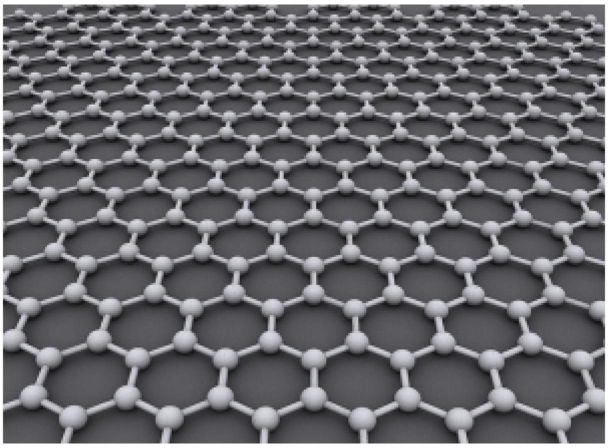
Photoluminescent Response in Graphene Foam



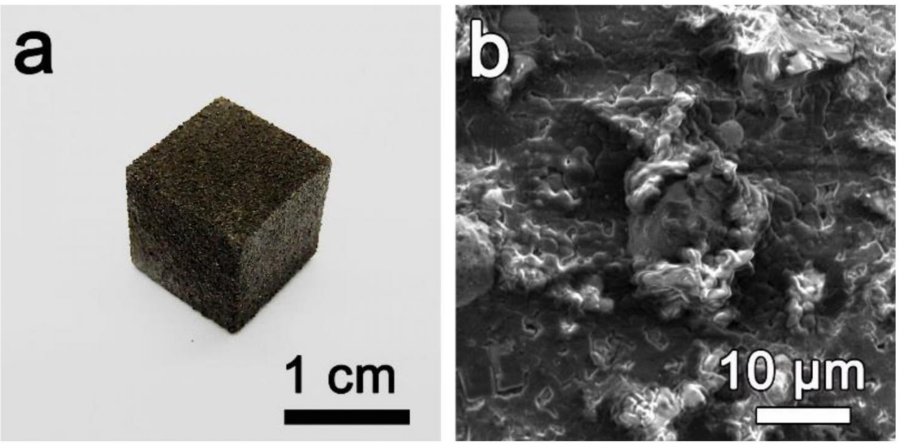
Crystalline Structure of GrapheneBy AlexanderAlUS [CC BY-SA 3.0 or GFDL], from Wikimedia Commons

Material science and engineering entails the design and discovery of new materials. This discipline incorporates the work of chemistry, physics, engineering along with ceramics, metallurgy, nanotechnology, biomaterials and others. The understanding of processing methods, physical and chemical structure, and the properties or behavior of materials is the heart of the materials paradigm. There are numerous historical examples of scientific progress limited by available materials so that breakthroughs in material science are often followed by advances in other areas of research.

Material science can arguably be considered the oldest example of engineering and applied science. In fact, material sciences are so important that we often separate historic periods by the material discoveries of the age, such as the stone age, bronze age, iron age, and what today could be considered the silicon age. Material science is responsible for discoveries of rubbers, plastics, semiconductors, and biomaterials to name just a few.

Spectroscopy has several applications in material science, from material identification to process and quality controls. Raman spectroscopy can provide insight into crystalline alignment, laser-induced breakdown spectroscopy is used to identify atomic composition, and emission monitoring spectroscopy analyzes plasma composition during chemical deposition processes. Avantes spectrometers are there, trusted around the world to deliver accurate spectral measurements for material scientists.

Graphene Breakthroughs



At left is a photo of a fingertip-sized cube of graphene foam;
at right is a close-up of the material as seen with a scanning electron microscope.
Credit: Tour Group/Rice University

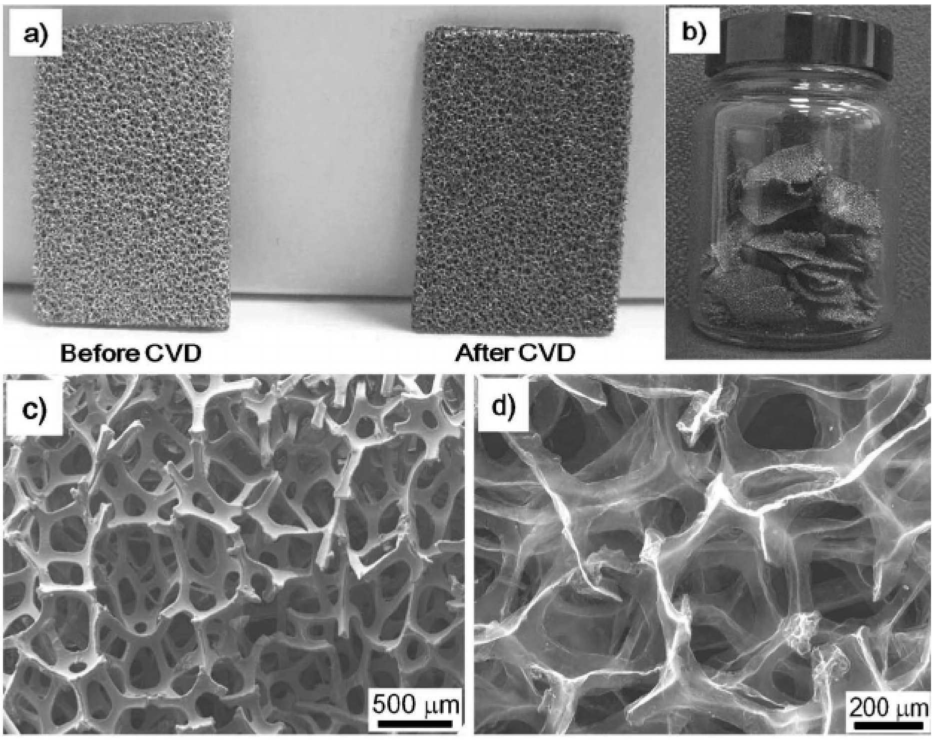
Graphene is a semi-metallic material that consists of a single layer of carbon molecules in a hexagonal grid arrangement and is the base structural element of other carbon-based materials such as graphite, diamonds, and carbon nanotubes.

Graphene has several unusual and unique properties. It is so thin that it is considered two dimensional, yet it is the strongest material ever discovered. Graphene is also a zero-bandgap semiconductor with surprising opacity for an atomic monolayer material. Because it is a zero-bandgap conductor, the light emitting capacity is limited and pristine graphene is not considered a likely candidate for light emitting devices. Graphene derivatives, on the other hand, such as oxidized graphene, graphene quantum dots, and carbon nanotubes have been observed emitting broadband white light emissions when subjected to focused infrared irradiation in a vacuum.

Graphene Foam

Graphene foam is created using chemical vapor deposition which creates self-assembled sheets of oxidized graphene deposited on a three-dimensional mesh of metal filaments and then the metal is removed. The resulting graphene foam is resilient, returning to its original shape after compression and able to support 3,000 times its weight. This mechanical strength, flexibility, and elasticity make this light-weight, high-conductive material an excellent candidate for several engineering applications.

The conductivity of graphene foam is also being explored for the development of flexible batteries with greater energy density than standard commercially available batteries. Another likely application is in chemical sensing with the ability to detect 20 parts-per-million of Nitrogen Dioxide.

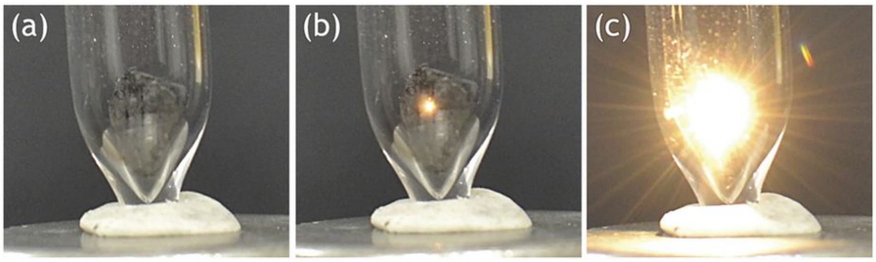


Zhao, Guixia, et al. "Synthesis of graphene-based nanomaterials and their applications energy-related and environmental-related areas." Rsc Advances 2.25 (2012): 9286-9303.

Laser-Induced White Light Emission

Researchers at the Polish Academy of Sciences from the departments of Low Temperature and Structure Research and Spectroscopy of Excited States investigated the light emission capacity of graphene foams. Following related research into light emission from irradiated quantum dots and induced incandescence of carbon nanotubes, these scientists were able to achieve white light emission from graphene foam irradiated with a sustained, focused, continuous-wave infrared laser diode.

These Laser-Induced White-light Emission (LIWE) experiments were able to achieve white light emissions with sustained excitation using a 975 nm continuous wave laser diode in a vacuum chamber. This light emission from the graphene foam place in an integrating sphere under vacuum was limited to the dimensions of the focal point of the excitation laser but demonstrating stable light characteristics that increased in intensity with a corresponding increase in laser power density.



(a) the graphene foam in a vacuum cuvette; (b) the photo of the graphene foam emission demonstrating lighting only from the spot at surface of graphene foam;(c) The photo of laser-induced intense white light emission of the graphene foam. -Strek, Wieslaw

Spectrometer Utility

These researchers employed Avantes instrumentation during experimentation to measure the photoluminescence response of the graphene foam. While an older instrument was used in the original research, the new AvaSpec-ULS2048CL-EVO would be an ideal instrument for this application. Additionally, spectroscopy can be utilized in the chemical deposition process for graphene foam fabrication for endpoint detection and process control, and morphology or crystallinity can be detected using Raman spectroscopy methods.

In the study of materials, one of the key principles is that the structure at an atomic level determines the behavior of the material on a macro scale. Spectroscopy gives researchers in this field the tools they need to develop the cutting-edge materials of the future.