

 Look Up Full Text

Full Text from Publisher



Save to EndNote online

Add to Marked List

1 of 2

## A critical review of the effects of fluid dynamics on graphene growth in atmospheric pressure chemical vapor deposition

By: Fauzi, FB (Fauzi, Fatin Bazilah)<sup>[1]</sup>; Ismail, E (Ismail, Edhuan)<sup>[1]</sup>; Ani, MH (Ani, Mohd Hanafi)<sup>[1]</sup>; Abu Bakar, SNS (Abu Bakar, Syed Noh Syed)<sup>[2]</sup>; Mohamed, MA (Mohamed, Mohd Ambri)<sup>[3]</sup>; Majlis, BY (Majlis, Burhanuddin Yeop)<sup>[3]</sup>; Din, MFM (Din, Muhamad Faiz Md)<sup>[4]</sup>; Abid, MAAM (Abid, Mohd Asyadi Azam Mohd)<sup>[5]</sup>

JOURNAL OF MATERIALS RESEARCH

Volume: 33 Issue: 9 Pages: 1088-1108

DOI: 10.1557/jmr.2018.39

Published: MAY 14 2018

Document Type: Review

[View Journal Impact](#)

### Abstract

Chemical vapor deposition (CVD) of graphene has attracted high interest in the electronics industry due to its potential scalability for large-scale production. However, producing a homogeneous thin-film graphene with minimal defects remains a challenge. Studies of processing parameters, such as gas precursors, flow rates, pressures, temperatures, and substrate types, focus on improving the chemical aspect of the deposition. Despite the many reports on such parameters, studies on fluid dynamic aspects also need to be considered since they are crucial factors in scaling up the system for homogenous deposition. Once the deposition kinetics is thoroughly understood, the next vital step is fluid dynamics optimization to design a large-scale system that could deliver the gas uniformly and ensure maximum deposition rate with the desired property. In this review, the influence of fluid dynamics in graphene CVD process was highlighted. The basics and importance of CVD fluid dynamics was introduced. It is understood that the fluid dynamics of gases can be controlled in two ways: via reactor modification and gas composition. This paper begins first with discussions on horizontal tubular reactor modifications. This is followed by mechanical properties of the reactant gasses especially in terms of dimensionless Reynolds number which provides information on gas flow regime for graphene CVD process at atmospheric pressure. Data from the previous literature provide the Reynolds number for various gas compositions and its relation to graphene quality. It has been revealed that hydrogen has a major influence on the fluid dynamic conditions within the CVD, hence affecting the quality of the graphene produced. Focusing on atmospheric pressure CVD, suggestions for up-scaling into larger CVD reactors while maintaining similar fluid properties were also provided.

### Keywords

**Author Keywords:** chemical vapor deposition (CVD) (deposition); fluid; thin film

**KeyWords Plus:** SINGLE-LAYER GRAPHENE; HIGH-QUALITY GRAPHENE; LARGE-AREA; GAS-FLOW; DOMAIN-STRUCTURE; SILICON-CARBIDE; COPPER FOIL; SUBSTRATE; CVD; SIMULATION

### Author Information


**Reprint Address:** Ani, MH (reprint author)


 IIUM, Dept Mfg & Mat Engr, Kuala Lumpur 53100, Malaysia.

#### Addresses:

 [ 1 ] IIUM, Dept Mfg & Mat Engr, Kuala Lumpur 53100, Malaysia

 [ 2 ] IIUM, Dept Mech Engr, Kuala Lumpur 53100, Malaysia

 [ 3 ] Univ Kebangsaan Malaysia, Inst Microengn & Nanoelect IMEN, Ukm Bangi 43600, Selangor, Malaysia

 [ 4 ] UPNM, Dept Elect & Elect Engr, Kuala Lumpur 57000, Malaysia

[ 5 ] UTEM, Fac Mfg Engr, Durian Tunggal 76100, Melaka, Malaysia

**E-mail Addresses:** [mhanafi@iium.edu.my](mailto:mhanafi@iium.edu.my)

### Funding

Funding Agency	Grant Number
Ministry of Higher Education Malaysia (MOHE)	LRGS15-003-0004 RIGS17-054-0629

### Citation Network

In Web of Science Core Collection

2

Times Cited

 Create Citation Alert

All Times Cited Counts

2 in All Databases

[See more counts](#)

88

Cited References

[View Related Records](#)

### Most recently cited by:

Fauzi, Fatin Bazilah; Ismail, Edhuan; Osman, Muhammad Naqib; et al. [Influence of mixed convection in atmospheric pressure chemical vapor deposition of graphene growth.](#) MATERIALS TODAY-PROCEEDINGS (2019)

Fauzi, Fatin Bazilah; Ismail, Edhuan; Ani, Mohd Hanafi; et al. [A critical review of the effects of fluid dynamics on graphene growth in atmospheric pressure chemical vapor deposition \(vol 33, pg 1088, 2018\).](#) JOURNAL OF MATERIALS RESEARCH (2018)

[View All](#)

### Use in Web of Science

Web of Science Usage Count

15

37

Last 180 Days

Since 2013

[Learn more](#)

This record is from:

Web of Science Core Collection  
- Science Citation Index Expanded

**Suggest a correction**

If you would like to improve the quality of the data in this record, please suggest a correction.

FRGS17-035-0601

International Islamic University Malaysia (IIUM)

[View funding text](#)**Publisher**

CAMBRIDGE UNIV PRESS, 32 AVENUE OF THE AMERICAS, NEW YORK, NY 10013-2473 USA

**Journal Information**Impact Factor: [Journal Citation Reports](#)**Categories / Classification**

Research Areas: Materials Science

Web of Science Categories: Materials Science, Multidisciplinary

**See more data fields**

◀ 1 of 2 ▶

**Cited References: 88**Showing 30 of 88 [View All in Cited References page](#)*(from Web of Science Core Collection)*

1. **Monolayer graphene growth on Ni(111) by low temperature chemical vapor deposition** Times Cited: 91  
By: Addou, Rafik; Dahal, Arjun; Sutter, Peter; et al.  
APPLIED PHYSICS LETTERS Volume: 100 Issue: 2 Article Number: 021601 Published: JAN 9 2012
2. **Large-Area Synthesis of Graphene on Palladium and Their Raman Spectroscopy** Times Cited: 28  
By: An, Xiaohong; Liu, Fangze; Jung, Yung Joon; et al.  
JOURNAL OF PHYSICAL CHEMISTRY C Volume: 116 Issue: 31 Pages: 16412-16420 Published: AUG 9 2012
3. **Taguchi method-ANN integration for predictive model of intrinsic stress in hydrogenated amorphous silicon film deposited by plasma enhanced chemical vapour deposition** Times Cited: 9  
By: Asafa, T. B.; Tabet, N.; Said, S. A. M.  
NEUROCOMPUTING Volume: 106 Pages: 86-94 Published: APR 15 2013
4. **Review-Critical Considerations of High Quality Graphene Synthesized by Plasma-Enhanced Chemical Vapor Deposition for Electronic and Energy Storage Devices** Times Cited: 5  
By: Azam, Mohd Asyadi; Zulkapli, Nor Najihah; Dorah, Norasimah; et al.  
ECS JOURNAL OF SOLID STATE SCIENCE AND TECHNOLOGY Volume: 6 Issue: 6 Pages: M3035-M3048 Published: 2017
5. **CHEMICAL PROCESSES IN VAPOR-DEPOSITION OF SILICON .2. DEPOSITION FROM SICL3H AND SICL4** Times Cited: 54  
By: BAN, VS  
JOURNAL OF THE ELECTROCHEMICAL SOCIETY Volume: 122 Issue: 10 Pages: 1389-1391 Published: 1975
6. **Role of Kinetic Factors in Chemical Vapor Deposition Synthesis of Uniform Large Area Graphene Using Copper Catalyst** Times Cited: 490  
By: Bhaviripudi, Sreekar; Jia, Xiaoting; Dresselhaus, Mildred S.; et al.  
NANO LETTERS Volume: 10 Issue: 10 Pages: 4128-4133 Published: OCT 2010
7. **NUCLEATION AND GROWTH OF SILICON BY CVD** Times Cited: 70  
By: BLOEM, J  
JOURNAL OF CRYSTAL GROWTH Volume: 50 Issue: 3 Pages: 581-604 Published: 1980
8. **Understanding and Controlling Cu-Catalyzed Graphene Nucleation: The Role of Impurities, Roughness, and Oxygen Scavenging** Times Cited: 42  
By: Braeuninger-Weimer, Philipp; Brennan, Barry; Pollard, Andrew J.; et al.  
CHEMISTRY OF MATERIALS Volume: 28 Issue: 24 Pages: 8905-8915 Published: DEC 27 2016
9. **Kinetics of SiHCl3 Chemical Vapor Deposition and Fluid Dynamic Simulations** Times Cited: 13  
By: Cavallotti, Carlo; Masi, Maurizio  
JOURNAL OF NANOSCIENCE AND NANOTECHNOLOGY Volume: 11 Issue: 9 Pages: 8054-8060 Published: SEP 2011