Liquid crystal for direct observation and understanding domain properties in 2D materials

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As the properties of materials, such as metals, organic and inorganic semiconductors, are governed by their shape of crystal domains and defect structures, controlling the domain is one of the most important issues in preparing high-quality two-dimensional (2D) materials. Thus, a number of works have been conducted over the last decade to control the domain structure of graphene and recently, 2D transition metal dichalcogenides. Unfortunately, conventional tools used for the analysis of nano structures are unavailable in the case of graphene and 2D materials because these materials are too thin to be investigated. Also, an extremely long observation time is required to investigate a narrow region around several nanometers using scanning tunneling microscopy or low energy electron diffraction. Herein, a new method to observe the domain structure of 2D materials is suggested by using the alignment phenomena of nematic liquid crystals (LCs) on the regular crystalline surface. By observing the LCs aligned along the crystalline orientation of 2D domains using polarized optical microscopy (POM), the domain structures of 2D materials including graphene and molybdenum disulfide (MoS_2) are easily visualized in a large area[1, 2].

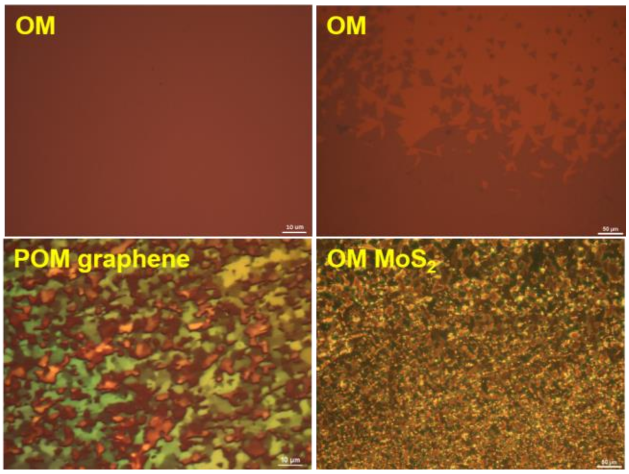

Fig. 1. Optically visualized domain structures of graphene and MoS_2, which are synthesized by CVD method

While it is impossible to observe the domain structure of 2D materials by optical microscopy due to the absence of optical contrast between each domain, birefringence colors from aligned liquid crsytals using POM succesfully reveal the domain structure of underlying materials as shown in Figure 1. By using the advantages of our method, various growth factors affecting the crystallization of graphene during chemical vapor depostion[3, 4] were investigated as well as the relationship between domain boundaries and electrical properties[5].

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