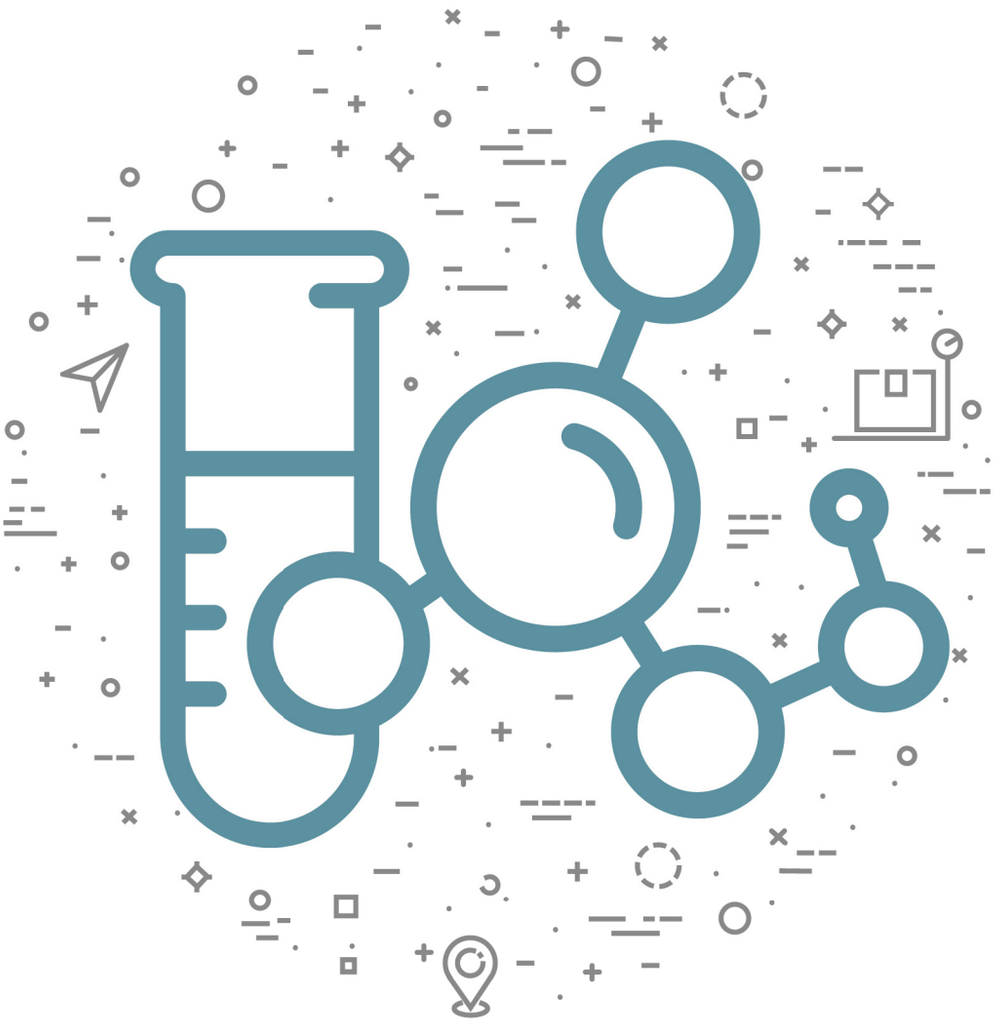
INVEST KOREA

INVESTMENT
OPPORTUNITIES
IN KOREA

Fine chemicals



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* Figures on the report show the likely adjustment of average yearly currency rates from Korean Won (KRW) to the US dollar (USD). A rate adjustment is adopted particularly reflecting the recent average market variations to eliminate the valuation effects arising from movements in exchange rates in case when the data expressed shows an annual growth rate on the paper.
* Rate adjusted figures are rounded off, but the sum is correct down or up to the decimal when the rounded values are not equal to the adjustment.

1 Industry Trends

Definition and Classification

■ The fine chemical industry is a processed and intermediate materials industry that takes the basic chemical products produced in the petrochemical industry and supplies raw and subsidiary materials to upstream industries such as automobile, ship, electronic, textile, construction, and medical device.

- Raw and subsidiary materials include pharmaceuticals, dyes, pigments, paint, ink, cosmetics, perfumes, surfactants, adhesives, and inorganic compounds for film and photography, pesticides, etc.
- Other advanced materials include displays, semiconductors, and renewable battery materials. In particular, this document discusses advanced materials, focusing on functional coating or film, renewable batteries, carbon nanomaterials, and engineering plastic.

■ Functional coating or film

- (Definition) Functional coating is the process of changing the properties of a gas layer on a substrate surface using a solution or gaseous substance with a specific function.
  - The broad definition of functional coating includes paint and devices for coating, processes, and final coated membranes.
- (Classification) The scope of functional coating is divided, according to the materials and methods used, into seven categories, which are nanocoating, powder coating, dry coating, UV cure coating, automotive film, display film, and polyimide film.

■ Renewable batteries

- (Definition) A renewable battery can be reused by charging and discharging, and it converts electrical energy into chemical energy for storage.
- (Scope) The scope of the renewable battery industry includes lithium-ion batteries used for compact IT devices, electric vehicles (EV), and energy storage systems (ESS).
  - Recent increases in the demand for EVs and e-mobility are leading the growth of the lithium-ion battery industry and, in general, the renewable battery industry.
  - A renewable battery's four core materials, which are a cathode material, anode material, electrolyte, and separator, have significant influences on battery characteristics. Furthermore, this document describes the industries related to the core materials used in renewable batteries.

■ Nanocarbon material

- (Definition) The nanocarbon material industry produces carbon-containing nano-fusion products.
- (Classification) Nanocarbon materials are classified according to product type: carbon nanoparticles, carbon nanowires, and carbon nanoplatelets.[1)]
  - Carbon nanoparticle products include carbon black, carbon balls, and activated carbon.

1) Classified by the classification system of nano convergence industry in the Nano Convergence Industry Survey annually published by the Ministry of Trade, Industry and Energy

- Carbon nanowire products include carbon nanotubes, carbon nanofibers, graphite nanofibers, and carbon nanohorns.
- Carbon nanoplatelet materials include graphene and exfoliated graphite nanoplatelets.

■ Engineering plastic (EP) materials

• (Definition) EP materials are produced from improved general-purpose plastic materials and can be used in various fields.
  - With improved impact resistance, abrasion resistance, low-temperature resistance, chemical resistance, and electrical insulation, EP materials are used in household goods, electrical and electronic products, as well as automobile and aircraft structural materials.

• (Classification) According to usage and type, EP materials are classified into general-purpose EP and super EP.
  - General-purpose EP bears a heat resistance temperature of 100°C or higher. Meanwhile, super EP can be used at an even higher temperature of 150°C or higher.
  - A total of 2,550,000 t of plastic products are used worldwide. Out of these plastic products, general-purpose EP accounts for approximately 10% (250,000 t) and super EP accounts for approximately 1% (10,000 t) of them.[2)]
  - Regarding the proportion of EP by product, 44.0% of EP products are polycarbonate (PC), 28.8% are polyamide (PA), 11.9% are polyacetal (POM), 11.6% are polybutylene terephthalate (PBT), and 3.7% are modified polyphenylene ether (PPE).[3)]

1.1 Market Trends in Korea

1.1.1 Functional Coating/Film

The functional coating/film industries in Korea secure stable demand because of globally competitive Korean upstream industries.

- The demand for coating technology is increasing in the display, semiconductor, and renewable battery industries.
  - Coating/film products are the core technology in determining the properties of final materials.
  - Conducting comprehensive research is important in creating coating solutions, establishing processes, and developing substrate film. As such, energy-saving advanced materials and thin-film processes applied to general industrial purposes are being developed.
- Functional coating materials are creating markets in various fields, such as the semiconductor, liquid crystal display, automobile, information and communication device, aerospace, appliance, and construction and civil engineering industries, as well as industries for daily necessities.

2) Plastics Europe (2017), Plastics-the Facts 2017
3) Yano Research Institute (May, 2015), Engineering plastics market forecasts and strategies, 2019

- Responding to market trends for compact and integrated materials needed for information and electronics, two rapidly growing markets, requires industries to have functional coating materials consist of specific properties, such as high heat resistance, ultrathin film, etc. Hence, retaining technologies needed to address such needs is essential to lead the functional-coating materials market.
- In Korean markets, both Miwon Specialty Chemical and Sartomer have various product portfolios based on their economies of scale for general-purpose products.

- Because of improvements in the quality of life, polyester (PET) film markets are expanding from traditional uses, such as packaging or display film, to other uses such as thermal contraction or solar light. Consequently, the PET film market maintains an annual average increase of 6% to 7%.
- Various functional coating/film products have been developed by small and medium-sized companies and venture capital companies in Korea whose products have entered the commercialization stage. Moreover, investment demands are still increasing to secure global market share.
  - Korean enterprises have potential growth as they link with demand industries.
  - In addition to being used in electronics industries, functional polymer films are used in various fields, including the industries for solar batteries and other energy, as well as food packaging, which features a wide range of applications.

Market Trends and Forecast for Functional Coating/Film

(Unit: USD million, %)

Category	Main items	2017	2019	2021	CAGR
Coating	Raw materials	1,274	1,378	1,490	4
	Dyes/pigments	256	270	285	2
	Eco-friendly	43	414	499	9
	Ceramic	69	90	117	12
	Physical/chemical	344	385	430	5
	Optical, electronic, thermal	234	274	440	13
	Subtotal	2,220	2,811	3,261	6
Film	Conductive	1,169	1,311	1,470	5
	Release	268	325	394	9
	Window	983	1,792	3,266	29
	Transparent	10,497	11,772	13,203	5
	Subtotal	15,371	18,285	22,034	7
Total		17,591	21,096	25,295	7

Sources: Ministry of SMEs and Startups (MSS), Korea Technology & Information Promotion Agency for SMEs (TIPA), NICE Information Service 2017, Technology Roadmap for SME 2018-2020, Chemical and fiber materials

The export of functional coating/film products has drastically increased compared to their imports to Korea.

- The annual growth rate of exports in 2012-2016 was 5%, while the annual growth rate of imports for the same period was -10%.
  - The trade specialization index (TSI) changed from -0.03 in 2012 to 0.28 in 2016, which illustrates the increase in exports of Korean enterprises and the overall transition into export specialization.
    * Trade Specialization Index (TSI): The TSI presents a comparative advantage of products. If the TSI is closer to 1, there is more export specialization for a particular item.

Trade Status of Functional Coating/Film and Related Industries

(Unit: USD million, %)

Item	2012	2014	2016	CAGR
Exports	4,554	5,659	5,524	5
Imports	4,797	4,064	3,138	-10
Balance of trade	-243	1,595	2,386	-
TSI	-0.03	0.16	0.28	-

Sources: MSS, TIPA, NICE Information Service 2017, Technology Roadmap for SME 2018-2020, Chemical and fiber materials

1.1.2 Renewable Batteries

- Lithium-ion batteries are emerging as a new growth engine that leads exports of Korean-manufactured storage batteries.
- As of 2017, 19,246 employees were working for 111 storage battery manufacturers, including manufacturers of lithium-ion secondary batteries. In addition, shipments accumulated to nearly USD 11.4 billion.
  - As of 2012, 81 storage battery manufacturers, which employed 11,040 people, are reported to exist. In 2017, the number of manufacturers increased by 1.4 times, along with the number of employees that increased by 1.7 times.
- Among exports of Korean storage battery manufacturers, renewable battery exports amassed USD 4.6 billion in 2012 and reached USD 7.2 billion in 2017, an increase of 1.6 times.
  - Exports of lithium-ion storage batteries amassed around USD 2.1 billion in 2012 and increased to USD 4.4 billion in 2017, leading the exports in the storage battery manufacturing sector.
- As medium and large-scale business models emerged in the market, the renewable battery industry has grown in popularity for the next generations.

- In the past, the demand for renewable batteries was mainly focused on compact IT devices, such as mobile phones or laptops. Because of next-generation industry groups such as EVs or ESS, sales and exports of renewable batteries have rapidly increased.
- In addition to the increasing demand for EVs and e-mobility, the Korean government's policy for fostering a new energy industry has included ESS. As such, various business models related to the renewable battery industry are being introduced.
- Renewable batteries are used even in the electric power system, excess electric power storage, or the activation of distributed resources. Furthermore, the uses of renewable batteries continue to expand.

1.1.3 Nanocarbon Materials

- According to the Nano Convergence Industry Survey, nanocarbon materials sales of Korea in 2017 reached USD 980 million, which accounts for approximately 8% of the nanomaterials industry's overall sales (USD 12.29 billion).
  - Carbon nanowire products, including carbon nanotubes (CNT), have the greatest sales share, reaching USD 881 million*, followed by carbon nanoparticles and carbon nanoplatelets, which reached USD 92 million and USD 1.5 million, respectively.
    * The sales of carbon nanowire products increased rapidly, with a recorded USD 117 million sales in 2015 alone.
- In 2017, the total export of the nanocarbon materials industry of Korea was USD 16 million, which accounts for less than 1% of the total exports of the nanomaterials industry, which was USD 2,385 million.
  - The exports of carbon nanowire products, which amassed USD 11 million, accounted for approximately 70% of the overall exports of nanocarbon materials.
- In 2015, the number of employees working in the nanocarbon materials industry was 389 and in 2017, it increased to 668, an addition of 280 employees.
  - The highest number of employees (325 employees) were employed in the field of carbon nanoparticles, followed by 302 employees in the field of carbon nanowires, and 41 employees in the field of carbon nanoplatelets.

1.1.4 Engineering Plastic (EP)

- According to the Yano Research Institute, the scale of the global EP market reached approximately 10,060,000 t in 2018, a 103.7% increase from 2017.
  - This market is predicted to increase annually by an average of 3.51%, expanding to 119,580,000 t by 2023.

- In terms of resin, PC accounts for the largest share of 44.0%, followed by PA at 28.8%, POM at 11.9%, PBT at 11.6%, and denatured PPE at 3.7%.
- In terms of use, EP, which is used for automobiles, occupies the highest percentage of over 30% as demands increase because of environmental regulations and low fuel consumption restrictions. This is followed by electronics, which occupies approximately 25% of EP, as a result of increased demand for compact and lightweight devices.

- The NICE Information Service forecasted that in 2015-2020, the EP market of Korea will increase from USD 1.1 billion to USD 1.5 billion, growing by an annual average of 7.33%.
  - According to the IBK Economic Research Institute, in terms of demand for EP in Korea, EP for automobiles appears to have the highest demand of over 40%, followed by approximately 32% for consumer goods and other industrial purposes, and approximately 26% for electronics.
    * There are various applications of EP in automobiles, such as in exterior materials (including PA6 and PA66 with high heat resistance often used for the engine room) and PBT used for plug connectors and other automotive electronics.
  - Meanwhile, the applications of EP in electronics are expected to decrease because of the lowering demand for PC or PBT as more metal materials are used in smartphones and tablet housing and also because PCs are used less as LCDs become thinner.
  - The recent trend shows the slow growth of EP applications for consumer goods and industrial purposes. A stagnant demand for PCs is predicted to be the main reason for this downturn as PCs account for over 80% of the market share.
- The super-PE market of Korea expects high growth, particularly an annual average increase of 13.9%, until 2021; however, the market scale is still considered to be relatively insignificant compared to the market scales of advanced countries.

Korean Market Scale and Forecast for Super-EP

(Unit: 100 USD million, %)

	2016	2017	2018	2019	2020	2021	CAGR
PPS	0.23	0.25	0.27	0.30	0.33	0.36	10.0
Super-EP polymer materials	1.94	2.21	2.52	2.86	3.26	3.71	13.9
Carbon-fiber composite materials	0.73	0.85	1.04	1.27	1.54	1.87	21.7
Total	2.9	3.31	3.83	4.43	5.13	5.94	13.0

Sources: MSS, TIPA, NICE Information Service 2017, Technology Roadmap for SME 2018-2020, Chemical and fiber materials

- The recent restrictions in environmental and fuel regulations increased the need for lightweight automobiles, also increasing the demand for polyphenylene sulfide (PPS) and super-EP.

  * Polyphenylene sulfide (PPS) is widely used in automobiles, electronics and fibers because of its high strength and high heat resistance characteristics.

- In Korea, only a few Korean automotive companies use super-EP applications, which is thought to be the main reason why market expansion has not yet happened.

1.2 Industrial Competitiveness

1.2.1 Functional Coating/Film

- The demand for and applications of coating/film is gradually increasing because of the development of advanced materials that use existing materials and reinforce their various functions. From a trend perspective, the coating/film market of Korea is also growing.
- Major raw materials, equipment, or core element technologies are highly reliable imports in Korea, whereas the high ratio of functional film/coating manufacturers are small and medium-sized enterprises (SMEs) and middle-standing enterprises that produce general-purpose industrial products production.
  - The demand for functional coating/film products made from eco-friendly materials is increasing.
  - In the functional coating market, the need for demand industries concerning materials with high-functional properties continues to increase. Korean enterprises occupy a high market shares in general-purpose products, while high-functionality products still appear to be reliable imports.
- In several optical coating film sectors, some Korean companies have technologies equal to those in advanced countries, such as the polarized film and light-diffusing film sectors, which are core parts of device displays.
  - In the polarized-film sector, LG Chem, thanks to reliable demand for LG display products, secures its position as the world's largest manufacturer.
  - In the anti-glare film sector, LG Chem, Cheil Industries, and SK Hass are manufacturing their products according to demand.
- In the PET film market, Japanese enterprises are leading because of their advanced technologies, while Korean companies are currently trying to keep up with them.

- In general packaging or general industrial purpose film markets, countries such as India and China are rapidly increasing their market shares. The optical film market continues to address the demand industries' need for improved product properties.
- SKC, which hopes to maintain its ranking as fourth (based on the size of its production facilities in the global market), merged with SKC HT&M and, as a result, strategically secured economies of scale.

The Technical Gap between Korea and Advanced Countries in Wet Coating Technology (as of 2017)

Category	Subcategory	Technology competitiveness		Countries with the most advanced technology (100)
		Technical gap (years)	Relative level of development (%)	
Flat panel display	Anti-glare film	3	80	Japan
	Phase difference film	5	60	Japan
	Polarized film	1	95	Japan, Korea
	Brightness enhancement film	3	80	US
	Other LCD-backlit film	1	95	Japan, Korea
	Transparent conductive coating	3	80	Japan
	Optical adhesive coating	3	80	Japan, US
Energy-related	Sealing film for solar cell	4	75	Japan, US, Germany
	Backsheet for solar cell	3	85	Japan, Germany, Italy
	Electrode coating for solar cell	3	80	Japan
	Coating for lithium-ion battery	1	95	Japan, Korea
Industrial and lighting purposes	In-mold film	3	80	Japan, Germany, Italy
	Hard coating	3	80	Japan
	Thermal barrier coating	3	80	Japan, US
Other	Barrier coating	3	80	Japan, US
	Anticorrosion, self-healing, bio	5	60	US, Japan

Sources: MSS, TIPA, NICE Information Service 2017, Technology Roadmap for SME 2018-2020, Chemical and fiber materials

1.2.2 Renewable Batteries

- Several Korean enterprises, such as LG Chem, Samsung SDI, and SK Innovation, are global manufacturers of lithium-ion batteries.
- In 2018, Samsung SDI and LG Chem occupied 25.3% and 20.0%, respectively, in the global market for compact renewable batteries, ranking as the world's 1st and 2nd.
  - LG Chem and Samsung SDI are affiliates of LG Electronics and Samsung Electronics, respectively, both of which are major consumers for compact renewable batteries. Under their respective parent groups, each company is actively collaborating with its sister company.

- In 2018, LG Chem ranked 4th in the EV batteries global market. In the ESS global market, Samsung SDI, LG Chem, and SK Innovation ranked as the world's 1st, 2nd, and 4th, respectively.
  - Although Korea's global market share for renewable batteries ranked fourth because of a discriminatory EV incentive policy in China, Korea managed to secure various trade routes with global automotive manufacturers.
  - Most EV manufactures, besides Tesla, design their vehicles with a pouch cell or prismatic cell. Therefore, LG Chem and SK Innovation, which mainly produce pouch cells, received attention in the market.

1.2.3 Nanocarbon Materials

- The 2018 Assessment of Technological Level observed that the US and Japan hold the most advanced technologies for the nanostructure control of ceramic and carbon materials and that Korea's technological level ranks at 80% compared to these advanced countries.
  - As of 2018, the technical gap between Korea and Japan in this field is estimated to be three years. At the same time, Korea's technology is estimated to be 3.5 years ahead of China but 1.5 years behind Europe.
- In terms of research competency, Korea was assessed to be advanced in the application and development stage but average in the basic research stage.

1.2.4 Engineering Plastic

- In terms of the global market share of EP manufacturers, GEP, Bayer, DuPont, BASF, and other US or European companies occupy 47% of the total market.
  - Lately, Japanese companies, including Mitsubishi, Asahi, and Teijin, are increasing their market shares.
- In Korea, technical developments are focused on general-purpose plastic and general-purpose EP, while investments on super-EP, which features high-added-value, are significantly less compared to advanced countries.
- Even for general-purpose EPs, except for PC and POM, the import dependency ratio continues to increase.
  - While some of the major general-purpose EPs, such as PC and POM, are being manufactured in Korea, the majority of raw materials for the PA series, PBT, and Modified Polyphenylene Oxide (mPPO) still mainly rely on imports.

- Despite increasing demands for PA6 and PA66, which are used for automotive parts, the reliance on raw material imports continues to grow.
- In relation to PPS, which accounts for a significant part of the corresponding market, US companies, such as Chevron and Ticona, as well as Japanese companies, such as Toray and Kureha, lead in competitiveness.

- (Super-EP) Although Korea is inferior to leading US, European, and Japanese companies in the market, investments in Korea are increasing, particularly for PPS resins, which are the base materials for lightweight vehicles.
- Investments in PPS, which account for approximately 30% of the super-EP market, are increasing in Korea along with investments in liquid crystal polymer (LCP) for which demand in electronics is expanding. Investments for polyether ether ketone (PEEK) used in semiconductors are also growing.
  - For PPS, conglomerates, including SK Chemicals and Kolon Plastics, are leading technical developments and production.
    * In 2013, SK Chemicals established a joint company with the Japanese chemical company Teijin called "Initz" in 2013 to start its PPS business. As of late, it has secured underlying technologies through collaborative industry, academic, and research projects, and sought to expand its production facilities.
  - LCP is mainly used for electronic parts. Moreover, the current global market is almost completely monopolized by a few US companies, including Ticona and DuPont, and Japanese company Sumitomo.
  - conglomerates and middle-standing enterprises are entering the compounds production market. However, it is difficult to establish competitiveness in raw material production because of the technological entry barrier.

2 Foreign Direct Investment Trends

2.1 Foreign Direct Investment Status

2.1.1 Renewable Batteries

- The battery-related industry accounts for the highest portion of foreign direct investments in electrical equipment industries. At the end of 2018, the foreign direct investment for the manufacturing of primary batteries and storage batteries related to the renewable battery industry was reported to reach a total of USD 250 million.
  - In 2017, the foreign direct investment for all related industries was USD 300 million. As a result, it appears to be the highest foreign direct investment in the last five years.

- The highest foreign investment was in the battery-related sector in electrical equipment industries as foreign investments tend to be high in battery-related industries.

- In the first half of 2019, two foreign direct investments of USD 22.8 million were made to the battery industry. Moreover, it appears that Japan continues to invest in this sector.
  - With Japan focusing primarily on their domestic investments, the country's foreign direct investments have decreased, but they still maintain foreign investments in renewable batteries and value chains in the semiconductor industries.

Foreign Direct Investment Trends for Primary Battery and Storage Battery Manufacturing

(Unit: No. of cases, USD thousand)

	2014	2015	2016	2017	2018
No. of cases	5	14	10	15	9
Amount reported	11,862	43,476	88,873	304,413	256,144

Sources: Ministry of Trade, Industry and Energy (MOTIE) website, Foreign Direct Investment Statistics (Accessed on August 1, 2019)

2.1.2 Nanocarbon Materials

- According to the Ministry of Trade, Industry and Energy (MOTIE), company R from New Zealand made an additional greenfield investment of USD 3,000 in Korea to produce carbon nanofibers for manufacturing micro particle filters, functional clothing, or mask packs.

2.2 Success Cases of Major Foreign-Invested Companies

2.2.1 Functional Coating/Film

- Foreign-invested companies founded in the Korean film and coating market are supplying high-value-added products, corresponding to the demands in large-scale upstream industries for semiconductors, renewable batteries, and electronics.
- In 1996, Oerlikon Balzers, a supplier of surface property improvement technology, established the Oerlikon Balzers Coating Center in Korea.
  - Their main business area is the production of coating equipment and physical vapor deposition (PVD) coating products.
  - As of 2019, the company had 37 employees, and in 2017, their sales were at USD 30 million.
- LINTEC is a foreign-invested company established in 2002, and 100% of its shares are held by the Japanese Lintec Corporation.

- Their main business is a cohesive fine coating for polarized film, which is used for manufacturing liquid crystal displays and film adhesion.
- As of 2018, the company has 123 employees, and sales were recorded to be approximately USD 69 million.

- Toray founded Toray BSF Korea LLC in Gumi, Gyeongsangbuk-do, in 2008. Currently, it is operating the consolidated subsidiary, which was entirely contributed by Toray Industries, Inc.
  - Their main business area is producing battery separator films for renewable batteries.

Status of Major Foreign Investments in Korea

Category	Country	Parent company name	Korean company name	Location	Products	No. of employees in Korea
Coating	Switzerland	Oerlikon Balzers	Oerlikon Balzers Coating Korea	Pyeongtaek, Gyeonggi-do	• PVD, PACVD base coating • Coating equipment	37
Film	Japan	Lintec	LINTEC Advanced technologies (Korea)	Pyeongtaek, Gyeonggi-do	• Cohesive, adhesive film • Film for semiconductors and electronic products	123
		Toray	Toray BSF Korea LLC	Gumi, Gyeongsang buk-do	• Battery separator film for renewable batteries	-

Sources: Summarized by the author based on each company's business report

2.2.2 Renewable Batteries

- Ecopro GEM
  - Ecopro GEM was established in 2018 as a foreign-invested corporation as a result of the partnership between Ecopro and GEM, a corporation in Shenzhen, the Guangdong Province of China that specializes in urban mining and recycling resources to produce anode material precursors for lithium-ion renewable batteries.
  - It is located at Industrial Complex 1 in Yeongil bay, Pohang-si, Gyeongsangbuk-do. (This complex is designated for part materials. Plant 1, with a total area of 18,500㎡, has been constructed in the foreign investors' designated area, a direct result of USD 136 million investments.)
  - In the 5 years after 2018, a total of USD 272 million worth of investments is going to be used to build manufacturing plants in sequence and hire approximately 600 employees.
  - These investments in Korea were because of various factors, including the close competition between China and Korea's technology in the lithium-ion battery industry.

- Toray Battery Separator Film (BSF) Korea Co., Ltd.
  - Toray BSF Korea is a foreign-invested company that was entirely contributed by Japan's Toray Industries, Inc. The company produces battery separator film for lithium-ion batteries.
  - Since its establishment in 2008, the company has invested USD 590 million in renewable battery separator film and battery separator film coating.
  - The decision for investments was made in consideration of abundant and excellent human resource capabilities, as well as the fact that major clients, such as Hyundai Motors, SK, and other global electronics and automotive corporations, are located in this area.
  - The Korean government designated Toray's Gumi plant 4 as a cutting-edge technology company and offered a free 50-year lease. Furthermore, the government reduced its local and corporation taxes.

2.2.3 Engineering Plastic

- Kolon Plastics, a Korean corporation, and BASF, a German corporation, jointly established Kolon BASF to manufacture POM.
  - In March 2016, each company contributed half of the total investment costs (USD 224 million) to build a manufacturing plant with an annual POM production capacity of 70,000 t. The construction of the POM manufacturing plant was completed in October 2018.
  - Decision factors for the investment: Sharing of expertise related to production, and the seamless supply of products to target global markets, specifically in the Asia-Pacific region
    * The joint company was established by combining BASF's quality control system and advanced eco-friendly technologies for saving energy usage and Kolon Plastics' efficient and reliable production management system.
  - Performance results: POMs are seamlessly supplied to Kolon Plastics and BASF, which both have their own sales network.
    * While both parties share the production facilities in the joint company, they produce customized products depending on the needs of their own clients and independently sell these customized products.
    * Approximately 100 employees are required for the maintenance of the plant and for logistics. Such creation of jobs and added value in connection with related businesses vitalized the local economy.
- In December 1999, Toray Advanced Materials Korea was established jointly through an investment by Saehan, a Korean corporation, and Toray, a Japanese corporation. In addition to the Gunsan plants, the Anseong plant and Yugu plant are also producing various chemical materials.

- In 2016, Toray Advanced Materials Korea constructed a new PPS 215,000 ㎡ production plant within the Saemangeum Industrial Complex in Jeollabuk-do.
- The company supplied PPS resins and compounds, as well as raw materials, including sodium hydrosulfide (NsSH) and paradichlorobenzene (p-DCB).
- Approximately USD 270 million have been invested in their Gunsan plants up to 2018, including USD 78 million via Toray's foreign direct investment funds. The company annually produces 8,600 t of resins and 3,300 t of PPS compounds.
- Decision factors for the investment: Accessible raw materials; interest in developing Asian markets, including the Chinese market, as well as European markets
  * The location offers advantages for connectivity with companies in both upstream and downstream industries, other infrastructures including the Gunsan port, and access to China.
  * An increase in exports to China, the world's biggest market, was expected, taking advantage of tariff reductions based on the China-South Korea Free Trade Agreement.
- Performance results: The local economy was revived, and jobs were created through strategic liaison and collaboration with companies in upstream industries and industries located in Gunsan.
  * As the first foreign direct investment company settled in the Saemangeum Industrial Complex, the company created more than 150 jobs and contributed to increases in local taxes and the sales expansion of Korean companies in related fields.

3 Policy and Location

3.1 Key Policies and Incentives

3.1.1 Functional Coating/Film

- **In general, materials-related industry policies in Korea are categorized into technical support, core parts and technology development, and SMEs and middle-standing enterprises for local innovation business support services.**
  - Technical education/training for the relevant SMEs are reinforced, and national tasks with respect to high-functional film and coating technology are supported.
  - This belongs to the World Premium Materials (WPM) and the Top 20 Core Parts Support Business designated by MOTIE.
  - Local economic innovation support centers are established and operated in each region.
  - As of 2019, Korea's material-related business support services were implemented by the MOTIE and the MSS.

- The MOTIE provides support services, such as aid for technology evaluation funds for SMEs and middle-standing enterprises, supports the development of material parts technologies, and fosters growth with partner companies through innovation in productivity.
- The MSS provides support services, including secondments of the research labor force and the support for companies that focus on innovation for technological development.

Programs for Coating and Film-Related Principal Policies in Korea

Organization	Business	Description
Ministry of Trade, Industry and Energy (MOTIE)	• Supports technology evaluation funds for innovative SMEs and middle-standing enterprises	• When an innovative SME or middle-standing enterprise seeks an evaluation of its technology from a technology evaluation institute to procure business funds (e.g., attracting investments or mergers/amalgamations), the MOTIE supports partial funding of the evaluation.
	• Supports development of material parts technologies (package type)	• MOTIE supports medium and long-term technology development plans for material parts by assisting with stage connectivity for materials, parts, modules, and demand, and verifies the reliability of the developed materials, thereby aiming to secure their competitiveness.
	• Supports productivity innovation for partner companies in second and third levels to foster growth together with partners	• MOTIE utilizes the contributions of conglomerates, public enterprises, and middle-standing enterprises to support technical innovation and process improvement for their second and third-level partner companies, thereby aiming to enhance overall industry competitiveness.
Ministry of SMEs and Startups (MSS)	• Provides a research labor force for SMEs (secondments)	• MSS sends an experienced research labor force from public research institutes to SMEs so that they can provide their technical expertise and support research development.
	• Develops technologies for innovative companies (global market expansion venture)	• MSS supports the rapid development of element technologies (e.g., materials, parts, and equipment) that rely highly on imports to improve global competitiveness.

Sources: Korea Adhesive Coating Association website (http://www.kacapotal.org/)

3.1.2 Renewable Batteries

- The Korean government included renewable batteries in their list of new export products and increased efforts to resolve any export-related issues. (May 2019)
  - To resolve any issues related to trade financing or foreign marketing, which may occur in the course of exporting, Korea created a department called the "Export Revitalization Team 2.0." (May-October 2019)
  - In addition to supporting trade financing and foreign marketing, the government provides comprehensive counseling about fostering industries, research and development, and regulation improvements to resolve issues for each company. For any issues that cannot be resolved via the company's worksite, the government follows up with the company through the government's Export Revitalization Situation Office.
- The Korean government supports renewable battery technology development through Research and Business Development (R&BD).
  - The 2019 Joint Research and Business Development (R&BD) provided technology development support services for the dry process of developing multi-particle nickel-cobalt-aluminum (NCA) into a single-particle (one-body) NCA.
  - To develop and commercialize the next generation of renewable batteries, which need to be more reliable and to feature high-energy density, the Korean government and battery manufacturers are jointly conducting research and development where they provide support services for developing technologies with respect to solid-state batteries, lithium-sulfur batteries, and lithium-metal batteries.
- When renewable energy and ESS are combined, a higher weighting with Renewable Energy Certificate is granted.
  - The importance of introducing an ESS emerged as a way of resolving intermittent power generation issues in renewable energy.
  - The government now grants incentives to combine renewable energy resources and ESS power businesses in an effort to revitalize the market.

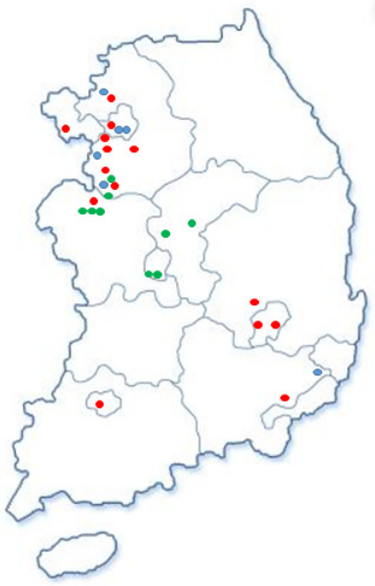
    * Pursuant to Article 12-5 of the Act on the Promotion of the Development, Use, and Diffusion of New and Renewable Energy, when a business combines renewable energy and ESS, the government gives preference to issuing Renewable Energy Certificates (RECs) under the Renewable Portfolio Standard (RPS) system. (For example, an REC with a weighting of 5.0 will be given when accommodating photovoltaic systems in ESS, while an REC with a weighting of 4.5 will be given when accommodating wind power in ESS.)

3.1.3 Nanocarbon Materials

- The Phase 3 – National Nanotechnology Roadmap (2018–2027) was created. (Ministry of Science and ICT, June 25, 2018)
  - In accordance with the Nanotechnology Promotion Act, the government shall establish the nanotechnology roadmap for the next 10 years every 5 years, designate 30 future technologies to be achieved via nanotechnology development, and prepare a detailed nanotechnology roadmap, which is required to achieve these future technologies.
- The strategic plan was prepared to secure original technology for future materials. (Ministry of Science and ICT, April 25, 2018)
  - In securing original technology for future materials, the government prepared a strategic plan to address the Fourth Industrial Revolution and to prepare for the future society, as well as the creation of a new advanced material industry.
- The strategy to promote the nano convergence industry was announced. (MOTIE, July 2018)
  - Goals were set to achieve 12% in nano-industrial sales in manufacturing, create 200,000 nano-related jobs, and create 20 of the world's top-class nano-fusion products in the 5 new and advanced industrial fields by 2025.
- The 2019 implementation plan for developing nanotechnologies was created. (10 departments, 18 government departments, March 2019)
  - Pursuant to Phase 4 – National Nanotechnology Initiative Strategic Plan (2016–2025), MOTIE invested USD 4 million to develop graphene and material parts technologies for core nano convergence technologies in 2018.
  - In the course of business support services for system industry-based institutes, a USD 2 million investment in 2019 was marked to lead the creation of the new fourth industry and to construct the base for plasma carbon nano convergence composite materials.

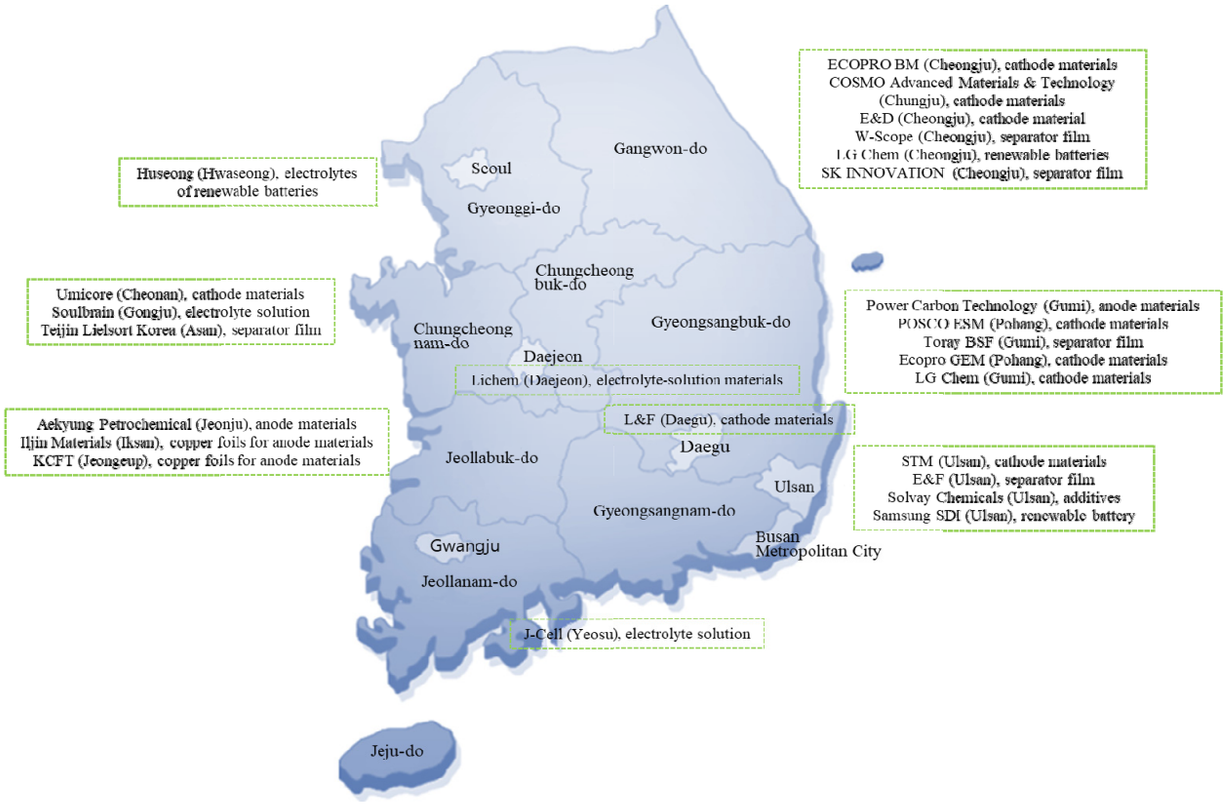
3.2 Major Locations

3.2.1 Functional Coating/Film



Sources: Indicated by the author
Note: Blue dots indicate raw material industries, red dots indicate coating industries, and green dots indicate film industries

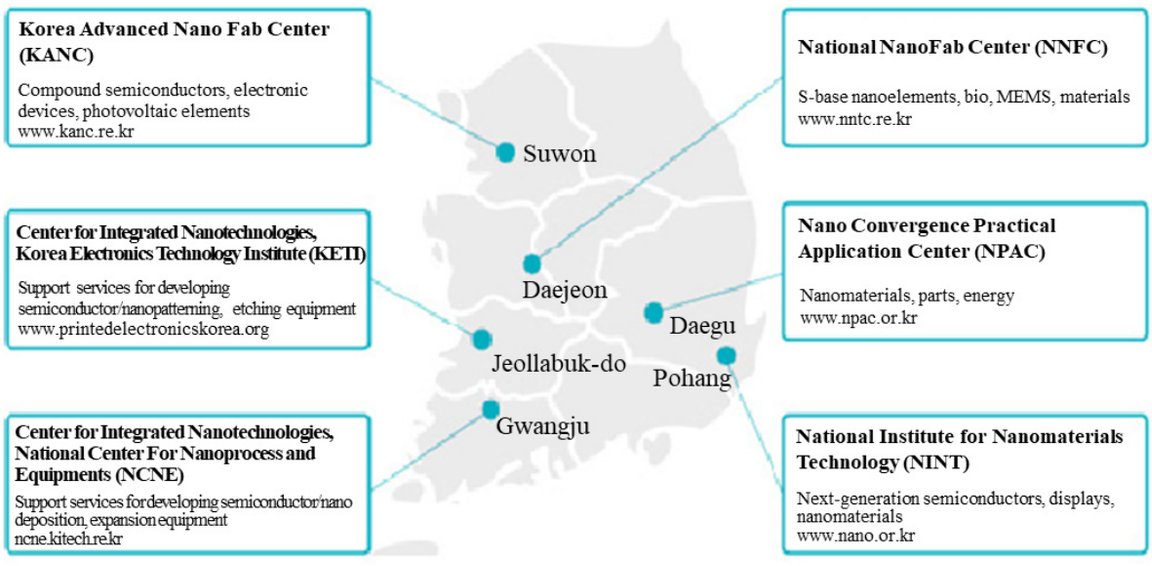
3.2.2 Renewable Batteries



Sources: Indicated by the author

3.2.3 Nanocarbon Materials

- National Nano Convergence Industrial Complex in Miryang
  - The construction of a 1,656,920 ㎡ national industrial complex, where USD 291 million of business funds were invested, is expected to be completed in 2020.
  - For attracting over 50 nanotechnology-related conglomerates and middle-standing enterprises to this national industrial complex, the target plan is expected to announce that the complex will include a nano convergence research complex and will be equipped to house nanotechnology and other manufacturing companies.
- The complex will provide a wide array of services related to nanotechnology measurement and process equipment and offer access to infrastructures of nanotechnology companies, universities, and research centers situated in the industrial complex
  - In the 10 years after 2001, when the National Nanotechnology Initiative Strategic Plan was established, approximately USD 708 million was invested for setting up services in 6 locations.



Sources: Ministry of Science and ICT (July 2019), Nanotechnology Annual Report 2018

- Facilities to support research and development and the commercialization of specific fields in nanotechnologies
  - Currently, eight centers are operating in university research centers and national research centers.

Principal Nanotechnology-Specific Facilities in Korea

Institute	Services	Cleanroom and scale of research facilities	Business funds (Unit : USD 1 million)	Service commencement date
Inter-University Semiconductor Research Center	Silicon nanoelements, compound semiconductors, photoelectric devices, etc.	1,548 ㎡ (class 100-10,000)	27.8	October 1988
ETRI Semiconductor Laboratory	Silicon compound semiconductors, element processing	1,419 ㎡ (class 10-1,000)	30.4	January 2000
Institute of Semiconductor Fusion Technology	0.6 ㎛ compound semiconductor displays	2,100 ㎡ (class 100-10,000)	32.6	September 2001
KIST Fab.	MEMS devices and nanoelements (including compound elements)	495 ㎡ (class 10-1,000)	7.5	February 2002
Jeonnam Bioindustry Foundation - Nano Bio Research Center	Nano-organism materials, medical parts and materials	1,380 ㎡	18.2	April 2010
Daegu Gyeongbuk Institute of Science & Technology Central Research Facilities	Fabrication of silicon semiconductors, MEMS, communication devices, sensors, micro processing, simulation and nano/bioanalysis	1,548 ㎡ (class 100-1,000)	62.7	May 2011
Cheorwon Plasma Research Institute	Nanomaterials (plasma)	2,925 ㎡	49.1	January 2012
Miryang Nano Convergence Commercialization Support Center	Commercialization of nano mold	2,000 ㎡	72.0	-

Sources: Ministry of Science and ICT (July 2019), Nanotechnology Annual Report 2018

3.2.4 Engineering Plastic

- (Korea BASF) Operating eight production facilities in Yeosu, Ulsan, Gunsan, Ansan, and Yesan
  - (Ansan plant) Producing engineering plastic, took over the EP business section from Honeywell Korea in 2003
  - (Yesan plant) Producing EP for automobiles and consumer goods, established in 2015
  - (Gimcheon plant) Jointly invested with Kolon Plastics (50:50), established in 2016, producing POM.
  - (Ulsan plant) Producing PolyTHF®, polyol, and PU system A

- (Toray Advanced Materials Korea) Operating eight production plants in Gumi, Gunsan, Yugu, and Anseong
  - (Gunsan plant) Producing engineering plastic PPS
  - (Gumi, Yugu, and Anseong plants) Producing chemical materials and products
- (Initz) Operating the PPS production plant in Ulsan

4 Potential Partners

4.1 List of Related Companies

4.1.1 Functional Coating/Film

- Sun Systems develops wildfire suppression agents and medical film coating agents. They also develop adhesives for medical patches and premixed film coating systems for pills and capsules.
- Ceko specializes in vacuum deposition coating technologies utilizing the carrier-based vacuum deposition technique and the technology for manufacturing high-quality surface coating agents.
  - With its technology for manufacturing functional nanocoating agents with high water-absorption resistance, the company supplies coating agents for various demand industries, including touch screen panels, optical lenses, glass for vehicles, etc.
- NIC Co., Ltd. develops multipurpose film for electronics and screen protection film.
  - The company introduced industrial films, such as highly durable reinforced film, by alternating glass materials and highly functional bulletproof film.
  - The company retains a production line for thin films used for electronic materials, cleanrooms, roll-to-roll systems, and optical adhesive films.
- IPI Tech Co., Ltd. successfully localized the production of heat resistant polyimide material film and retained special film coating technology using non-thermoplastic polyimide varnish.
  - The company supplies polyimide materials to major conglomerates in Korea in the field of smartphones and semiconductors and in chemical industries.
- Everchemtech, a company that specializes in electronic materials and new and advanced materials, exports coating agents that can be applied to the inline process, electromagnetic radiation blockers for flexible printed circuit boards, and electrically conductive adhesive film to China.

- Because of the successful localization of production, the company has become a supplier to major Korean conglomerates. The company focuses on antistatic coating agents which utilize conductive polymers and continues to research graphene materials for future growth.

- INTECO Co., Ltd, a high-functional film manufacturer, successfully localized the production of OLED products.
  - INTECO Co., Ltd is an affiliate of INTEC Nano-Materials. While INTEC Nano-Materials focuses on research and development, INTECO focuses on film, and INTEC CND focuses on producing materials.

Major Coating/Film Companies in Korea

Category	Company	Products	Website	Location
Raw materials	Gangnam Hwaseong	Phenolic resin, polyurethane resin	www.kangnamchem.com	Head office: Seocho-gu, Seoul Technical research center: Ansan plant, Pyeongtaek, Ansan
	Kukdo Chemical	Epoxy, curing agents, polyol, polyurethane, etc.	www.kukdo.com	Head office: Geumcheon-gu, Seoul Business location: Gangseo-gu, Busan, Iksan, Jeollabuk-do, Siheung, Gyeonggi-do
	DONGCRYL	Aqueous acrylic emulsion	www.dongcryl.co.kr	Head office: Paju, Gyeonggi-do
	Jungang Polytech	Raw materials for paint, coating materials, latex	japt.koreasme.com	Head office: Yangsan, Gyeongsangnam-do
Coating agents	Sooyang Chemtec	Light curing resin for PDLC film, adhesive for high-performance tapes (for semiconductor processing), highly durable PC coating agents	www.sooyangchem.com	Head office·Plant: Yesan-gun, Chungcheongnam-do
	AVACO	Displays, solar cell production processing equipment	www.avaco.co.kr	Head office: Dalseo-gu, Daegu Plant: Daegu, Paju, Gyeonggi-do, Gumi, Gyeongsangbuk-do
	UNIVAC	Optical coating (anti-reflective, IR cutoff filter, polarization, anti-fingerprint, reflector), decoration coating products	www.univac.co.kr	Head office: Gimhae, Gyeongsangnam-do

Category	Company	Products	Website	Location
	DONGWOO HTS	PaCVD, DLC Coating	www.dwhst.co.kr	Head office: Siheung, Gyeonggi-do Plant: Daegu, Gwangju
	iNFOVION	Vacuum equipment/parts	www.infovion.com	Head office: Yeongdeungpo-gu, Seoul
	Samwon Vacuum	Vacuum equipment/parts (high-vacuum deposition equipment), coating products and production equipment	www.samwonvacuum.co.kr	Head office: Seo-gu, Incheon
	Shin Han Vacuum	PVD coating, ultra hard coating	www.shpic.co.kr	Head office: Bucheon, Gyeonggi-do
	Sungmoon Electronics	Vacuum-evaporated thin film for film capacitors and vacuum-deposited metal film	www.smec-korea.com	Head office: Pyeongtaek, Gyeonggi-do
	Sun Systems	Medical film coating agents, pills and capsule coating agents	www.sunsystems.co.kr	Head office: Seocho-gu, Seoul Plant: Hwaseong, Gyeonggi-do
	Ceko	Functional nanocoating agents with high water absorption resistance	www.ceko.co.kr	Head office: Seongnam, Gyeonggi-do
Film	Shinwha Intertek	Smart photovoltaic film, high performance tape	www.shinwha.com	Head office: Cheonan, Chungcheongnam-do
	MNTech	Photovoltaic film, window film, reflective film, touch panel	www.mntech.co.kr	Head office and Technical research center: Cheongju, Chungcheongbuk-do
	SANGBO	Window film, paint protection film, prism film, screen decorative film, AgNW TCFs, PEDOT TCF, QD film, etc.	www.sangbogroup.com	Head office: Gimpo, Gyeonggi-do
	KOYJ	Photovoltaic film (prism film, light-diffusing coating, antistatic agent), LGP, OLED equipment, automotive electronics for EVs, etc.	www.koyj.co.kr	Head office: Chungju, Chungcheongbuk-do Branch: Yangju, Gyeonggi-do
	TOPNANOSYS	Antistatic coating, air-penetrating film	www.topnanosys.com	Head office: Cheonan, Chungcheongnam-do
	I-Components	Gas barrier coating film, photovoltaic film (PMMA, PC, PES)	www.i-components.co.kr	Head office: Pyeongtaek, Gyeonggi-do

Category	Company	Products	Website	Location
	NIC	Multipurpose film for electronics, screen protective film	www.e-nic.kr	Head office: Cheonan, Chungcheongnam-do
	IPITECH Co., Ltd.	Heat-resistant polyimide materials, non-thermoplastic polyimide varnish	www.ipitechnology.com	Head office: Daejeon Yuseong
	Everchemtech	Electromagnetic radiation blockers for flexible printed circuit board, electrically conductive adhesive film	www.everchemtech.com	Head office: Hwaseong, Gyeonggi-do
	Intecho	OLED film	www.intech-nm.com	Head office: Daejeon Yuseong

4.1.2 Renewable Batteries

Company	Products	Website	Location
LG Chem	Lithium-ion batteries (final products)	www.lgchem.com	Cheongju, Chungcheongbuk-do
Samsung SDI	Lithium-ion batteries (final products)	www.samsungsdi.co.kr	Ulsan Metropolitan City
SK INNOVATION	Lithium-ion battery separator films and final products	www.skinnovation.com	Jeungpyeong, Chungcheongbuk-do

4.1.3 Nanocarbon Materials

Company	Products	Website	Location
LG Chem	Carbon nanotubes	www.lgchem.com	Yeosu plant
Kumho Petrochemical	Carbon nanotubes	www.kkpc.com	Asan plant
JEIO	Carbon nanotubes	www.jeiocnt.com	Ansan
Teraon	Heat-generating nanocarbon materials	-	Seongnam
PICOPACK	Carbon nanotubes X-ray tube parts	www.picopack.co.kr	Daejeon
Nano Chem Tech	CNT antistatic coating solutions	www.nanosbiz.com	Yongin
SANGBO	CNT antistatic coating solutions, graphene film	www.sangbogroup.com	Gimpo
EXA E&C	CNT heating elements, graphene	www.exaenc.com	Seoul
KUK-IL GRAPHENE	Graphene powder, thin film	www.kukilgraphene.com	Daejeon

4.1.4 Engineering Plastic

Company	Products	Website	Location
Kolon Plastics	POM, PA6, PA66, PBT, PPS, PET	www.kolonplastics.com	Gwacheon, Gimcheon, Gumi
LG Chem	Engineering plastic	www.lgchem.com	Iksan plant
Samyang TRILITE	EP compounds including PC, PBT, TPE, and M-PET	www.samyangcorp.com/Chemistry/plastic01_01	Jeonju plant
HDC Hyundai Engineering Plastics (HDC Hyundai EP)	EP compounds	www.hdc-hyundaiep.com	Dangjin, Jincheon Gimcheon, Ulsan
Korea Engineering Plastic	PA6, PA66, PBT, etc.	www.kepital.com	Ulsan plant, Pyeongtaek plant

4.2 Related Organizations

4.2.1 Functional Coating/Film

Name	Website	Main roles
Korea Adhesive Coating Association	www.kacapotal.org	• Promotes adhesive and coating products to the companies that manufacture the same • Analyzes industrial statistics and shares information • Collects principal policies, supports programs, and provides adequate matching services

4.2.2 Renewable Batteries

Name	Website	Main roles
Korea Battery Industry Association	www.k-bia.or.kr	• Provides updates on the status and trends of the renewable battery industry

4.2.3 Nanocarbon Materials

Name	Website	Main roles
National Nanotechnology Policy Center	www.nnpc.re.kr	Provides support services for national nanotechnology policies, strategy establishment, research and development planning, and the promotion of collaboration between domestic and foreign entities
Korea Nanotechnology Research Society	www.kontrs.or.kr	Promotes the exchange of information and labor forces between academic, research, and industrial research entities in relation to nanotechnology development and collaboration

Name	Website	Main roles
Nano-Convergence Foundation 2020	www.nanotech2020.org	Based on the government's research and development performance results with respect to original nanotechnology, this foundation promotes R&BD businesses by connecting institutes that have nanotechnology with demanding companies that have business ideas.
Nano Technology Research Association	www.nanokorea.net	Establishes a collaboration network comprised of industrial academics and research to set the foundation for improving the nano convergence industry, supports business establishment for nano convergence companies, and holds the Nano Korea event.
Organization for Nano-convergence Industrial Coop	www.nanoin.org	Promotes the development and commercialization of nanotechnology and supports activities to establish nanotechnology businesses
Nano Safety Metrology Center	www.safenano.re.kr	As a control tower for nanotechnology safety research, this center establishes the safety response system in relation to nanomaterials and the international certificate system.
Korea Infrastructure Organization for Nanotechnology	www.kion.or.kr	Through organic collaboration with domestic nanotechnology infrastructure, this organization engages in research and development of nanotechnology, efficient support services for commercialization, and revitalization of nanotechnology infrastructures.

4.2.4 Engineering Plastic

Name	Website	Main roles
Korea Federation of Plastic Industry Cooperatives (KFPIC)	www.kfpic.or.kr	Provides updates on industrial status and trends of the engineering-plastic industry

kotra
Korea Trade-Investment Promotion Agency

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KOTRA 20-163

Investment Opportunities in Korea

Fine chemicals

Publisher	KOTRA	**Writer**	Investment Public Relations Team, KOTRA
Date of Publication	Mar. 2020	**Reference**	Korea Institute for Industrial Economics and Trade
Contact information (Call)	(82-2) 1600-7119		www.kiet.re.kr (Yongwon Cho)
Official website	www.kotra.or.kr www.investkorea.org	**ISBN**	979-11-6490-324-5 (95320)