

# The Global Market for CVD Graphene

https://marketpublishers.com/r/GD8500636BBEN.html

Date: June 2018

Pages: 220

Price: US\$ 665.00 (Single User License)

ID: GD8500636BBEN

## **Abstracts**

Chemical Vapor Deposition (CVD) is the favoured approach for the production of large area graphene films for application as transparent conductive layers in flexible electronics, touchscreens, sensors, and energy. This approach is industrially-scalable and produces films that have higher quality, homogeneity and are cheaper than those produced by chemical exfoliation.

The high-value applications for graphene generally require graphene films (solar cells, electronics, transparent electrodes, ultracapacitors, etc.). However, preparation of large-area, defect-free, continuous graphene film remains a challenge. Large consumer electronics companies are heavily involved in product development in this segment along with a number of smaller companies developing CVD Graphene films that be mass-produced and transferred to nearly any substrate. Low cost production and etch-free transfer of graphene films could potentially disrupt multi-billion dollar markets including sensors, energy storage, and flexible electronics.

#### Report contents include:

Stage of commercialization for CVD graphene applications, from basic research to market entry.

Market drivers, trends and challenges, by end user markets.

Market outlook for 2018.

In-depth market assessment of opportunities for CVD graphene in electronic, optoelectronics, biosensors and energy storage.

Production capacities by company (m2).



In-depth company profiles, including products, capacities, and commercial activities.

Detailed forecasts for key growth areas, opportunities and user demand.

Assessment of applications for other 2D materials competitive with and complementary to CVD graphene.

42 company profiles.



## **Contents**

#### 1 RESEARCH METHODOLOGY

- 1.1 Market opportunity analysis.
- 1.2 Market challenges rating system.

#### 2 EXECUTIVE SUMMARY.

- 2.1 Two-dimensional (2D) materials
- 2.2 CVD Graphene.
  - 2.2.1 The market in 2018
  - 2.2.2 Products.
  - 2.2.3 Production

#### **3 OVERVIEW OF GRAPHENE**

- 3.1 History.
- 3.2 Forms of graphene.
- 3.3 Properties

#### **4 CVD GRAPHENE SYNTHESIS**

- 4.1 CVD Graphene.
- 4.2 Production methods
- 4.3 Graphene quality.
- 4.4 Synthesis and production of CVD graphene
- 4.5 Pros and cons of CVD production

#### **5 END USER MARKET SEGMENT ANALYSIS.**

- 5.1 Commercial production capacities
  - 5.1.1 CVD graphene film production by country/year, 2010-2018/ 000s m2
- 5.2 Graphene pricing.
  - 5.2.1 Pristine Graphene Flakes pricing
  - 5.2.2 Few-Layer Graphene pricing
  - 5.2.3 Graphene Nanoplatelets pricing
  - 5.2.4 Reduced Graphene Oxide pricing
  - 5.2.5 Graphene Quantum Dots pricing.



- 5.2.6 Graphene Oxide Nanosheets pricing
- 5.2.7 Multilayer Graphene (MLG) pricing
- 5.2.8 Mass production of lower grade graphene materials
- 5.2.9 High grade graphene difficult to mass produce.
- 5.2.10 Bulk supply
- 5.2.11 Commoditisation

#### **6 MARKETS FOR CVD GRAPHENE**

#### 6.1 ELECTRONICS

- 6.1.1 FLEXIBLE ELECTRONICS, WEARABLES, CONDUCTIVE FILMS AND DISPLAYS
  - 6.1.1.1 MARKET DRIVERS AND TRENDS.
  - 6.1.1.2 PROPERTIES AND APPLICATIONS
  - 6.1.1.3 GLOBAL MARKET SIZE AND OPPORTUNITY
  - 6.1.1.4 MARKET CHALLENGES.
- 6.2 TRANSISTORS AND INTEGRATED CIRCUITS.
  - 6.2.1 MARKET DRIVERS AND TRENDS
  - 6.2.2 PROPERTIES AND APPLICATIONS
  - 6.2.2.1 Integrated circuits
  - 6.2.2.2 Transistors
  - 6.2.2.3 Graphene Radio Frequency (RF) circuits.
  - 6.2.2.4 Graphene spintronics
  - 6.2.3 GLOBAL MARKET SIZE AND OPPORTUNITY
  - 6.2.4 MARKET CHALLENGES
- 6.3 MEMORY DEVICES.
  - 6.3.1 MARKET DRIVERS AND TRENDS
  - 6.3.2 PROPERTIES AND APPLICATIONS
  - 6.3.3 GLOBAL MARKET SIZE AND OPPORTUNITY
  - 6.3.4 MARKET CHALLENGES
- **6.4 PHOTONICS** 
  - 6.4.1 MARKET DRIVERS AND TRENDS
  - 6.4.2 PROPERTIES AND APPLICATIONS
    - 6.4.2.1 Si photonics versus graphene
    - 6.4.2.2 Optical modulators.
    - 6.4.2.3 Photodetectors
    - 6.4.2.4 Saturable absorbers
    - 6.4.2.5 Plasmonics
    - 6.4.2.6 Fiber lasers



### 6.4.3 GLOBAL MARKET SIZE AND OPPORTUNITY

#### 6.4.4 MARKET CHALLENGES

#### 7 SUPERCAPACITORS

- 7.1 MARKET DRIVERS AND TRENDS
- 7.2 PROPERTIES AND APPLICATIONS
  - 7.2.1 Flexible and stretchable supercapacitors
- 7.3 GLOBAL MARKET SIZE AND OPPORTUNITY
- 7.4 MARKET CHALLENGES

#### **8 PHOTOVOLTAICS**

- 8.1 MARKET DRIVERS AND TRENDS
- 8.2 PROPERTIES AND APPLICATIONS
  - 8.2.1. ITO replacement
  - 8.2.2 Graphene-silicon (Gr-Si) Schottky junction solar cells
  - 8.2.3 Halide perovskites/graphene hybrids
  - 8.2.4 Solar energy harvesting textiles
- 8.3 GLOBAL MARKET SIZE AND OPPORTUNITY
- 8.4 MARKET CHALLENGES

#### 9 FLEXIBLE LED LIGHTING.

- 9.1 MARKET DRIVERS AND TRENDS
- 9.2 PROPERTIES AND APPLICATIONS
  - 9.2.1 Flexible OLED lighting
- 9.3 GLOBAL MARKET SIZE AND OPPORTUNITY
- 9.4 MARKET CHALLENGES

#### 10 BIOSENSORS

- 10.1 MARKET DRIVERS AND TRENDS.
- 10.2 PROPERTIES AND APPLICATIONS.
- 10.3 GLOBAL MARKET SIZE AND OPPORTUNITY.
- 10.4 MARKET CHALLENGES.

# 11 CVD GRAPHENE PRODUCER AND PRODUCT DEVELOPERS PROFILES. 141-166 (42 COMPANY PROFILES)



12 APPENDIX 1: OTHER 2-D MATERIALS.

13 REFERENCES



## **List Of Tables**

#### LIST OF TABLES

- Table 1: CVD graphene target markets-Applications and potential addressable market size
- Table 2: Main CVD graphene producers by country and annual production capacities, m2
- Table 3: Properties of graphene.
- Table 4: CVD graphene-Markets, applications and current global market
- Table 5: Main production methods for graphene
- Table 6: Large area graphene films-Markets, applications and current global market
- Table 7: CVD graphene film capacity by country/year, 2010-2018/000s m2.
- Table 8: Types of graphene and prices.
- Table 9: Pristine graphene flakes pricing by producer
- Table 10: Few-layer graphene pricing by producer
- Table 11: Graphene nanoplatelets pricing by producer.
- Table 12: Reduced graphene oxide pricing, by producer.
- Table 13: Graphene quantum dots pricing by producer
- Table 14: Graphene oxide nanosheets pricing by producer
- Table 15: Multi-layer graphene pricing by producer.
- Table 16: Market drivers for use of CVD graphene in flexible electronics and conductive films
- Table 17: Applications and benefits of CVD graphene in flexible electronics and conductive films.
- Table 18: Comparison of ITO replacements
- Table 19: Wearable electronics devices and stage of development
- Table 20: Graphene properties relevant to application in sensors.
- Table 21: Market size for CVD graphene in flexible electronics and conductive films
- Table 22: Market opportunity assessment for CVD graphene in flexible electronics, wearables, conductive films and displays
- Table 23: Global market for wearable electronics, 2015-2027, by application, billions \$
- Table 24: Market challenges rating for graphene in the flexible electronics, wearables, conductive films and displays market
- Table 25: Market drivers for use of CVD graphene in transistors, integrated circuits and other components
- Table 26: Comparative properties of silicon and graphene transistors
- Table 27: Applications and benefits of CVD graphene in transistors, integrated circuits and other components



- Table 28: Market size for CVD graphene in transistors, integrated circuits and other components.
- Table 29: Market opportunity assessment for CVD graphene in transistors, integrated circuits and other components.
- Table 30: Market challenges rating for graphene in the transistors and integrated circuits market.
- Table 31: Market drivers for use of CVD graphene in memory devices.
- Table 32: Market size for CVD graphene in memory devices
- Table 33: Applications and commercialization challenges for graphene in the memory devices market
- Table 34: Market drivers for use of CVD graphene in photonics.
- Table 35: Graphene properties relevant to application in optical modulators.
- Table 36: Applications and benefits of graphene in photonics
- Table 37: Market size for CVD graphene in photonics
- Table 38: Market challenges rating for graphene in the photonics market
- Table 39: Market drivers for use of CVD graphene in supercapacitors
- Table 40: Comparative properties of graphene supercapacitors and lithium-ion batteries
- Table 41: Applications and benefits of CVD graphene in supercapacitors
- Table 42: Market size for CVD graphene in supercapacitors.
- Table 43: Market opportunity assessment for CVD graphene in supercapacitors
- Table 44: Market challenges rating for graphene in the supercapacitors market
- Table 45: Market drivers for use of CVD graphene in photovoltaics.
- Table 46: Market size for CVD graphene in photovoltaics
- Table 47: Market size for CVD graphene in photovoltaics
- Table 48: Potential addressable market for photovoltaics
- Table 49: Market challenges rating for graphene in the solar market
- Table 50: Market drivers for use of CVD graphene in LED lighting and UVC
- Table 51: Applications of CVD graphene in lighting
- Table 52: Market size for CVD graphene in LED lighting
- Table 53: Investment opportunity assessment for CVD graphene in the lighting market
- Table 54: Market impediments for graphene in lighting
- Table 55: Market drivers for use of CVD graphene in sensors.
- Table 56: Applications and benefits of graphene in biosensors
- Table 57: Graphene properties relevant to application in sensors.
- Table 58: Comparison of ELISA (enzyme-linked immunosorbent assay) and graphene biosensor
- Table 59: Market size for CVD graphene in biosensors.
- Table 60: Market opportunity assessment for CVD graphene in the biosensors market
- Table 61: Market challenges rating for graphene in the sensors market



- Table 62: 2D materials types.
- Table 63: Electronic and mechanical properties of monolayer phosphorene, graphene and MoS2
- Table 64: Market opportunity assessment for phosphorene applications.
- Table 65: Market opportunity assessment for graphitic carbon nitride applications
- Table 66: Market opportunity assessment for germanene applications.
- Table 67: Market opportunity assessment for graphdiyne applications
- Table 68: Market opportunity assessment for graphane applications
- Table 69: Market opportunity assessment for hexagonal boron nitride applications.
- Table 70: Market opportunity assessment for molybdenum disulfide applications.
- Table 71: Market opportunity assessment for Rhenium disulfide (ReS2) and diselenide (ReSe2) applications.
- Table 72: Market opportunity assessment for silicene applications
- Table 73: Market opportunity assessment for stanine/tinene applications
- Table 74: Market opportunity assessment for tungsten diselenide applications
- Table 75: Comparative analysis of graphene and other 2-D nanomaterials



# **List Of Figures**

#### LIST OF FIGURES

- Figure 1: Global consumption of CVD graphene 2017, by region.
- Figure 2: Graphene layer structure schematic.
- Figure 3: Graphite and graphene
- Figure 4: Graphene and its descendants: top right: graphene; top left: graphite = stacked graphene; bottom right: nanotube=rolled graphene; bottom left: fullerene=wrapped graphene.
- Figure 5: Fabrication methods of graphene
- Figure 6: Schematic illustration of the main graphene production techniques
- Figure 7: Graphene synthesis-CVD technique.
- Figure 8: CVD Graphene on Cu Foil
- Figure 9: Moxi flexible film developed for smartphone application
- Figure 10: Flexible graphene touch screen.
- Figure 11: Galapad Settler smartphone
- Figure 12: Flexible organic light emitting diode (OLED) using graphene electrode
- Figure 13: Graphene electrochromic devices. Top left: Exploded-view illustration of the graphene electrochromic device. The device is formed by attaching two graphene-coated PVC substrates face-to-face and filling the gap with a liquid ionic electrolyte
- Figure 14: Flexible mobile phones with graphene transparent conductive film
- Figure 15: Foldable graphene E-paper
- Figure 16: Wearable gas sensor.
- Figure 17: Potential addressable market for CVD graphene in the flexible electronics, wearables, conductive films and displays market.
- Figure 18: Global market for wearable electronics, 2015-2027, by application, billions \$
- Figure 19: Global transparent conductive electrodes market forecast by materials type, 2012-2027, millions \$.
- Figure 20: Schematic of the wet roll-to-roll graphene transfer from copper foils to polymeric substrates
- Figure 21: The transmittance of glass/ITO, glass/ITO/four organic layers, and glass/ITO/four organic layers/4-layer graphene
- Figure 22: Graphene IC in wafer tester.
- Figure 23: A monolayer WS2-based flexible transistor array.
- Figure 24: Schematic cross-section of a graphene based transistor (GBT, left) and a graphene field-effect transistor (GFET, right)
- Figure 25: Potential addressable market for CVD graphene in transistors and integrated circuits.



- Figure 26: Potential addressable market for CVD graphene in the transistors and integrated circuits market
- Figure 27: Graphene oxide-based RRAm device on a flexible substrate.
- Figure 28: Layered structure of tantalum oxide, multilayer graphene and platinum used for resistive random access memory (RRAM)
- Figure 29: A schematic diagram for the mechanism of the resistive switching in metal/GO/Pt
- Figure 30: Carbon nanotubes NRAM chip
- Figure 31: Stretchable SWCNT memory and logic devices for wearable electronics
- Figure 32: Potential addressable market for CVD graphene in the memory devices market.
- Figure 33: Hybrid graphene phototransistors.
- Figure 34: Wearable health monitor incorporating graphene photodetectors.
- Figure 35: Flexible PEN coated with graphene and a QD thin film (20nm) is highly visibly transparent and photosensitive
- Figure 36: Potential addressable market for CVD graphene in photonics
- Figure 37: Skeleton Technologies ultracapacitor.
- Figure 38: Stretchable graphene supercapacitor.
- Figure 39: Potential addressable market for CVD graphene in supercapacitors.
- Figure 40: Solar cell with nanowires and graphene electrode
- Figure 41: Schematic illustration of the fabrication concept for textile-based dye-
- sensitized solar cells (DSSCs) made by sewing textile electrodes onto cloth or paper
- Figure 42: Potential addressable market for CVD graphene in photovoltaics
- Figure 43: LG OLED flexible lighting panel
- Figure 44: Flexible OLED incorporated into automotive headlight.
- Figure 45: Potential addressable market for CVD graphene in lighting
- Figure 46: First generation point of care diagnostics
- Figure 47: Graphene Field Effect Transistor Schematic.
- Figure 48: Potential addressable market for CVD graphene in the biosensors market
- Figure 49: Schematic of 2-D materials
- Figure 50: Black phosphorus structure
- Figure 51: Black Phosphorus crystal
- Figure 52: Bottom gated flexible few-layer phosphorene transistors with the hydrophobic dielectric encapsulation
- Figure 53: Graphitic carbon nitride.
- Figure 54: Structural difference between graphene and C2N-h2D crystal: (a) graphene;
- (b) C2N-h2D crystal. Credit: Ulsan National Institute of Science and Technology.
- Figure 55: Schematic of germanene.
- Figure 56: Graphdiyne structure



Figure 57: Schematic of Graphane crystal

Figure 58: Structure of hexagonal boron nitride

Figure 59: BN nanosheet textiles application.

Figure 60: Structure of 2D molybdenum disulfide

Figure 61: SEM image of MoS2

Figure 62: Atomic force microscopy image of a representative MoS2 thin-film transistor.

Figure 63: Schematic of the molybdenum disulfide (MoS2) thin-film sensor with the

deposited molecules that create additional charge

Figure 64: Schematic of a monolayer of rhenium disulfide

Figure 65: Silicene structure

Figure 66: Monolayer silicene on a silver (111) substrate.

Figure 67: Silicene transistor

Figure 68: Crystal structure for stanene.

Figure 69: Atomic structure model for the 2D stanene on Bi2Te3(111).

Figure 70: Schematic of tungsten diselenide.

Figure 71: Schematic of Indium Selenide (InSe).



#### I would like to order

Product name: The Global Market for CVD Graphene

Product link: https://marketpublishers.com/r/GD8500636BBEN.html

Price: US\$ 665.00 (Single User License / Electronic Delivery)

If you want to order Corporate License or Hard Copy, please, contact our Customer

Service:

info@marketpublishers.com

# **Payment**

To pay by Credit Card (Visa, MasterCard, American Express, PayPal), please, click button on product page <a href="https://marketpublishers.com/r/GD8500636BBEN.html">https://marketpublishers.com/r/GD8500636BBEN.html</a>

To pay by Wire Transfer, please, fill in your contact details in the form below:

First name:	
Last name:	
Email:	
Company:	
Address:	
City:	
Zip code:	
Country:	
Tel:	
Fax:	
Your message:	
	**All fields are required
	Custumer signature

Please, note that by ordering from marketpublishers.com you are agreeing to our Terms & Conditions at <a href="https://marketpublishers.com/docs/terms.html">https://marketpublishers.com/docs/terms.html</a>

To place an order via fax simply print this form, fill in the information below and fax the completed form to +44 20 7900 3970