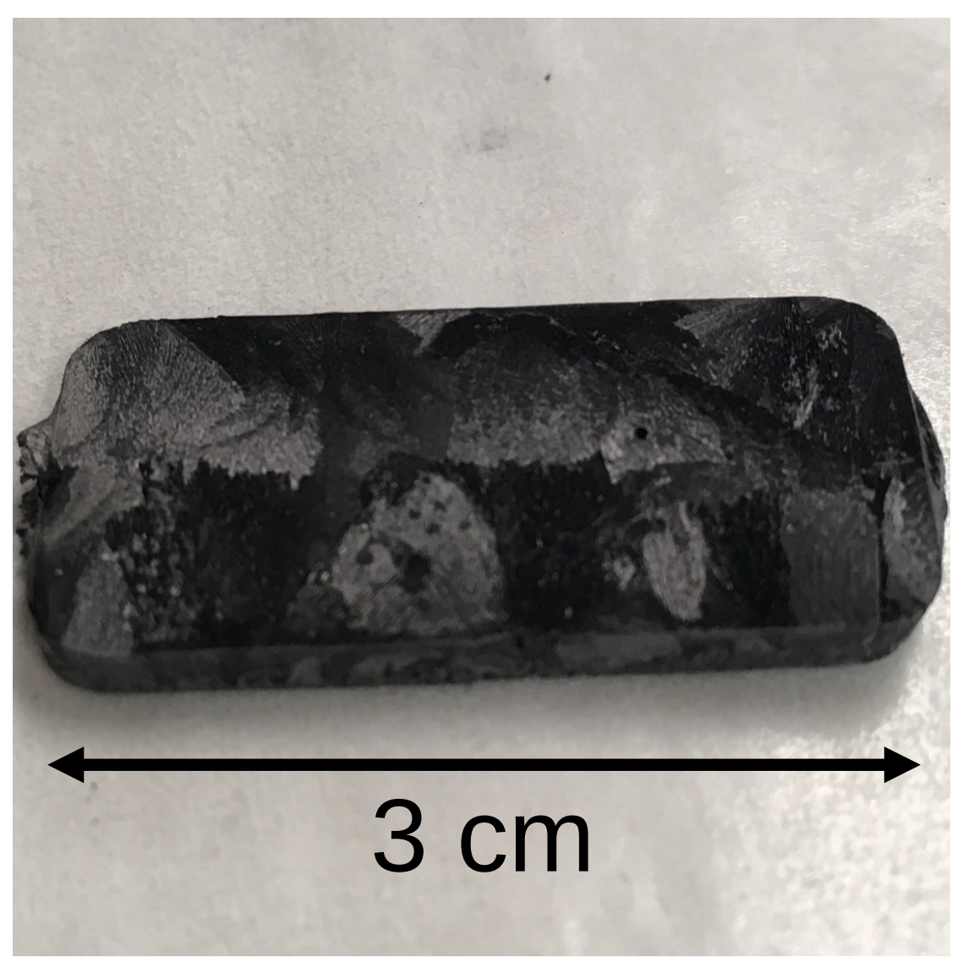


Figure 5: *Graphene Foam*

References

- [1] A.C. Ferrari *et al*, *Nanoscale*, **7**, 4598, (2015)
- [2] L. Kong *et al*, *Journal of Physical Chemistry C*, **117**, 19701, (2013)
- [3] L. Qiu *et al*, Nature Communications 3, 1 (2012).

Acknowledgments

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