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Investigating a Commercial Future for Graphene: An Interview with Professor Andrea Ferrari

Interview conducted by Alexander Chilton

Professor Andrea Ferrari, Director of the Cambridge Graphene Centre, talks to AZoNano.com about the commercial future of graphene.

AC: Could you provide our readers with an overview of the history of the Cambridge Graphene Centre and provide a brief summary of the research activities currently taking place at the Centre?

AF: The Cambridge Graphene Centre formally started in February 2013, after the announcement of significant funding of over £12 million from EPSRC to the University of Cambridge. We need to make a distinction between the Centre as a physical building and physical location, and the work on graphene.

The science and technology of the Centre has been going on for several years. In fact, we started working on graphene in Cambridge in 2003 and our first publication concerning graphene was in 2004. So, Cambridge has been working on graphene for a long period of time but as the formal new institution, the Centre started in 2013.

AC: What are the main goals the Cambridge Graphene Centre aims to achieve within the fields of graphene and 2d nanomaterial research?

AF: As you correctly indicated, usually all graphene centres, at least those in Europe, use graphene as sort of a broad term but the idea is that it is graphene and all the other two-dimensional materials as well as hybrid systems of graphene and 2d materials, or composites with polymers, and so on.

The aim of the Centre in the long term is to take graphene and related materials from the lab, eventually, to the point where it can be considered for application in industry. That is our mission: from the lab to the factory floor. Of course, we are not a factory. That means we will get to the point where industry will be able to decide if they want to implement it or not.

AC: What are your current primary research interests at the Cambridge Graphene Centre?

AF: The Cambridge Graphene Centre is rather large. In the new building, we are going to have over 100 desks. There's a variety of people. We have more than 30 academics that are involved in the Centre, so it's a large operation.

The Cambridge Graphene Centre has an interest in all aspects of graphene and related two-dimensional materials, from the production and growth of these materials to their characterization, to the fundamental understanding of their properties, to their application in electronic devices, photonic devices, optoelectronic devices, composite energy and telecommunications, and flexible and bendable electronics. Those are the main areas.

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Video Credit: DigitalAgendaEU

AC: Could you summarise some of the recent developments that have come out of the Cambridge Graphene Centre to our readers?

AF: We constantly have developments here. Every year, we have tens of new publications on graphene. Something very recent is, for example, a paper is going to be published on utilizing graphene to create ultra-fast lasers with a laser path of only 26 femtoseconds, which is one of, if not the fastest laser ever realized with this kind of material.

We have also recently published the science and technology roadmap for graphene and related two-dimensional materials with a lot of other collaborators in Europe that is going to map the application of graphene and related materials in a variety of sectors over the next few years.

We also recently developed an approach in order to characterize structures made with graphene and other two-dimensional materials to look at how the layers are interacting with each other and how other properties are affecting the final behaviour of the structure.

We have also published research into a new kind of photodetector with very large responsivity, much outperforming the one you find in traditional silicon detectors. These are just some of the highlights of what we have done recently.

AC: You are also Chairman of the Executive Board of the European Graphene Flagship. Could you provide a brief overview of this organisation for our readers?

AF: I am the Chair of the Executive Board of the Graphene Flagship, which has the biggest budget in the world in graphene and related materials with a planned founding of $1 billion over ten years, of which $500 million comes directly from the European Commission.

At the moment, it has 142 partners across Europe, including several companies, and the Flagship is organized in a variety of what are called work packages covering applications that range from electronic devices to composites to energy.

AC: In early 2015, the Flagship published the peer reviewed 'science and technology roadmap for graphene'. Could you explain what this graphene roadmap is and how it works?

AF: The roadmap is our best understanding, at this moment in time, of what steps need to be taken in order to take graphene and related materials from the lab, eventually, to the factory floor, as well as a best guess, based on our understanding right now, of what the areas of major interest are.

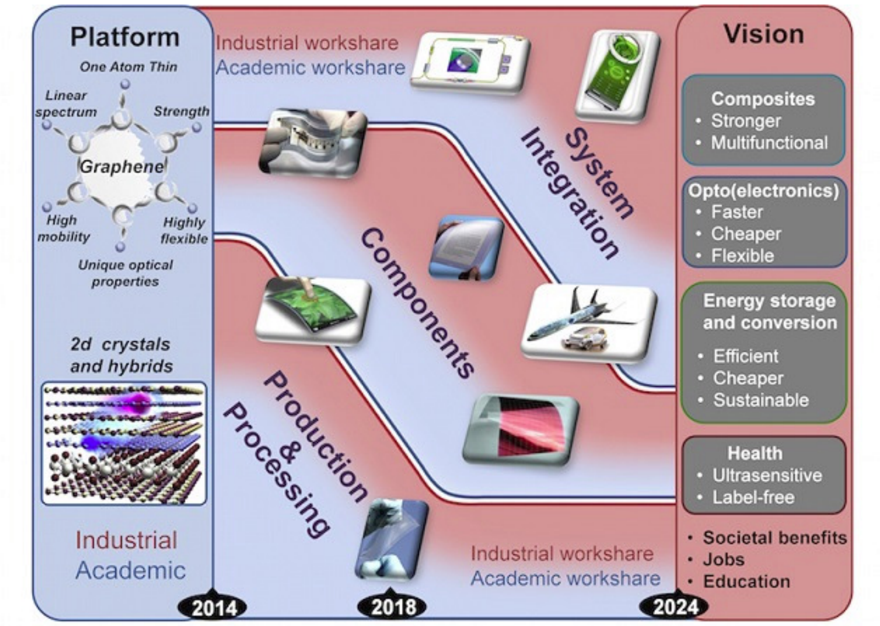

Image Credit: The Graphene Flagship

This roadmap is different from the usual one you have in industry, in the sense that usually an industry has a road map and a map formulated in order to achieve certain products. This is a bottom-up road map, in the sense that a variety of people from both academia and industry came together and tried to figure out how to develop the future graphene technology.

We have given time frames and timelines for development in a variety of areas, and this document captures our best understanding at the time of publication. Of course, over time, this roadmap will be improved, and, in fact, we plan to have the first upgrade of a few areas of the road map in 2016, and then every two years between now and 2024, we plan updates in specific areas of interest.

AC: You mentioned an end date of 2024 for the roadmap. Does the year 2024 hold a special significance?

AF: Yes, it marks the end of ten years for the Flagship. This roadmap was developed with the efforts of many of the partners of the Graphene Flagship. The Flagship started on 1st October, 2013 and so it will end in October of 2023, and that is why I say 2024. It is the year after the Flagship will have finished.

For this reason, we have focused our attention on the ten years from the start of the Flagship to its provisional end. It is in theory possible that the Flagship will be extended at the end of the ten years because there is no requirement for it to end. However at this point, funding has been given for ten years.

Video Credit: Cambridge University

AC: Do we know what the unique selling point of graphene is yet?

AF: We have known graphene's USP for many years. The program is not about finding the unique selling point because, in fact, there are many USP of graphene which are very well understood and identified. The program is asking: *"how do we make sure that we can translate this selling points in working technology, and how do we make sure that the cost of this technology is competitive?"*

One needs to understand the difference between research in the lab, and the development of a product for a market. I'll give you a simple example:

A student here in the university could produce a screen, a flat screen or a flexible screen but in the university setting, not all the pixels will be working. That's not a problem because you can still have an image, and maybe the screen will fade after a certain period of time but that is also not a problems because the physics is understood.

In the development stage, that can take ten times longer and ten times the funding, or perhaps even more. You need to make sure that everything works perfectly and that each single pixel is stable for a very long period of time. Then, at the end, you need to make sure that the cost of the new technology is competitive with any alternative technology, not today but at the time when you take it to market.

So, there are many obstacles to overcome in order to take the new material to market, and those are not necessarily of a scientific and strictly technological nature, but they can be more of an economic or other sort of basis, and that's the key point. So, the USP is clear. The challenge is: *"how do we make sure the USP is actually translated and deposited in the market?"*

AC: What are the biggest challenges which the graphene industry has to overcome before this 'wonder material' can be fully commercialised?

AF: The challenge is to clearly identify areas where graphene is not just incremental but is really enabling a completely new application that is not otherwise possible. It is always a risk to do just incremental developments because the current technology is not static.

While new incremental technology is being developed, the current technology will also move forward. Then there will be a question of cost, and by definition, the current technology is already implemented, so the costs are already lower.

The capital equipment has already been discounted over time, and that needs to be considered. So, the challenge is really to make sure that we find an area of application for graphene that can really enable new products that are not possible otherwise.

AC: When do you believe that we will be able to make a judgement on whether graphene has become fully commercialised? How will we be able to judge whether graphene has become the next silicon or the next carbon nanotubes?

AF: Typically, there are major differences. For software, if we look at Facebook, somebody creates the software at a university, and two years later, they run a major company. Then, ten years later, it's a billion-dollar company. That's software, not even hardware, so it's not even a new device that can be put into the market.

I'm talking about the materials that have to enable the creation of new devices that then have to be put into the market. So, if you look at the history of new materials, they typically take between 20 to 40 years from their start to the point where they can be put into novel devices for the consumer market. If we take 2004 as the start date, I don't think we can pass any serious judgment on graphene before 2024.

I think at that stage, we can really take a look at the material and really say if it's a failure or not. There are already indications that graphene is coming to the market. There is the well-known case of the HEAD tennis racket and some other devices. There is also a company, called Vittoria, that has recently launched a bicycle tire with graphene in it.

AC: Where can our readers find out more information about your work with the Cambridge Graphene Centre and the European Graphene Flagship?

AF: For the Cambridge Graphene Centre, the website is www.graphene.cam.ac.uk

For the Graphene Flagship, the website is www.graphene-flagship.eu

About Professor Andrea Ferrari

Andrea C. Ferrari earned a PhD in electrical engineering from Cambridge University, after a Laurea in nuclear engineering from Politecnico di Milano, Italy. He is Professor of Nanotechnology and head of the Nanomaterials and Spectroscopy group at the Department of Engineering and Nanoscience Centre of Cambridge University.

He is the founding Director of the Cambridge Graphene Centre and of the EPSRC Centre for Doctoral Training in Graphene Technology. He is the Chair of the Executive Board of the European Graphene Flagship. He is Fellow of Pembroke College, Cambridge, Fellow of the American Physical Society, Fellow of the Institute of Physics, and Royal Society Wolfson Research Merit Award Holder.

His research interests include nanomaterials growth, modelling, characterization, and devices. In particular, he focuses on graphene, nanotubes, diamond-like carbon and nanowires for applications in electronics and photonics.

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