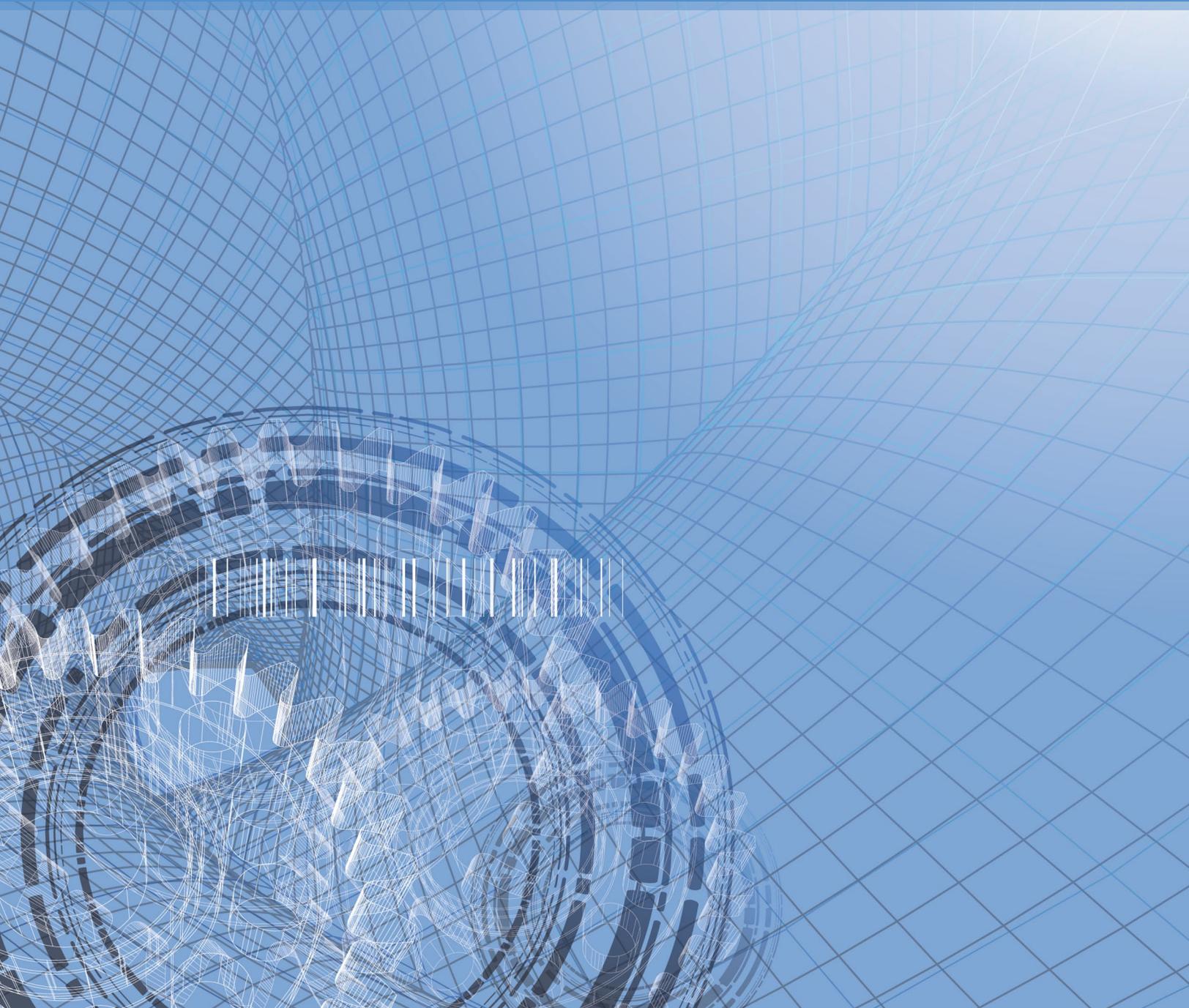


Advanced Materials: Creating Chemistry between Innovators and Investors



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Introduction

At Cleantech Group, we think Advanced Materials might be the dark horse of the cleantech sector. While it hasn't generated the same headline successes (or failures) as industries like solar, electric vehicles, or energy storage over the past few years, this sector has captured a relatively consistent stream of investments, representing about 10-20 deals per quarter for over five years straight. On the other hand, M&A activity has been low besides a handful of high-profile, large dollar value deals. In addition, IPOs have largely been limited to somewhat small, predominantly Chinese offerings.



Despite the lack of headlines, we believe this sector will continue to be a critical lynchpin of the broader cleantech industry because it represents the enabling technologies that define the performance characteristics of those headline-grabbing subsectors. Advances in technologies from graphene to composites to bio-based materials will offer a cornucopia of innovation opportunities as they become better understood by the market.

Phoenix Venture Partners, a leading venture capital group focused on advanced materials, describes this sector eloquently:

“Advanced materials is unlike other traditional venture capital sectors, which are dedicated to fully integrated end product manufacturing, distribution, and marketing in addition to technology development. Advanced materials are enabling and tend to have diverse applications across multiple industries: enabling new products, enhanced performance of existing products, and superior manufacturing process improvements.”

Companies in this sector are not only creating more durable and efficient derivatives of existing materials and designing novel materials from the ground up, but are also developing new materials discovery platforms and manufacturing processes. These materials and processes enable some of the most promising growth sectors – including water, agriculture, oil & gas, solar, aerospace, and others – while avoiding controversial connotations with cleantech and some of the risky projects undertaken by these industries. If Advanced Materials can continue to meet converging technological and financial demands, this sector can become a major financial opportunity for entrepreneurs and investors alike. Jordi Lopez Launes, Investment Manager for Solvay and Aster, thinks that “Advanced Materials is the driver of most of the cleantech sectors, pervading the majority of challenges that cleantech wants to address.”

▶ Insight from the Market

Similar to other subsectors of the cleantech ecosystem, navigating the Advanced Materials landscape requires both a technical understanding of material properties and applications, as well as a business perspective that appreciates the human and financial aspects of materials discovery and commercialization.

In speaking with VCs, corporate investors, and entrepreneurs, we heard several recurring themes regarding the Advanced Materials discovery and investment landscape:

Insight: Application discovery is a scientific process, but enabled by personal relationships

No matter how interesting a novel material is in the lab, it can't provide a growth platform for an entrepreneurial or established company unless it has both a clear application and a customer base behind that application. The hundreds of thousands of different materials and manufacturing processes used in today's global economy are already optimized to known technological and financial constraints, meaning it's no easy feat to find the key application that a new material can feasibly disrupt.

In addition to the standard scientific publications and marketing channels, materials developers must act just like entrepreneurs in any other sector: they need to hit the road, make connections, and listen to the needs of a diverse set of industry players. At Cleantech Group's recent Power Breakfast event on Advanced Materials, Wayne Dickinson of **Graphene Technologies** recounted a serendipitous connection with a contact at an oil & gas major – a connection that led to a partnership using the company's graphene product for biofuels production. Personal connections and relationships are critical in learning about and understanding the technical needs of potential customers, and educating those prospective customers whose day-to-day operational functions may limit the resources they can devote to regularly surveying the market for materials innovations.

Insight: VCs and corporates approach Advanced Materials with differing investment hypotheses

VC firms and corporates alike are looking for attractive deals in the Advanced Materials space. On the VC front, some firms such as **Phoenix Venture Partners** are exclusively focused on the sector, whereas others such as **Kleiner Perkins Caufield & Byers (KPCB)** invest in advanced materials as part of a broader innovation-oriented strategy. A number of corporates in the chemicals and materials space themselves, such as **Dow Chemical** and **BASF**, have set up their own venture funds to identify and profit from innovative entrepreneurs. **Solvay** has a multifaceted model where it has its own venture fund as well as LP or contribution investments in **Conduit**, **Pangaea**, **Phoenix Venture Partners**, and **Aster**.

Despite the common interest, VCs' and corporates' investment theses largely differ along an "outsiders" vs. "insiders" mentality. While VCs seek disruptive technologies that can upend entire industries, corporates inherently need to protect their own interests, and lean toward

incremental innovations that augment their core capabilities. The two groups do however agree on the difficulty of adapting entire supply chains to create or utilize new materials, as well as the challenges of the application discovery process in the first place. Entrepreneurs that address these challenges early on have the opportunity to attract a wider range of prospective investors.

Insight: Corporate partnerships are critical, but delicate

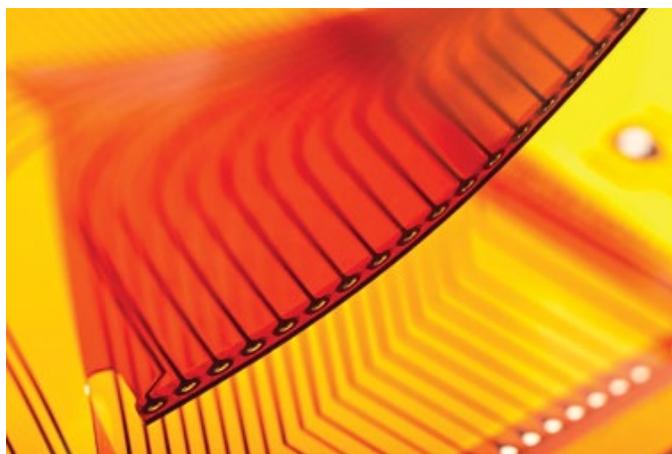
Corporate partnerships can provide Advanced Materials startups with support from business units, as well as access to customers, pilot opportunities, and market insights. From a VC perspective, a startup's corporate partnership may be a proxy for technological feasibility as well as financial stability. However, partnerships can also limit materials startups, locking them in exclusivity agreements that become acquisitions in disguise. Similarly, corporate board seats can ensure accountability for a startup's success, but may scare away potentially competitive corporate partners.

While these issues may arise in other sectors as well, the materials sector is particularly sensitive to commoditization and sits upstream from most of industry, with corporates preferring to offer more differentiated specialty products rather than invest in technologies that simply lower input costs across the industry. Though materials startups typically seek exits via acquisition anyway, corporate partnerships require them to find a delicate balance between getting a good deal and still retaining a range of channels to the market.

Investment Trends

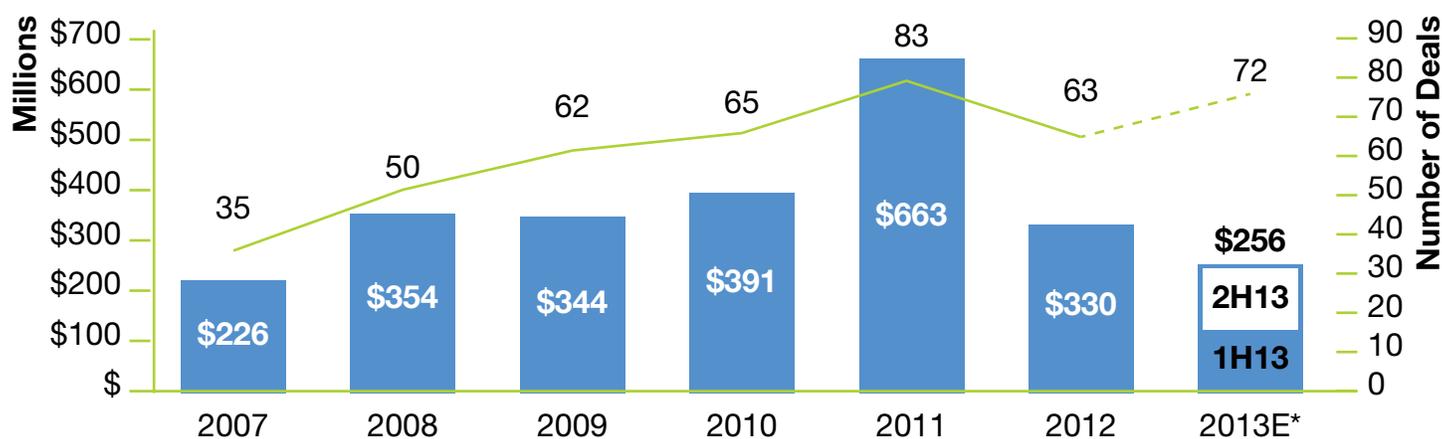
Advanced Materials companies have attracted \$4.9 billion in investment over the past 11 years, \$3.5 billion of which came from venture capital investments. For the past five years the sector has consistently attracted around five percent of total cleantech venture capital. Compared to other cleantech sectors, Advanced Materials attracts a wider range of funding types, from government grants to corporate investments. Venture groups focused on spinning out university research are also popular in this area, with the IP Group and Imperial Innovations particularly active in this type of funding.

Venture investment in Advanced Materials increased steadily in both deal count and dollars invested in the 2007-2011 time period. However, investment fell off in 2012, a trend that continued through 1H13. The deal count generally declined from 1Q11 through 1Q13, but jumped up again in 2Q13. Much of the decline in dollars invested is due to a



decrease in the number of early stage deals in the sector over the past few years. This is where government grants come in, providing much needed money to early stage companies that have not yet proved their promising technologies. The number of grants to Advanced Materials companies increased between 2011 and 2012 and looks to increase further in 2013.

► Global VC Investment in Advanced Materials



*2H13 Data Estimated

Source: Cleantech Group's i3 Platform

In the past few years there have been a number of medium-sized VC funding rounds for Advanced Materials companies. In particular, a number of investments targeted companies expanding operations into new geographies. **Beneq**, a Finnish developer of spray nanotechnology used to add solar control properties to soda-lime-silica-glass, received EUR 25 million (~\$32.8 million) in Growth Equity from **RUSNANO** to set up a facility in Russia. Likewise, **Polyera**, a US-based supplier of functional materials for the printed and flexible electronics industries, received \$24.5 million from **Chengwei Capital**, **Solvay Ventures** and **Tsing Capital** to invest in Asia operations.

Advanced Materials exits have been somewhat scarce, save for a handful of large dollar value acquisitions and a few Chinese IPOs. **Solutia**, a US-based producer of plastic performance materials for the solar industry, was acquired for \$4.7 billion in 2012 by **Eastman Chemical Company**. **Danisco**, a Danish producer of specialty food ingredients and catalysts, was acquired by **DuPont** for \$6.3 billion in 2011. **Martek Biosciences**, a US-based developer of nutritional products, fermentation technology and products derived from microalgae, was acquired for \$1.1 billion by Netherlands-based **DSM** in 2010. **Ceradyne**, a US-based producer of advanced technical ceramics for automotive, oil & gas, nuclear, solar, electronics and defense, was acquired for \$860 million by **3M** in 2012. Other corporates that have made acquisitions in this space include **BASF**, **Applied Materials**, **GT Advanced Technologies**, **Autodesk**, and **Air Liquide**.

Leading Innovators

Advanced Materials startups are creating some of the most exciting breakthroughs in cleantech, and investors are helping to guide the most promising innovations to maturity. To offer a glimpse into this dynamic market, we highlight a few entrepreneurial companies that we believe are leaders in the space.



Founded: 2010
Location: Sweden

Chromaforma has developed an efficient and environmentally benign process that simplifies the phosphine separation process and streamlines production processes where phosphine is used, reducing energy and solvent consumption as well as waste. The company targets pharmaceuticals and other companies within the fine chemical industry. Chromaforma is also developing a new application based on this technology to selectively separate heavy metals from water. Initial trials have been successful, and the company is partnering with industry to set up field trials in 2014.



Founded: 2004
Location: Waltham, MA

Novomer produces polymers by recycling pollutants. Its catalyst technologies transform carbon dioxide (CO₂) into novel materials that contain up to 50 percent CO₂ by mass, and have a wide range of applications for other chemical processes. These materials are targeted at the packaging, automotive, construction, home products, and electronics industries. Novomer is currently developing partnerships with global corporations.



Founded: 2006
Location: Finland

Beneq is a leading supplier of production and research equipment for thin film coatings, and is also the world's premier manufacturer of thin film electroluminescent (TFEL) displays. Beneq thin film equipment is used for coatings in solar photovoltaics, flexible electronics and other emerging thin film applications. Beneq has introduced several revolutionary innovations, including roll-to-roll atomic layer deposition (ALD) and high-yield aerosol coating. In addition to process equipment, Beneq also offers thin film coating services.

▶ Leading Investors

Advanced Materials is a sector that attracts a particularly high percentage of its overall funding from government grants, often because it requires capital-intensive basic research long before a profitable business model can even be considered. In particular, the **US Department of Energy**, the **Swedish Energy Agency**, and the **US National Science Foundation** have each made a number of grants to companies in this area. Top cleantech venture capital firms also have an interest in this area, with **Phoenix Venture Partners**, **ARCH Venture Partners**, **IP Group**, **Braemar Energy Ventures**, and **Chrysalix Energy Venture Capital** each holding a handful of Advanced Materials companies in their portfolios. In addition, more generalist investors, namely **Kleiner Perkins Caufield & Byers**, **Khosla Ventures**, **Draper Fisher Jurvetson**, and **Emerald Technology Ventures** have all made investments in this area.

▶ Government Agencies

The **US Department of Energy** and **ARPA-E** provide support for Advanced Materials companies through a number of programs, including the Clean Energy Manufacturing Initiative, SunShot Initiative, and initiatives and funding pools for bio-based products, advanced materials for vehicles, and many others. Companies that have received grants from the DOE and ARPA-E include:

- **Novomer**, a Massachusetts-based producer of polymers made from carbon dioxide and other renewable materials
- **Enki Technologies**, a California-based developer of anti-reflective and anti-soiling coatings that improve PV module efficiencies
- **Bandgap Engineering**, a Massachusetts-based developer of a method for nano-structuring silicon for solar PV and lithium-ion battery applications
- **Vorbeck Materials**, a Maryland-based developer of applications using patented graphene material

The **US National Science Foundation** provides over 11,000 grants annually across all fields of science and engineering and allots discrete sets of funds for energy-related projects and companies. The most common grant received by cleantech companies has been the Small Business Innovation Research award, which provides funding for small businesses to engage in R&D. Companies that have received grants from the National Science Foundation include:

- **Orthogonal**, a New York-based developer of photolithography chemicals compatible with organic flexible electronic components
- **nanoLambda**, a Pennsylvania-based producer of plasmonic nano-optic-based sensor devices

The **Swedish Energy Agency** provides support for R&D in the areas of supply, conversion, distribution and use of energy. The agency provides grants and support for the development of new technologies as well as commercialization. Companies that have received grants from Swedish Energy Agency include:

- **Graphenic**, a Swedish developer of graphene
- **Svenska Aerogel**, a Swedish provider of recyclable materials based on aerogel material

The **New York State Energy Research and Development Authority (NYSERDA)** aims to reduce energy consumption, promote renewable energy and protect the environment. Recent funding has supported developments in energy storage, solar, smart grid and EV charging. Grant recipients include:

- **Automated Dynamics**, a New York-based manufacturer of advanced composite structures and high performance composite processing equipment
- **Ecovative Design**, a New York-based developer of plant-based packaging technologies

Venture Capital

IP Group is a UK-based investment group that develops technologies from its partner universities. In addition to venture capital, the firm provides support for commercialization and business development. IP Group focuses on energy, medical equipment, biotech, IT, chemicals, and materials. IP Group floats on the AIM. Portfolio companies include:

- **Nano-porous Solutions**, a UK-based developer of multi-layer absorbent hollow fiber material used in separations and filtration processes
- **Chamelic**, a UK-based developer of surface coatings that repel dust from solar arrays

Phoenix Venture Partners is a California-based VC firm with offices in Massachusetts and Singapore. The firm invests in advanced materials companies and provides access to strategic relationships with manufacturers. Portfolio companies include:

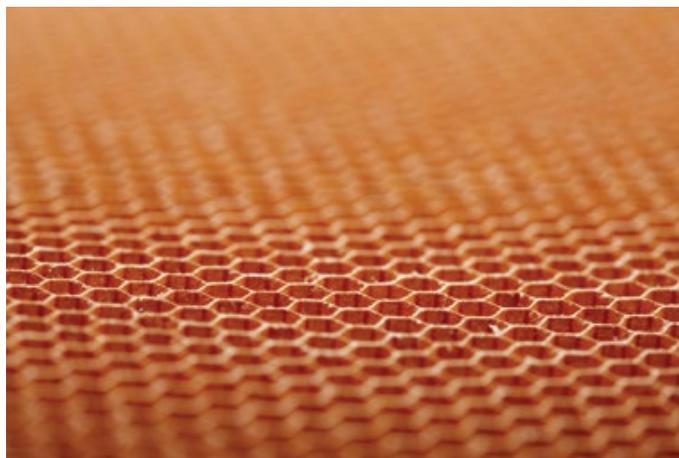
- **Autonomic Materials**, an Illinois-based manufacturer of self-healing polymeric systems
- **C3Nano**, a California-based developer of nanomaterials-based transparent conductive film for consumer electronic devices and solar applications

ARCH Venture Partners is a Chicago-based venture capital firm with offices in Austin, Seattle, San Francisco, and Europe. The firm invests in seed and early stage companies in life sciences, physical sciences and IT. ARCH has \$1.5 billion under management. Portfolio companies include:

- **Cambrios Technologies**, a California-based developer of nanotechnology solutions for commercial electronic devices with transparent conductors
- **Shocking Technologies**, a California-based developer of voltage switchable dielectric materials

Braemar Energy Ventures is a New York-based venture capital firm focusing on both traditional and alternative energy. The firm invests in early and late stage companies and often partners with other VC firms and strategic investors. Portfolio companies include:

- **Bioformix**, an Ohio-based developer of adhesives and plastic alternatives such as monomers, resins and polymers
- **MC10**, a Massachusetts-based developer of technology that transforms rigid high performance electronics into malleable systems



Chrysalix Energy Venture Capital is a Vancouver-based VC firm focused on energy technologies including energy generation, transmission control and storage, energy use and resource management. The firm also has partner firms based in Europe and Asia. Portfolio companies include:

- **Nanosteel**, a Rhode Island-based developer of nano-structured, iron-based steel alloys for the oil & gas, mining and power industries
- **GaN Systems**, a Canadian developer of gallium nitride (GaN) technologies for power conversion applications

▶ Corporate Venture Groups

BASF is a German chemical company with a venture arm that has offices in Germany, the US, and Asia. **BASF Venture Capital** invests in companies that align with the strategic interests of the BASF Group. The firm often invests in early stages and coordinates with other venture firms. Portfolio companies also receive research and commercialization support and include:

- **Solidia Technologies**, a New Jersey-based developer of sustainable building materials that use waste materials and consume carbon dioxide
- **Allylix**, a California-based developer of a process for sustainably producing terpenes for the flavor, fragrance, foods, pharmaceutical and agricultural markets

Dow is a US chemical company with a venture arm, Dow Venture Capital. Dow Venture Capital invests in companies that fit with the corporate group's strategic aims and include companies in the water, renewable energy generation, energy conservation and agriculture sectors. Dow Venture Capital offers equity capital as well as support for R&D, relationships and commercialization. Portfolio companies include:

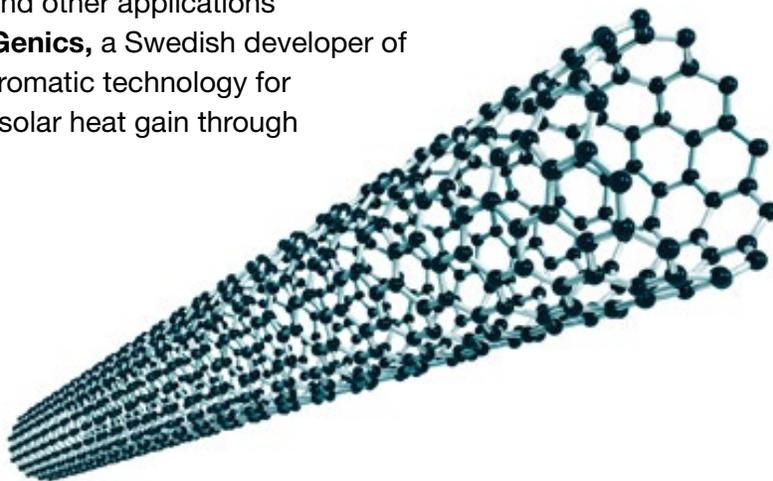
- **Blade Dynamics**, a UK-based developer of wind turbine technology including coatings for rotors and blades
- **ZBD Displays**, a UK-based developer of materials for graphic e-paper displays for retailers to display

Solvay is a Belgian chemical company with a venture capital arm, **Solvay Ventures**, but also sponsors **Aster Capital** along with **Alstom** and **Schneider Electric**. Solvay Ventures focuses on printable organic electronics, sustainable energy, nanotechnology and renewable chemistry. Aster focuses on energy, mobility, resource management and energy efficiency. Solvay, through its venture arm or through Aster, has invested in:

- **Polyera**, an Illinois-based developer of functional materials for printed and flexible electronics, including solar cells
- **FiberRio Technology**, a Texas-based producer of manufacturing equipment technology for nanofiber and other nanomaterials

DuPont is a US chemical company with its own venture arm, DuPont Ventures. DuPont Ventures invests in advanced materials, agriculture, cleantech, construction, nutrition and transportation technologies. Portfolio companies receive support with testing, commercialization, relationships and marketing and include:

- **Nanocomp Technologies**, a New Hampshire-based manufacturer of carbon nanotube-based sheets, tapes, wires and slurries for lightweight armor, batteries, transportation, thermal management devices and other applications
- **ChromoGenics**, a Swedish developer of electrochromatic technology for reducing solar heat gain through windows

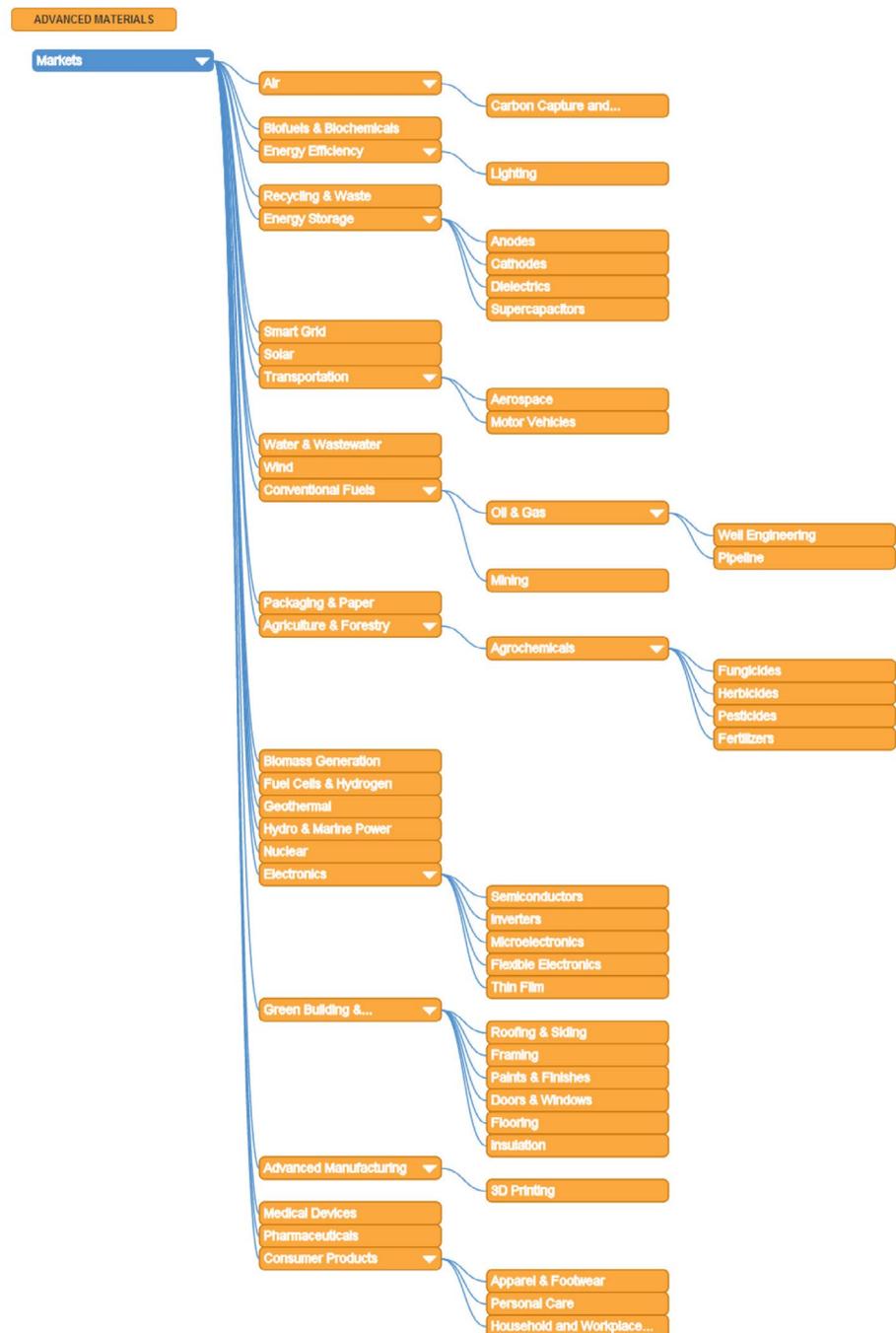


Advanced Materials Taxonomy

These investors and portfolio companies represent a fraction of the hundreds of companies in this corner of the cleantech ecosystem. To make sense of this landscape, our Advanced Materials taxonomy looks at the sector through the prisms of Technology, Applications, Markets and Services. Examples of tags in the Technology prism include Polymers, Metals and Alloys, Ceramics and Nanomaterials. Applications indexed include Coatings, Lubricants, Adhesives and Textiles. Markets include Electronics, Solar, Conventional Fuels, and Consumer Products.

This taxonomy allows users to approach the sector from a variety of perspectives in order to explore the different technologies and markets, as well as discover new companies within areas of interest. Based on feedback from a number of stakeholders in the Advanced Materials innovation ecosystem, this taxonomy will enable VCs, corporates, government agencies, entrepreneurs, and others to evaluate the market with a tool that marries an engineer's materials taxonomy with an investor's market value chain.

A snapshot of the Markets prism is shown here. To see the full Technologies, Services and Applications prisms, as well as the rest of the Cleantech Group's proprietary taxonomy of all eighteen primary cleantech sectors, please click here:



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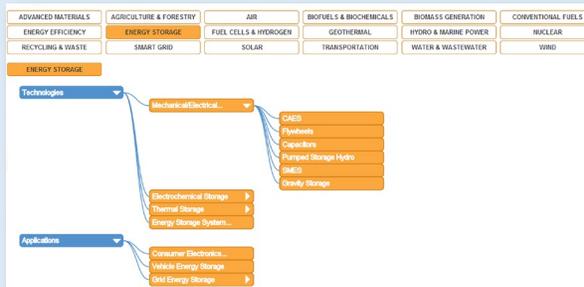
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