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QUICK REPORT

TECHNOLOGY TREND ANALYSIS

Aerogel—a material literally full of air—and its applications

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Aerogels are made from gels of various raw materials—including silica, alumina, polymers, or carbon-based material—that remove solvents using methods such as supercritical drying. Thus, they contain an extremely high quantity of holes, giving them a porosity of over 90%. There is even an aerogel of which over 98% is air. In short, it is a solid with a hollow structure that is literally full of air. This means that aerogels have extremely low thermal conductivity, high sound-insulating properties, small refractive indexes, and other properties that could not be realized in conventional solids.

The properties of aerogels were discovered in the 1930s, so more than 80 years have already passed since we have understood their possible applications. Although they demonstrate highly fascinating properties as raw materials, it cannot be said that they have deeply penetrated the market as products. However, there are reports that the market for aerogels is continuing to expand worldwide due to various factors, including the recent high demand for thermal control systems. Therefore, in order to elucidate what kind of products aerogels could be used for and how market players in Japan are approaching them, we performed an analysis of patent publications related to aerogels within Japan.

Macro Trends in Aerogel-Related Patents

Our target population for aerogel-related patents consisted of Japanese unexamined patent applications (published and republished) since 1993, including all patents that contain the word "aerogel" (and all its possible spellings in Japanese) in the full body of their text. There were approximately 4,280 such patents. However, if we restricted our search field to summaries or claims, the number of patents was roughly 720.

The numbers for aerogel-related unexamined patent applications are shown in Figure 1. As the chart shows, the numbers have continued upward, with some rises and falls along the way. The rise since around 1996 is particularly notable.

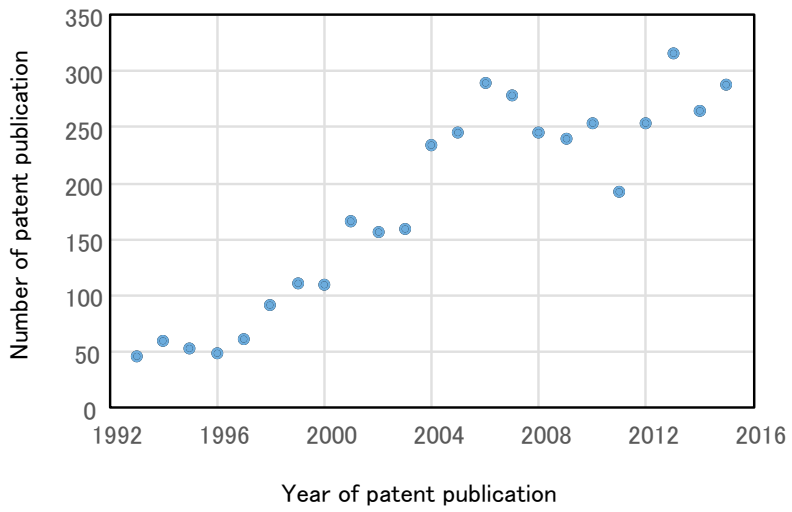

Figure 1 - Unexamined Patent Applications for Patents Related to Aerogels

The major players in all the patents we collected are shown in Figure 2. The company with the greatest number of unexamined patent applications in the period we looked at is Konica Minolta Japan, Inc. (TYO: 4902), followed by Panasonic Corporation (TYO: 6752), JSR Corporation (TYO: 4185), and Fujifilm (TYO: 4901). Meanwhile, although the top two patent applicants do not change if we narrow our field to patents published since 2011, there are changes in the lineup that follows. One change is that companies such as Adeka Corporation (TYO: 4401) and Mazda Motor Corporation (TYO: 7261) have moved up, while another is that foreign companies, such as 3M, Dow Corning, L'Oréal, and BASF, rank highly. Looking just at the patents, it is undeniable that the Japanese influence is slightly losing ground in terms of applications for aerogels.

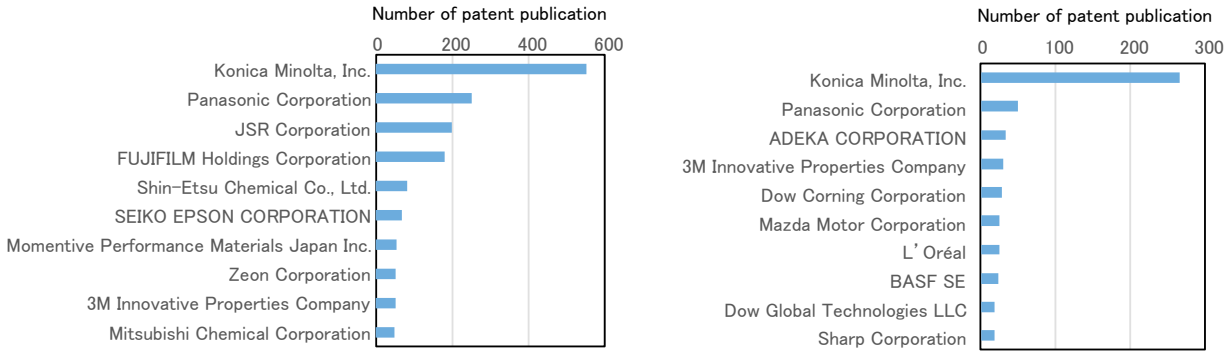

Figure 2 - Major Players in Patents Related to Aerogels (L) since 1993, (R) since 2011

Cluster Analysis of Aerogel-Related Patents

We performed a cluster analysis of the aerogel-related patents that we gathered, using our proprietary XLUS TechRadar system. The results of this analysis are shown in Figure 3. Our cluster analysis makes a visual representation of patents based on the mutual similarities among the full text of different patents. Therefore, patents that are

highly similar are located near each other, while those that differ are placed farther apart based on the degree of similarities. Furthermore, the direction of the axes holds no special meaning, and the entire structure is calculated so that it has the optimal position.

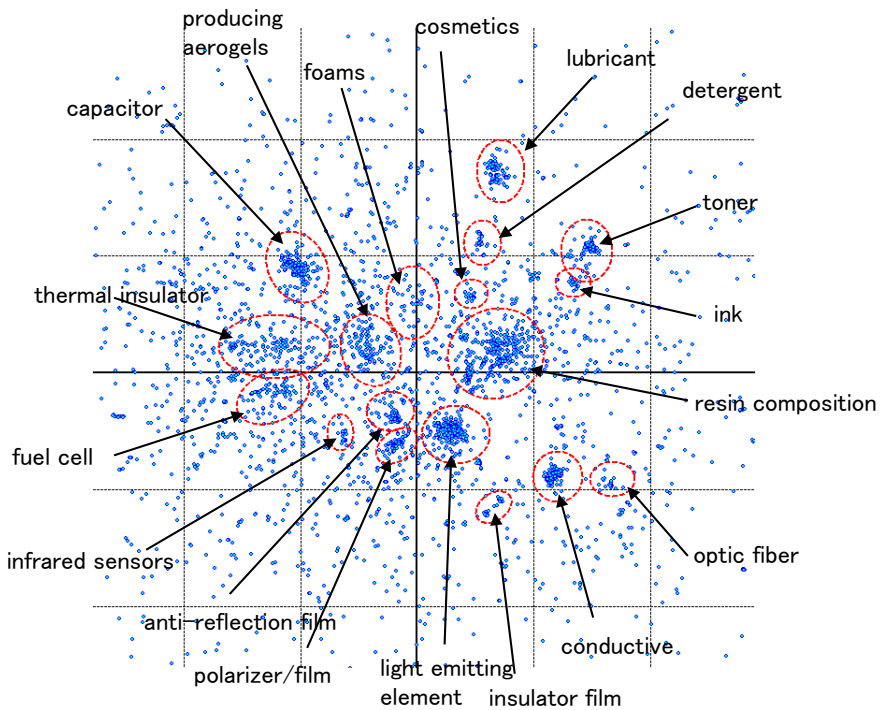

Figure 3 - Results of the Cluster Analysis of Aerogel-Related Patents

Looking at the results of our cluster analysis, several densely populated regions clearly take shape. Near the center of the chart, there is an accumulation of patents related to foam and to methods for producing aerogels, while patents related to applications extend into the surrounding areas. Applications for aerogels cover a variety of fields, among which we can see—in the upper right area of the chart—applications for cosmetics, detergents, lubricants, and image-formation-related applications such as toner and ink. For instance, aerogels are added to lubricants as thickeners, while they are added to products such as toners as fillers. These can be considered applications that utilize the network structure of aerogels. Moving to the bottom center of the cluster analysis chart, we see many patents related to optical applications, including light-emitting elements, polarizing plates, and anti-reflection coatings. These applications primarily exploit the low-refractive index of aerogels. Next, we see applications for infrared and other types of sensors to the right of the optics region, and these utilize the porosity of aerogels. The left side of the cluster analysis chart contains applications for heat-insulating materials, fuel cells, and capacitors. The heat-insulating materials make use of the low thermal conductivity of aerogels, while applications for fuel cells and capacitors use carbon aerogels, among others.

To see how the technology regions with aerogel-related patents have changed over the years, we made visualizations of the cluster analysis data, which are seen in Figure 4.

Within the diagrams, regions shown in red have a high density of patents, with the density decreasing, in order, from yellow to green and, finally, to blue. In addition, the vertical axes in Figure 4 all have the same scale.

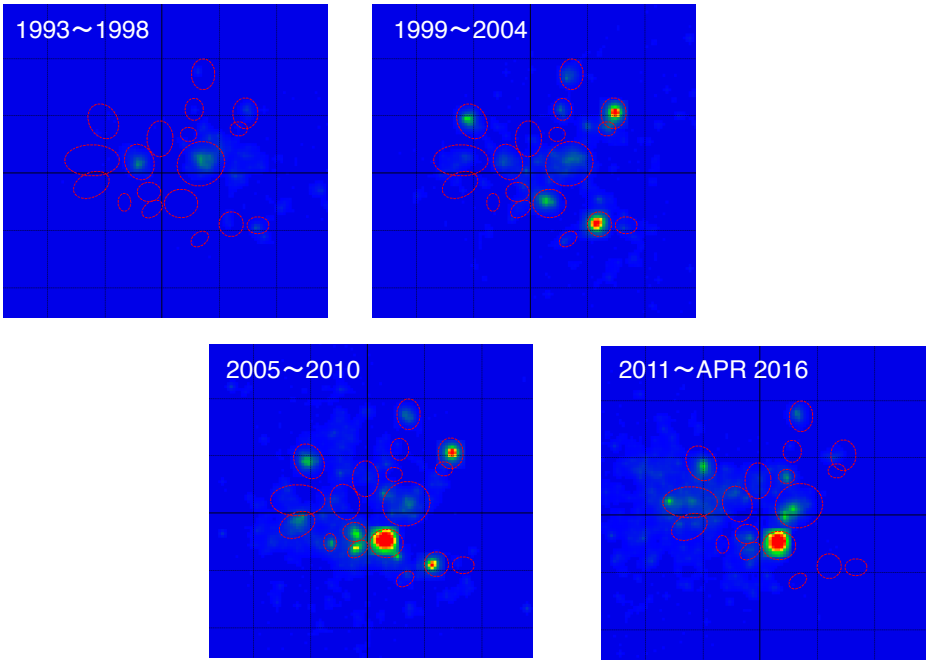

Figure 4 - Changes in Technology Regions for Aerogel-Related Patents

In the 1990s, patents were primarily seen in relation to aerogel production and resin compositions. Then, in the first half of the 2000s, patents started to be published for applications in products such as toners, conductive materials, and capacitors. In the second half of the 2000s, patent applicants shifted to optical applications. There was a particularly large number of patents for applications in light-emitting elements. There was also an increase in applications for products such as fuel cells. Finally, since 2011, we see a trend of increasing numbers of patents for applications in heat-insulating materials, along with applications for light-emitting elements.

Patent Application Regions for Major Players

The visualization of the patent application regions for major aerogel-related players is found in Figure 5, which shows the positions for applications from three companies that have been major players for the entire period of the analysis—Konica Minolta, Panasonic, and JSR—while Adeka and Mazda have been on the rise since 2011.

Looking to Konica Minolta, it is clear that its patent applications are focused on light-emitting elements. The company has a significant number of patents related to organic EL, and these applications describe using aerogels in the low-refractive index layers of organic EL applications. Konica Minolta's number of patents in this region beats other companies by a landslide, with over 500 patents. However, when we limit this to patents

that contain the word "aerogel" in their summaries or claims, the patents all but disappear. We believe this may be due to numerous applications for patents that do not necessarily focus on the aerogel applications for light-emitting elements.

Panasonic is characterized by patent applications that cover a wide range of regions. Its key application regions are in areas that include aerogel production, heat-insulating materials, infrared and other types of sensors, light-emitting elements, and optical fibers. Since 2011, the company has applied for a particularly large number of patents for heat-insulating material applications. Panasonic has 117 patent applications that contain the word "aerogel" in their summaries or claims, which is nearly half the total population of 248 patents, meaning that the company has many technologies that use aerogels. Moreover, in May 2015, it announced its heat-insulating sheet for electronic devices, which uses aerogels.

JSR has a significant number of patent applications for conductive materials, such as conductive elastomers and conductive rubber. However, when these are limited to summaries and claims, we see no patents, which means that the company is not likely to be specializing in aerogels. In addition, at present, we are only able to confirm that JSR has unexamined patent applications up through 2011.

Adeka debuted in the high ranks of patent applications in 2011, and these are aimed at regions related to photocurable resins and lubricants such as grease. However, we were unable to find any patents with "aerogel" in their summaries or claims, so we believe that Adeka is not applying for patents with a focus on aerogels.

Mazda's patent applications are found in the region for heat-insulating materials. They are specifically focused on heat insulation in engines. They are related to technologies that aim for results such as increasing the heat insulation in engines or reducing cooling loss; representative heat-insulating materials use hollow particles and other particles that are found in aerogels, such as balloon-type aerogels. We were also unable to find any patents with "aerogel" in Mazda’s patent summaries or claims.

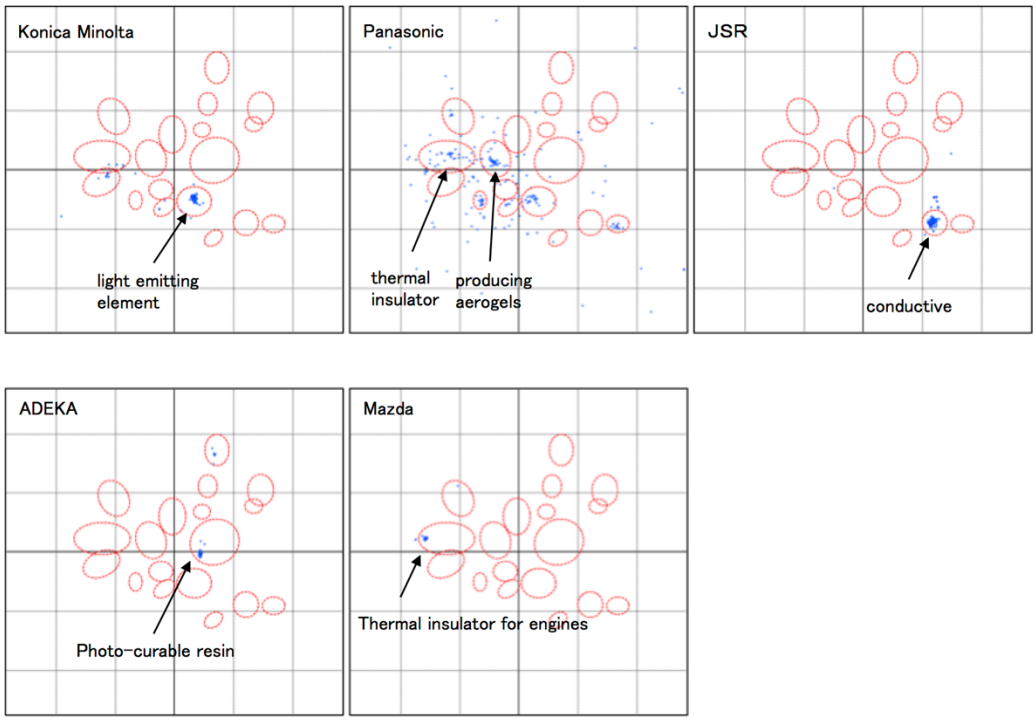

Figure 5 - Application Positions for Major Players in Patents Related to Aerogels

Conclusion

Aerogels are materials with properties that do not exist in conventional materials, including thermal insulation and low-refractive indexes. When we look at the number of academic publications related to aerogels, we see a growth trend, indicating that aerogels hold a high level of interest as a research topic. The US and China are leagues ahead in the number of research papers published. Japan also has many research papers on this topic, but it is roughly one-third of the numbers produced by the top two countries. Some market analysts expect aerogel-related markets to grow in the future. In addition, from the perspective of efficient energy use, we believe the properties of aerogels, such as low thermal conductivity and low-refractive indexes, make them attractive materials.

There is a bottleneck in lowering costs for aerogels, which is preventing their market penetration, but we believe that it is essential that market players plan for the low-cost production of aerogels and find applications for this unusual material. Therefore, we hope that aerogel research will become more active in Japan, so that the market can continue to see a variety of materials, reductions in their costs, more understanding of their properties, and the fine-tuning of their applications.

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