

A myriad of nanostructures of elemental carbon

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Carbon does not stop amazing the scientific community – again and again. Until the 1980's, elemental carbon was believed to crystallize either as diamond, an ultra-hard and transparent solid, or graphite, a grayish layered substance used in pencils and lubricants. This perception changed completely with the discovery of the C₆₀ “buckyball” and other fullerenes, deemed significant enough to warrant the 1996 Chemistry Nobel prize. What followed was a ‘Carbon Rush’ – a counterpart of the Gold Rush of the 19th century – with carbon nanotubes, peapods and more recently atomically thin graphene layers becoming the hottest research topics in Condensed Matter Physics and Materials Science.

The reason is simple: Among the myriad of complex nanostructures formed by carbon, each surprises by a unique combination of properties, commonly associated with other materials. Whereas many nanocarbons and their properties were studied first by experiment, theoretical predictions – many of them in the group of Professor Tomanek at Michigan State University – preceded the experimental verification of other others. Some of these properties are the unsurpassed elastic modulus and toughness of carbon nanotubes, which make them hundred times stronger than steel at one-sixth of the weight. Others are the finding of plasmons, namely collective electronic excitations characteristic of metals, in C₆₀ molecules, understanding the elusive superconductivity in doped C₆₀ crystals and predicting magnetism in all-carbon nanostructures. Spontaneous formation of peapods, nanotubes filled by fullerenes, was observed after their existence was postulated. The record thermal conductivity value, predicted for nanotubes and graphene, has also been confirmed experimentally and is now considered a pillar for molecular electronics applications of carbon nanostructures.

For his theoretical studies of carbon nanostructures, David Tomanek has been awarded the 2008 Japan Carbon Award for Life-Time Achievement, the highest award of the Japan Carbon Society.