

GRAPHENE | Investing News

Investing in Graphene Companies

Graphene Cost,
Graphene
Properties and
Graphene Market

A collection of articles from Graphene Investing News to help new investors in this market

By Charlotte McLeod



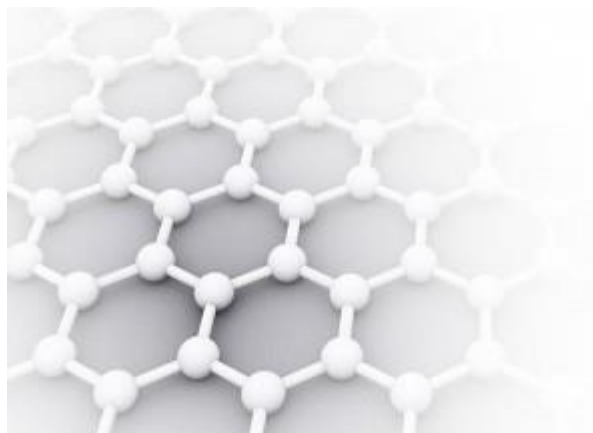
Your trusted source for investing success

Table of Contents

What is Graphene?	2
5 Top Graphene Properties	4
What Factors Impact Graphene Cost?	6
Investing in Graphene Companies	9
Alternate Graphene Companies to Invest In.....	13

What is Graphene?

Widely regarded as the "wonder material" of the 21st century, graphene's beginnings are modest. The 2D material was first produced in 2004, when two professors at the University of Manchester used Scotch tape to peel flakes of graphene off a chunk of [graphite](#).



The material is a crystalline allotrope of carbon, a characteristic it shares with [diamonds](#) and graphite. Put simply, all three are made up of carbon atoms that are bonded together in different ways. For instance, graphite consists of carbon atoms bonded together in sheets of a hexagonal lattice, while graphene is made up of a single sheet of graphite.

Of course, simply knowing about graphene's composition doesn't explain why so many people are excited about it. To give investors a better idea of the promise it holds — in terms of both applications and profit potential — the Investing News Network has put together a brief overview on graphene basics, including production, uses and its future. Together, they are a start to answering the question "what is graphene?"

What is graphene? Graphene production

As mentioned, graphene has a short history and was first produced in 2004 using the Scotch tape method described above. Also known as the micromechanical cleavage technique, the [Graphene Flagship](#), whose mission is to bring graphene out of the lab and into society, [states](#) that advantages to the process are its cheapness and low equipment requirements.

That said, the Scotch tape method cannot be executed at a large scale. As a result, other methods of production have been developed. For instance, graphene can be grown on silicon carbide and other substrates via chemical vapor deposition; in addition, graphene flakes can be created when natural graphite is placed in a solution. Direct chemical synthesis can also be used to make "small graphene structures with well-defined geometries," states the Graphene Flagship.

What is graphene? Graphene applications

The professors who first produced graphene eventually went on to earn a Nobel Prize for their work with the material, and a quick glance at the things graphene is capable of makes it easy to see why.

As [The Guardian explains](#), graphene's impressive list of characteristics includes being a better electricity conductor than [copper](#), impermeable to [gases](#), 200 times stronger than steel — but six times lighter — and “almost perfectly transparent since it only absorbs 2% of light.” Further, “chemical components can be added to its surface to alter its properties.”

Explaining how those properties can be applied, the [University of Manchester states](#) that graphene is making inroads in diverse industries, including transport, medicine, electronics, [energy](#), defense and desalination.

A specific example of how graphene may be used in the future recently came out of the battery space — researchers have discovered that the material may be able to [double the lifespan](#) of [lithium](#)-ion batteries, which have risen to the fore since Tesla Motors' (NASDAQ:[TSLA](#)) announcement that it plans to build a massive lithium-ion battery gigafactory.

What is graphene? Future outlook

While that all sounds pretty positive, graphene by no means comes without drawbacks. One key issue is production costs. As mentioned, there are multiple ways to produce graphene; however, they are not cost effective. Indeed, as Dr. Gordon Chiu of graphene research, development and investment company [Grafoid](#) has emphasized, making graphene is [not yet economically feasible](#).

That issue is tied into another important consideration: applications. While the above information shows that there are many potential applications for graphene, the cost of producing the material means that as yet there are no noteworthy commercial applications for it.

Scientists are of course [looking to change that](#) — the Graphene Flagship is just one group that's working on the issue. Formed in 2013, the organization has a budget of 1 billion euros and hopes to see graphene being used in society in the next decade.

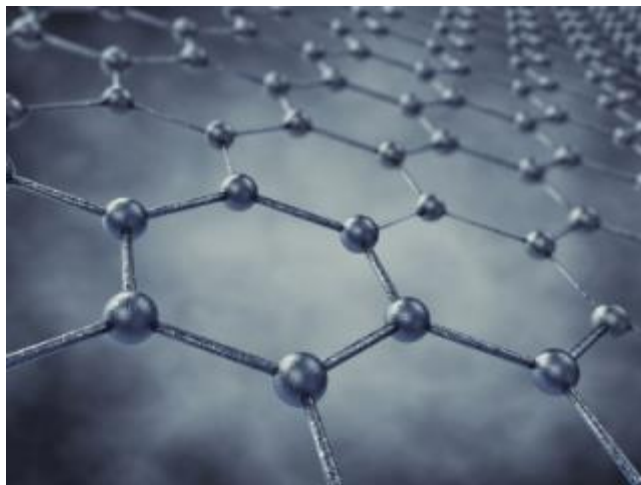
A final issue is that a little graphene goes a long way. That means even if commercial applications for the material are developed, there may still not be significant demand. Stephen Riddle of Asbury Carbons [has predicted](#) that while graphene will be “a raw material of the future,” there will not be much demand for it in the near term.

Despite those drawbacks, many believe prospects for graphene are good. It will certainly be interesting to see what new applications for the material are developed and if ultimately commercial applications are found.

5 Top Graphene Properties

As mentioned, graphene is widely regarded as the “wonder material” of the 21st century, largely because of its many desirable characteristics.

Those characteristics are varied as well as numerous. For instance, graphene is both incredibly strong, as well as light and thin. It's also a good conductor of heat and electricity, and is impermeable.



Here's an overview of those five key graphene properties. While they are by no means the material's only exciting attributes, they are some of the ones that are most commonly referred to, and are a good starting point for investors just learning about the exciting possibilities of graphene.

1. It's strong

Strength is one of graphene's most oft-cited characteristics — and for good reason. Graphene is the strongest material ever discovered, and is not only [200 times stronger than steel](#), but also [stronger than diamond](#).

Outlining its strength in technical terms, [Graphenea states](#) that graphene has an ultimate tensile strength of 130 gigapascals. By comparison, A3 structural steel has an ultimate tensile strength of 400 million pascals, and Aramid (Kevlar) has an ultimate tensile strength of 375.7 million pascals.

Interestingly, despite its strength, graphene can still be both stiff and elastic. Essentially, that means it can be stretched to about 20 to 25 times its original length and still not break.

2. It's thin and light

As noted previously, graphene was originally produced when scientists used Scotch tape to peel flakes of graphene off a chunk of [graphite](#). It should just come as no surprise that the material is very thin. In fact, it's a 2D material, and is only 1 atom thick. To illustrate exactly what that means in real terms, many have used the example that a single sheet of graphene weighing just 1 gram could cover an entire football field.

Graphene is also extremely light. Specifically, it's six times lighter than steel, or, as Graphenea explains, it weighs 0.77 milligrams per square meter — much lighter than a square meter of paper, which is about 1,000 times heavier.

3. It's a good heat conductor

Graphene is not only the strongest material ever discovered, but also better at carrying heat than any other metal. It's even better at conducting heat than [copper](#) and [silver](#), two metals known for doing just that.

4. It can also conduct electricity

In addition to being a superb conductor of heat, graphene is also great at conducting electricity. That's hardly surprising given that heat and electricity conduction go hand in hand — put simply, both processes involve the transportation of energy using electrons.

Graphene's structure is responsible for its ability to conduct electricity well. While graphite consists of carbon atoms bonded together in sheets of a hexagonal lattice, graphene is made up of a single sheet of graphite; the hexagonal lattice offers little resistance to electrons, allowing them to move easily through the material.

What's perhaps more interesting than the fact that graphene can conduct electricity is that it can do so in interesting ways. For instance, electrons move through graphene more quickly than they do in other materials, and are more mobile.

5. It's impermeable

Finally, graphene is impermeable to gases, even very light gases, such as hydrogen and helium. Essentially, the carbon atoms that make up graphene's hexagonal lattice are so closely knit that gases can't get through them.

What Factors Impact Graphene Cost?

Researchers are understandably excited about graphene's many desirable and unique properties, and believe it has the potential to spur advances in a variety of sectors — from transport to medicine to electronics.



However, despite its many exciting applications, graphene is not currently widely used, and its cost is a key reason why. While the price of graphene has come down since 2010, when it reportedly cost [tens of thousands of dollars](#) to make a piece of graphene the size of a postage stamp, it remains expensive, and specific pricing data is hard to come by.

With that in mind, here's a look at how graphene is made, and why the production process plays such a key role in graphene cost.

Origins of graphene

Graphene's origin story is by now well known. The 2D material was first produced in 2004, when two professors at the University of Manchester used Scotch tape to peel flakes of it off a chunk of [graphite](#).

The story gives the impression that it's easy to make graphene, but that's not entirely true. While it is simple to make a small amount of the material — anyone with some Scotch tape and a piece of graphite can do it — it's not easy to make a lot of graphene.

An [article](#) published by The Atlantic sums up the situation well: by using the Scotch tape method it's possible to produce a very small amount of graphene; however, the material's myriad applications "require more than a tiny flake of graphene, and scaling up production requires something other than a really big piece of scotch tape."

Making graphene

The Scotch tape method of making graphene is known as exfoliation, and there are other ways to create graphene via exfoliation as well. For instance, a diamond wedge can be used to cleave layers from graphene.

But what are some other ways of making graphene? Currently the most popular method is chemical vapor deposition (CVD). As The Atlantic explains, the process involves a mix of gases reacting with a surface to create a graphene layer. The process creates high-quality graphene, but the graphene is often damaged when it comes time to detach it from its substrate.

Looking at the process in greater depth, [Graphenea states](#) that another problem with CVD is that it's difficult to create a totally uniform layer of graphene on a substrate.

Graphenea also notes that much work is being put into reducing problems with CVD. For example, scientists are experimenting with treating the substrate before the reaction to create graphene takes place. Even so, it's expected that such adjustments will take a long time to be realized.

The Graphene Flagship identifies [a number of other ways](#) of making graphene as well, including direct chemical synthesis; the material can also be made by putting natural graphite in a solution.

Graphene cost factors

Getting an understanding of how graphene is produced is crucial to understanding graphene cost. That's because the way in which graphene is produced relates to how much it ultimately costs.

As Graphenea explains in [another article](#), graphene cost is linked to graphene quality. As an example, it points to graphene oxide, which is inexpensive. While it can be used for advanced composite and biotechnology applications, it can't be used in batteries, flexible touch screens and "other advanced opto-electronic applications."

In contrast, CVD graphene, which the publication says "offers sufficient quality for almost any graphene application," is priced based on production volume and the cost of transferring the graphene from the substrate on which it is grown. Essentially what that means is that buying high-quality graphene in large volumes is cheaper than buying a small quantity of it.

The issue there, of course, is that with no commercial applications for graphene yet available, few are looking to buy the material in large quantities. As a result, graphene is for the most part not cheap to buy.

The future

Those involved in the graphene space hope that ultimately commercial applications for the material will be developed, spurring advances that will make mass production of the material a reality.

Investing in Graphene Companies

It's clear that graphene's benefits won't be fully reaped until commercial applications for it exist, and it is being produced on a large scale. Nevertheless, many people are interested in investing in graphene companies.

However, with the industry still in its infancy, investing in graphene companies can be a risky endeavor. After all, who's to say which companies will go on to be successful and which will fall by the wayside?



The so-called “wonder material’s” exciting characteristics don’t help matters. As mentioned, graphene has the potential to spur advances in a variety of sectors — from transport to medicine to electronics — and as a result it’s easy for companies to exaggerate their activities. Indeed, the UK’s Financial Conduct Authority has warned in the past of [scams concerning graphene](#).

Finally, investing in graphene companies can be tough simply because so many that are focused on the material are private. While such companies may ultimately become public via an IPO or other means, there’s no guarantee of that happening.

With that in mind, here’s a look at some of the publicly traded graphene companies currently on the market, plus a few private graphene companies where it’s possible for investors to gain a toehold. For investors looking to get in on the excitement surrounding graphene, they may be good options.

Applied Graphene Materials (LSE:AGM)

Applied Graphene Materials has developed a proprietary “bottom up” process for producing high-specification graphene. The company’s belief is that graphene’s value “lies in its ability to transfer its intrinsic properties into other materials” — in other words, it’s interested in the graphene’s potential to enhance the characteristics of other materials.

The company offers [graphene powder](#), and is also able to [disperse graphene powder](#) across a range of matrixes.

China Carbon Graphite Group (OTCMKTS:CHGI)

Headquartered in Shanghai, China Carbon Graphite Group manufactures and distributes [graphite](#) products and graphene-related products through its subsidiary, Royal Elite New Energy Science & Technology (Shanghai).

[Among other products](#), the company sells graphite electrodes, graphite bipolar plates and graphite oxide. In terms of graphene, it's able to produce high-quality, stable graphene oxide dispersion that can be stored for several months.

Grafoid

As mentioned, many companies focused on graphene are private, and Grafoid is one of them. However, [Focus Graphite's](#) (TSXV:[FMS](#)) close relationship with Grafoid — it's the company's largest single shareholder at 7.8 million shares — means that Focus investors have exposure to Grafoid. The company may thus be one for graphene-focused investors to consider.

Grafoid is a graphene research, development and investment company that invests in, manages and develops markets for processes that produce economically scalable graphene for the use of corporations and institutions.

Its key product is its high-purity, economically scalable MesoGraf™ graphene, which is created via a unique proprietary process. The company prides itself on this process, which it says is much more environmentally friendly than current methods for producing graphene. Grafoid's hope is that MesoGraf™ may eventually eliminate current graphene cost issues.

Graphene 3D Lab (TSXV:GGG)

Graphene 3D Lab is focused on developing and commercializing [technologies](#) that improve the capabilities of 3D printing. To that end, it's created a product called Conductive Graphene Filament; it's sold at the company's [online store](#), and gives users the ability to 3D print circuitry and sensors for electronic applications.

Long term, Graphene 3D Lab plans to offer next-generation functional materials for 3D printing, thereby “enabling the printing of entire operational devices in a one-step, fully-computerized process.” Ultimately it hopes to see 3D printing move from being a niche technology to being key to the manufacturing process.

Graphite exploration company [Lomiko Metals](#) (TSXV:[LMR](#)) holds 10.43 percent of Graphene 3D Lab, as well as 40 percent of Graphene Energy Storage Devices and 100 percent of Lomiko Technologies, two other private companies focused on graphene.

Group NanoXplore

Group NanoXplore is another private graphene company; however, investors can get exposure to it via Mason Graphite (TSXV:[LLG](#)), which founded the company in 2014 and has a 40-percent stake in it. In fact, a [recent Nanalyze article](#) describes the relationship as similar to that of Lomiko and Graphene 3D Lab.

On its website, NanoXplore highlights the quality of its graphene, noting that it's able to produce high volumes of the material at affordable prices due to its "unique production process." That process is reportedly "environmentally friendly and compatible with a wide range of manufacturing processes and government regulations." All in all, the company offers [different products](#) divided into four family groups.

The Nanalyze article states that ultimately the company's goal may be to develop spin offs to develop products using its graphene.

Haydale Graphene Industries (LSE:HAYD)

Haydale Graphene Industries is the holding company for both Haydale and Haydale Composite Solutions. The former has developed a [patent-pending proprietary scalable plasma process](#) that's aimed at functionalizing graphene and other nanomaterials. Using the technology, Haydale is able to supply tailored solutions to both raw material suppliers and product manufacturers.

Meanwhile, the latter is focused on the design, development and commercialization of advanced polymer composite materials. Haydale Composite Solutions takes care of the entire development cycle, from applied research to setting up manufacturing plants.

XG Sciences

Privately owned XG Sciences manufactures and sells xGnP® Graphene Nanoplatelets, which it says "feature the beneficial properties of graphite or graphene ... as well as those derived from its unique size and shape." As a result, the nanoplatelets are the ideal for a number of applications, including printed electronics. [Here's an overview](#) of the company's product offerings.

POSCO (NYSE:[PKX](#)), a multinational steelmaker based in South Korea, holds a 20-percent stake in XG Sciences, and thus offers a way for interested investors to get a foot in the door at the company.

Private graphene companies

The graphene stocks listed above are by no means the only graphene-focused companies out there, especially in terms of the private space. Investors interested in keeping an eye on those that are privately owned may want to consider: 2D Carbon Tech, ACS Material, Advanced Graphene Products, Anderlab Materials, Grafoid, Graphene Platform and Graphenea.

Alternate Graphene Companies to Invest In

As can be seen, it's tough to find graphene companies to invest in. Very few pure-play graphene stocks exist in general, and even fewer are public.

Given those factors, some graphene-focused investors have turned to companies that have a partial focus on graphene. For the most part those are [graphite](#) companies that are looking into whether the material they have in the ground is suitable for graphene production, but there are some non-graphite companies also making forays into graphene as well.



Below is an overview of some companies that are not fully focused on graphene, but have expressed an interest in the material. For investors looking for graphene companies to invest in, they may be worth keeping an eye on.

Graphite companies with a graphene component

Alabama Graphite (TSXV:[ALP](#)) — Alabama Graphite made headlines early in 2015, when it [announced the discovery](#) of “naturally occurring flake graphene” at its Coosa project in Alabama. No other company has ever claimed to have found natural graphene.

As yet, not much more information about the discovery has been released, though Alabama Graphite did [say a couple of months later](#) that it had found “additional types of naturally occurring graphene-based derivatives called few-layer graphene (2-5 layers), multi-layer graphene (2-10 layers), and graphite nanoplates (less than 100 nm thick)” at Coosa.

Bora Bora Resources (ASX:[BBR](#)) — Sydney-based Bora Bora Resources holds a suite of graphite projects in Sri Lanka, and also has a binding heads of agreement with privately owned RS Mines.

Privately owned RS Mines sells mainly graphite products in its [online store](#), but also stocks graphene oxide paste. The company creates those products using crystalline vein graphite from its Sri Lanka-based Queens mine. The binding heads of agreement allows Bora Bora to earn into the Queens mine, which is adjacent to its Matale/Kurunegala graphite project.

Elcora Resources (TSXV:[ERA](#)) — Elcora has full operational control and a 40-percent equity interest in Sakura Graphite, which operates the Sri Lanka-based Ragedara mine. According to the company, the mine is currently operating at about 1,000 tonnes per year.

In terms of graphene, the company has plans for a graphene laboratory. Among other things, it hopes to use the facility to identify which known techniques for producing graphene from graphite will best suit its clients. Elcora also hopes to ultimately construct a graphene manufacturing facility.

Energizer Resources (TSX:[EGZ](#)) — Energizer is focused on its Madagascar-based Molo project, which it [released a feasibility study](#) for earlier this year. In July, the company [announced](#) that Haydale Graphene Industries (LSE:[HAYD](#)) has verified that graphite from Molo has passed initial testing to be viable source of graphene nanoplatelets.

Saint Jean Carbon (TSXV:[SJJ](#)) — Saint Jean Carbon owns various graphite properties in Quebec, including the past-producing Walker property, as well as the Wallingford, St. Jovite, East Miller and Clot properties.

In April 2015, Saint Jean [signed a letter of intent](#) (LOI) with Spain's Graphenea, a leading graphene company. Under the LOI, Saint Jean agreed to "act as the distributor of a wide range of graphene products marketed to customers across the Canadian market." Since then, Saint Jean has delved further into the graphene space, most recently [filing its first primary patent](#); it involves the production of graphene without the use of harsh chemicals.

Talga Resources (ASX:[TLG](#)) — Talga has five graphite projects in Sweden, and preliminary economic assessments have started on the two most advanced. Ultimately, the company's plan is to produce graphene from those projects using its "unique, simple and cost-effective process."

Talga said in its [Q3 quarterly activities review](#) that trial mining is taking place at its Vittangi project, adding that graphene and nano/micro graphite samples have been produced for commercial evaluation. More recently, the company [joined the Graphene Flagship](#) via its subsidiary, Talga Advanced Materials. The Graphene Flagship has a budget of 1 billion euros, and is the largest graphene research platform in the world.

Triton Minerals (ASX:[TON](#)) — Triton holds a majority interest in Grafex, which holds eight exploration licenses in Mozambique. Together, those licenses make up three projects: Balama North, Balama South and Ancuabe. All are highly prospective for graphite, and Triton's hope is to establish graphite from the projects as an industry benchmark.

The company [recently announced](#) that graphene oxide was successfully produced using graphite from its projects.

Zenyatta Ventures (TSXV:[ZEN](#)) — Zenyatta is currently developing its Ontario-based Albany hydrothermal graphite deposit. It believes the deposit has the potential to produce high-purity graphite “that may compete in high-technology markets traditionally reserved for synthetic graphite.”

In terms of graphene, the company [announced earlier this year](#) that testing completed at Israel's Ben-Gurion University of the Negev shows that Albany graphite could be used in graphene products.

Large companies with a graphene component

As stated, it's not only graphite companies that are dipping their toes into the graphene space. On the other end of the spectrum, some very large companies are looking at entering the market. Investors keen to find graphene companies to invest in may want to keep an eye on that type of company as well.

In brief, here's a selection of big companies that are reportedly working with graphene: BASF (OTCMKTS:[BASFY](#)), Cabot (NYSE:[CBT](#)), IBM (NYSE:[IBM](#)), Nokia (NYSE:[NOK](#)), Samsung Electronics (OTCMKTS:[SSNLF](#)), Sony (NYSE:[SNE](#)) and Toyota (NYSE:[TM](#)).