

UK Metamaterials Network

Mechanical Metamaterials - 1st Special Interest Group meeting

Held via gather.town on 25 January 2021

SIG Leads: Prof Fabrizio Scarpa (University of Bristol)

Convenor: Dr Anja Roeding (University of Exeter)

Group discussion participants:

Group A	Group B
Tom Bassett, MBDA Chris Bingham, BAE Systems Sébastien Guenneau, Imperial College London Kevin MacDonald, Southampton Stephen Morris, KTN Valerie Pinfield, Loughborough Tien Thuy Quach, Nottingham Fabrizio Scarpa, Bristol Anton Souslov, Bath Olga Umnova, Salford Bogdan Ungureanu, Imperial Chris Worrall, TWI	Adam Armitage, MBDA Marcelo Dias, Edinburgh Xiaonan Hou, Lancaster Lin Li, Manchester Evros Loukaides, Bath Emma Perry, Oxford Simon Pope, Sheffield Daniel Underhill, MBDA Neil Witten, Innovate UK

The aim of this meeting was to bring together the Mechanical Metamaterials Special Interest Group (SIG) members for an initial discussion on the current challenges of this research area in the UK, and what we as a network can do to address these challenges.

Summary of the discussion outcomes

1. What are the challenges for this research area?

a. Manufacturing and 3D printing at scale

Most objects are being made at the lab scale, and we are very far away from large scale manufacture. Some 3D structures have been seen, but mainly in the US and consist of metallic structures with negative thermal expansion coefficients or negative Poisson ratios. These are not very large structures but they are on cm scale. 3D mechanical metamaterials for optical applications are also less common.

The most challenging aspects of manufacturing:

- For lattices, you have very slender structures which additive manufacturing (AM) still struggles with.
- For metal printing there are lots of issues with defect control (e.g. with fatigue life).
- Joining issues are present when using multi-material AM.

b. Technology transition from research labs into industrial applications.

There is some push for industry-based collaboration, but awareness of metamaterials as complementing technology or the single solution is not well developed.

The links between academia and industry are not well developed. There is a real need to create a meaningful problem-oriented discussion and understand mutual challenges and capabilities of the academic and industrial sectors.

Some companies such as MBDA are beginning to look at metamaterials as possible candidates for future technologies. However, challenges for companies looking to implement this internally include defects and costs control.

The existence of a mechanical metamaterials database similar to the Materials Genome Project was felt as essential to allow industry accessing, understanding and using metamaterials for general design. This need was also felt across other Network SIGs.

c. Design and manufacturing design.

Often this can be done separately due to different specialisations. Currently no specific software to design metamaterials for specific requirements is available.

d. Definition of mechanical metamaterials - clarity of generic group

A definition of mechanical metamaterials that was shared across the board was about materials systems with unusual properties engineered by design. The design aspect is very important, because it implies that one could create metamaterials for bespoke applications out of custom requirements – which is actually realistic.

e. Blue sky funding

The EPSRC Big Idea initiative (Metamaterials Revolution) may be a catalyst to develop concepts of mechanical metamaterials from the ground-up and possibly merging materials nanoscience and biology to create paradigmatic metamaterials.

2. Are there sub-topics of high priority within this SIG?

- Acoustics
- Robotics / Soft robotics
- Bio-medical prosthesis
- Design - integrating material design and manufacturing - parameters
- Manufacturing technologies
- Combining design and manufacturing tools
- Testing of properties

3. What are currently available capabilities within the UK? (people / facilities)?

This question requires further scoping among the UK community (academia and industry). Initial capabilities mentioned during the meeting are:

- Manufacturing (e.g. SLM AM multi materials, Manchester)
- Design
- Characterisation
- Numerical Modelling and Simulation
- Elastic and active mechanical metamaterials (design, modelling, analysis).
- Negative Poissons Ratio - Exeter and Bristol plus Sheffield Hallam
- Origami and Kirigami - Oxford, Cambridge, Imperial, Bristol
- Acoustic - Modelling - Nottingham, Southampton, Bath, Bristol, Exeter

A key observation is that the community and its capabilities are very fragmented at present.

Outside of the UK:

Discussions were focused on the mechanical metamaterials activities in France.

- France: the acoustic and mechanical metamaterial communities are mostly (but not exclusively) represented by GDR CNRS META and MECAWAVES; ESPCI Paris (Lab of Mathias Fink), FEMTO-ST in Besançon (Muamer Kadic, very active in chiral metamaterials) and IEMN Lille (group of Anne-Christine Hladky and Marco Miniacci)
- in terms of mechanical metamaterials, there is an active research area in seismic metamaterials, in collaboration with Menard (Vinci Group)
- people in LAUM (Le Mans) and Bordeaux are very active indeed in soft metamaterials
- FS has shown during the presentation that other countries (US, PRC, Italy, Germany, Netherlands) are active and important players in the field of mechanical metamaterials.

4. What outcomes would you like to see from this network investment?

- Library of metamaterials for cross-check & expand multiple applications, Funding for Showcase or Oral/Poster presentation.
- Critical mass - workshops, events, newsletters
- US - database of existing materials and properties - encourage interaction
- Next generation of early career researchers
- A joint research proposal and collaborations.
- Development of the supply chain from an exploitation point of view.

5. What activities should we run as a network over the next 3 years to work towards those outcomes?

- Potential Models of Mentors-Mentees and/or Internal clubs, summary/highlight of the current companies/ updated research group
- Develop review/strategy documents which can act as a
 - comprehensive and definitive guide to the state of the field and prospective directions;
 - strategy document to help align R&D and Industry, identify gaps and outline long-term possibilities.
- Communication workshops/networking events, e.g.
 - Topical workshop on “metamaterials to address acoustic fatigue issues - structural failures due to vibration from noise; can metamaterials be more fatigue resistant per unit mass than conventional materials?” (interest from BAE Systems)
 - Soft materials as topic of interest to e.g. Airbus and Thales
- Develop a metamaterials database.