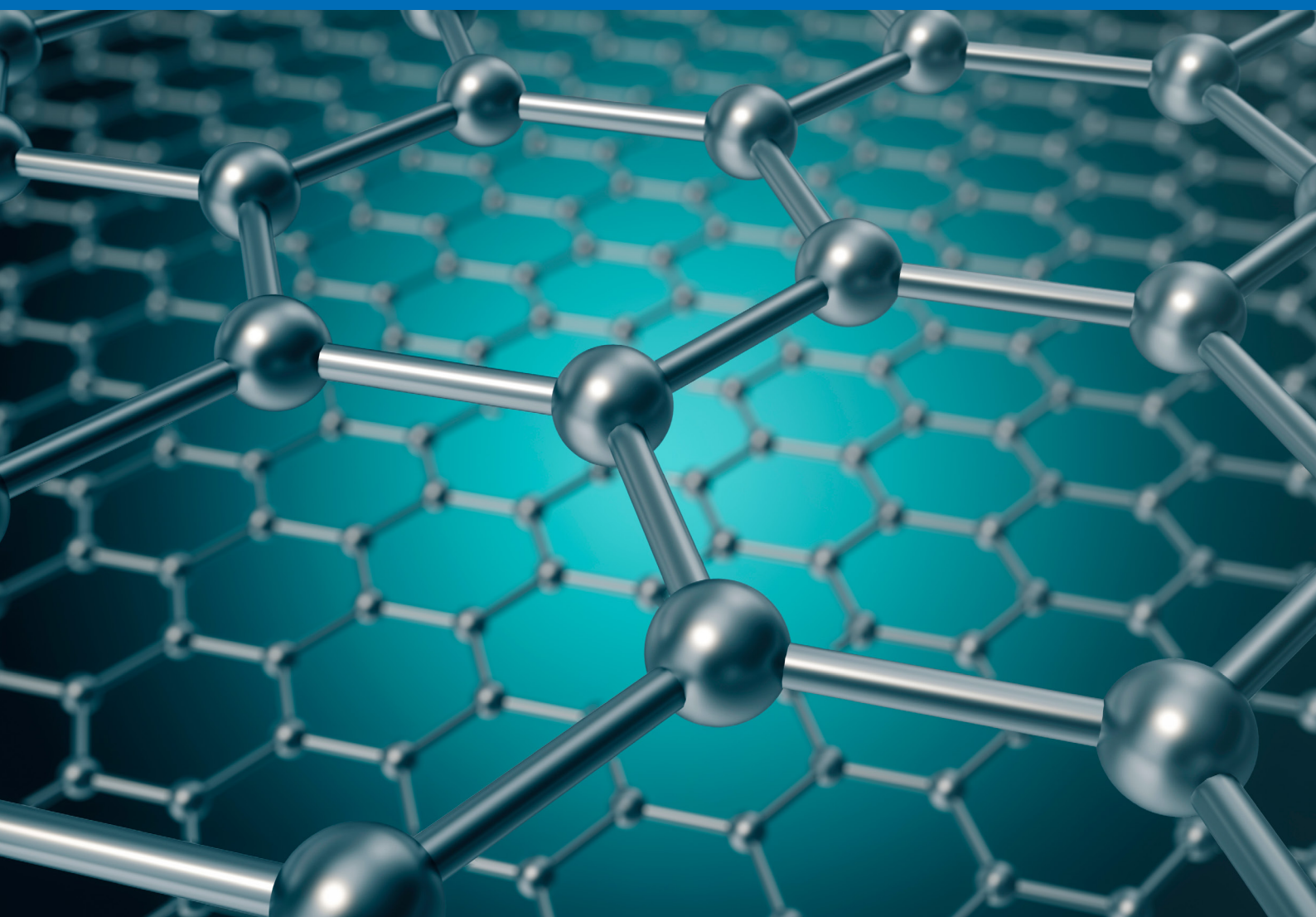


PAS 1201:2018

Properties of graphene flakes – Guide



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Foreword

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0 Introduction

0.1 General

Graphene, the two-dimensional (2D) form of carbon, was first isolated at the University of Manchester and reported in 2004 by Professor Andre Geim and Professor Kostantin Novoselov [1]. The importance of this discovery was acknowledged by the award of the 2010 Nobel Prize for Physics, and initiated intense global activity in research and commercialization of variants of 2D carbon materials [2], [3].

Carbon is an extremely versatile element, being found as different forms, or allotropes, in synthetic or naturally-occurring minerals such as graphite and diamond, which exhibit markedly different properties. Graphite is a layered material, and comprises a stack of single layers of carbon atoms which are weakly bonded between the layers.

Graphene was originally isolated by Geim and Novoselov from mined graphite, the material used in pencil lead, and was extracted by repeatedly peeling off layers using adhesive tape – a process known as mechanical exfoliation. This exfoliation process successively reduced the carbon layers down to a single layer, denoted as graphene. The term graphene strictly refers to a single layer of carbon atoms arranged in a crystalline hexagonal arrangement, as illustrated in Figure 1.

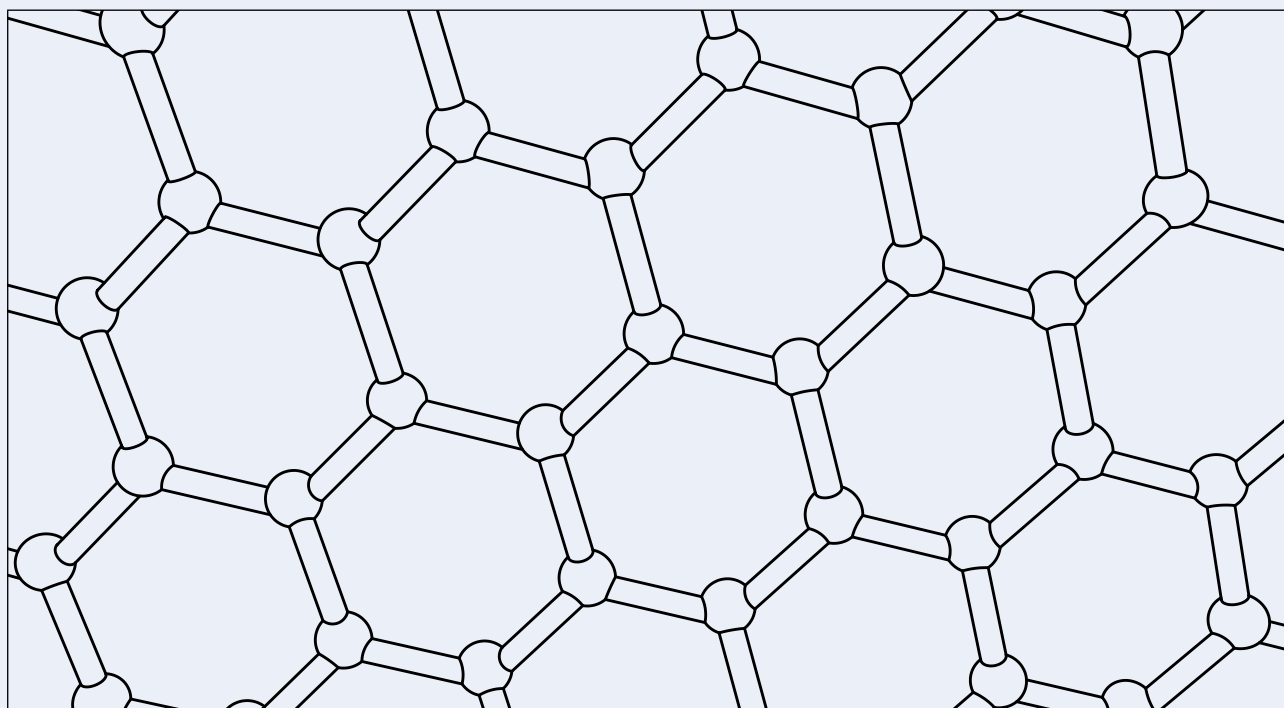
Subsequently, a diversity of new manufacturing methods have been developed for producing 2D planar carbon materials, each process producing different variants of particles, liquid dispersions or sheets.

The term “graphene” has entered the vocabulary as a label to refer to batches of 2D carbon particles which can contain flakes of differing layer thicknesses, not just a single layer.

This PAS uses the term “graphene flakes” to refer to powders or liquids containing graphene.

NOTE Graphene is defined in PD ISO/TS 80004-13.

Figure 1 – Illustration of the hexagonal arrangement of carbon atoms in a single layer of graphene



0.2 Manufacturing routes

A wide diversity of manufacturing processes have been, and are being, developed to produce powders containing graphene flakes and 2D carbon particles. In very general terms, they can be divided into two approaches: top-down (subtractive) and bottom-up (additive).

Top-down processes include exfoliation of a solid precursor such as highly ordered natural (mined), or synthetic, graphite. Bottom-up processes include thermal or chemical conversion of gases or liquids.

A schematic of the two generic manufacturing approaches is shown in Figure 2.

Figure 2 – Illustration of the stages in typical top-down and bottom-up approaches for manufacturing graphene flakes

