Workshop on Manufacturing of Graphene based Composites

- A short summary

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26 people gathered for a workshop at Swerea SICOMP in Öjebyn, Piteå to discuss **Manufacturing of graphene based composites**.

Helena Theander, the director of SIO Grafen, started the workshop and introduced the purpose of the meeting to work together in a joint project to increase knowledge across the entire Swedish network of manufacturing of graphene based composites. The workshop is the starting point in defining a best practice study and finding organisations willing and able to contribute to the study.

Helena also discussed the vision, goals and activities of SIO Grafen, which are explained in detail in the agenda (siografen.se/agenda-grafen-2018). Helena also showed that there have been in total 49 innovation projects initiated within SIO Grafen and that the previous open call had a record number of applications. The interest and innovation in graphene is growing quickly!

Patrik Fernberg, Swerea SICOMP, hosted the workshop and explained Swerea's expertise, including all the five organisations IVF, KIMAB, MEFOS, SICOMP and SWECAST. Swerea SICOMP is a leading research institute in the field of polymer fibre composites with applications within for example aeronautics, automotive and sports equipment.

Vincenzo Palermo, professor of Graphene composite materials, Chalmers and **Vice-Director of the Graphene Flagship**, talked about how to use 2-dimensional materials in a 3-dimensional world. He stressed the importance of being realistic with graphene. Even though individual flakes can be 200 times stronger than steel and conduct electricity better than most metals, it doesn't mean that these properties can be directly translated to the macroscale. He explained that there are many different types of graphene and that it can be difficult to know which type to use in different applications. He compared this with the situation with polymers in the last century where it took time before it was understood how to work with and optimise the 1-dimensional polymers in a 3-dimensional world. Just as with polymers, Vincenzo believes there is a huge potential for graphene composites.

Guan Gong, Swerea SICOMP, was responsible for the literature study which formed the base for the workshop and the future best practice study. She thoroughly went through the findings from the literature study. She compared the reinforcement of graphene in composites with the reinforcement with fibres. Guan showed that the effect of graphene can be

maximised in the low loading range, in certain areas (for example polymer rich regions and polymer-fibre interfaces) and to introduce multifunctionality.

She also discussed how different manufacturing methods and conditions influence the interaction between the graphene and the composite matrix. She continued to discuss how this affects the properties of the final composite.

Nazanin Emami, professor at Luleå University of Technology, described her work on graphene oxide reinforced high performing thermoplastics composites for tribological applications. She showed several examples (for example hip replacements) where they successfully have utilised graphene and also carbon nanotubes.

Roland Kádár, Chalmers, explained that the processing of the composite is very important for the final properties. He showed how the microstructure of the graphene and polymer can be tailored to yield anisotropy in the composite. This can be used for example for improved barrier properties or to create a significantly higher conductivity in the plane than through the plane. He stressed the importance of perspective and finding the correct application. What is a disadvantage in one case can be an advantage for another application.

The first day was concluded with a mentimeter vote where all participants could state their interest, experience and view of what they would like the best practice study to investigate. Polymers (both thermoplastics and thermosets as well as both with graphene as sole filler and in conjunction with fibres) were found to be of more interest than metals and ceramics. There was a very broad interest in many different kinds of manufacturing methods and properties.

Daniel Berglund, Swerea SICOMP, started the second day by describing the testbed LIGHTest. It is a centre where materials can be tested and characterised, production methods can be developed or improved and sustainable material process methods are in focus. He explained how the testbed gives an excellent opportunity especially for SMEs that have a clear and structured idea of what they want, to test new materials and methods without any risk of having to buy expensive equipment themselves.

He also discussed the need to accept a higher cost for new materials and solutions. He compared with ultra-high strength steel and how it in the beginning was used in smaller parts at high cost, but now has a widespread use at a significantly lower price.

All participants were invited to a study visit to Swerea SICOMP’s laboratories.

After discussing a few different potential best practice studies, the participants were divided into two groups. The first group discussed a more general study, whereas the second was more focused on barrier properties and thermoplastic materials.

Group A

The first group discussed the interplay between the properties of the graphene itself, the interaction with the polymer matrix and the final properties of the composite, and how it is all influenced by the processing. The group put together a first draft of a process plan in order to investigate how different materials and processing influences the electrical and thermal conductivity as well as the rheology of the composite. The idea is to investigate a few different model systems in order to learn more about the percolation behaviour and how the final properties are influenced by different material and processing choices. Please contact Patrik Fernberg (Patrik.Fernberg@swerea.se) if you are interested in participating.

Group B

The second discussion group focused on barrier properties and thermoplastic materials. Two different approaches were suggested. Both of these suggestions would need further development in order to be a suggestion for a best practise study.

1. **Superhydrofobicity in PEEK and PPS (with graphene and other 2D materials)**
   The most interesting technical properties to evaluate are dispersion, interfaces and functionalisation

2. **Oxygen barrier in polyimide (with graphene and GO)**
   The most interesting technical properties to evaluate are dispersion, interfaces and size.

Processing methods can be coating and infusion in polymers.