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Substrate Placement Inside CVD Tube for Graphene Production

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Abstract. Electronics and energy storage industry demand production of high-quality graphene which currently still a challenge. Chemical vapor deposition (CVD) has shown promises for high-quality graphene production. However, it involves control of many parameters from different aspects such as thermal-fluid, mass transport, and chemical reaction. Thermal fluid aspect plays a significant role in CVD production of graphene but yet to be explored extensively. For a tubular hot-wall CVD with the heating reactor, issue of flow instability that will prolong the existence of vortices and spiral flow until the substrate required attention. Therefore current study aims to find the optimum substrate position inside the furnace. For that purpose the gas flow streamline will be observed, and minimum axial distance of the substrate will be determined. The tubular CVD is modeled using ANSYS Fluent®. The current model will not consider the chemical reaction involves and only single gas is used. This should be enough to seek the influence of thermal-fluid aspects involves in CVD. The CVD tube will be divided into 3 sections where the middle part (furnace) was heated up to 1273K and the other two sections were kept at 300K. Gas was supplied to the tube and the distance from the furnace inlet to the point where the flow is fully developed is measured. Streamlines for the flow is also observed. The streamline shows that there is an induced secondary flow starting at the inlet which lasted until a certain axial distance. For flow with 50 sccm of flowrate needs an axial distance of 5 cm while flow with 250 sccm of flowrate needs 7 cm in order to become a smooth flow. Our results show that the placement of the substrate in the tubular hot-wall CVD required attention in CVD design. For flow with higher flowrate, it requires longer distance for the flow to become smooth and laminar and vice versa.

Introduction

Driven by its exceptional electrical characteristic of graphene, a lot of research has been done in order to synthesize pristine graphene [1]–[4]. This an atomic layer of carbon in hexagonal honeycomb lattice arrangement [5] can be used in high-speed electronics, data storage, supercapacitors, solar cells, and electrochemical sensing [6], [7]. Unfortunately, till today mass production of graphene still faces many problems such as structural imperfections, including grain boundaries [8], point defects [9] and uneven thickness[6], [10] that forbid the synthesis of pristine graphene [11].

There are a few methods to synthesize graphene. Most published results have been obtained with exfoliated graphene, which is presently the closest to flawless but it is too expensive for mass production and not suitable for industrial scale production [2], [12]. Other than that, there are epitaxial growth of graphene [13], reduction of graphene oxide [14], and chemical vapor deposition (CVD). Among these methods, CVD has become the most promising approach because it is most economical method, transferable and ability to produce high quality and large-area graphene films [7], [15], [16].

Basically, chemical vapor deposition is a process for the synthesis of thin films via chemical reactions between molecules in the gas phase and on a surface of a metal substrate. Nowadays, CVD