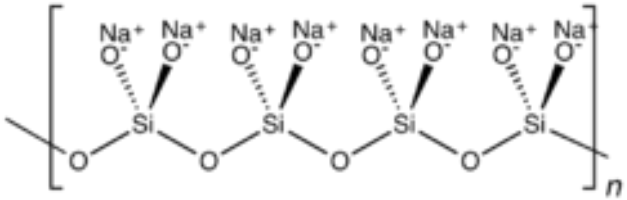
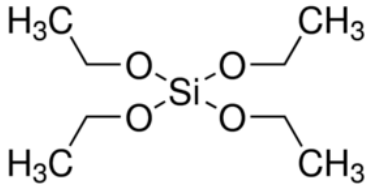
Silica Aerogel Precursors

- Silica aerogel was initially made by Kistler using sodium silicate (also termed waterglass) as the gel precursor. This is a cheap feedstock, but comes with strong capillary forces through the hydroxy groups.
- In the early 1970s tetramethyl orthosilicate (TMOS) was used as a replacement precursor. This was replaced by non-toxic and much safer tetraethyl orthosilicate (TEOS) or polyethoxydisiloxane (PEDS) in the early 1980s. More recently alternative precursors like methyltrimethoxysilane (MTMS) have been used, this gives advantages into forming different products, which can be flexible or with the capacity to form monoliths under ambiently dried conditions (this precursor is in the included slide). Functional fluorine modifications have also been investigated.

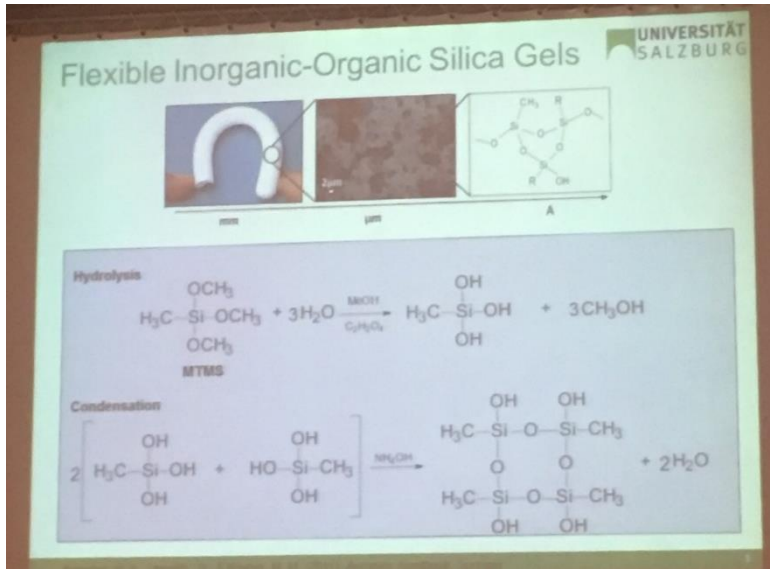


Waterglass



TEOS

As the silica aerogel industry expands it is important to consider the silane suppliers. Evonik are an important manufacturers:
"With its acquisition of the US company Silbond, Evonik consolidates its global market leadership in functional silanes"
March 2014, corporate.evonik.com



Source: *Photo taken at International seminar on aerogels 2016*

Powder Aerogel SWOT analysis

What is it?	Powder aerogels are the smallest aerogel particle size. Manufactured in a fast continuous process.
Who makes this?	JIOS (AeroVa) and Svenska Aerogel (Quartzene) are main manufacturers. REM-Tech and Insugel are also emerging companies.
Who uses this?	Products typically include including the powder into boards, blankets, coatings and paints.

Strengths	Weaknesses
• Cheap and modular manufacturing processes • Provides comparable properties to larger aerogel particles. • The smaller size is sometimes preferred for incorporation in certain products – granules are often jet milled for these purposes (eg cosmetics) • Easily included into composites.	• No transparency properties – no potential in daylighting applications. • The properties are not as favourable compared to that of the monolith or granule. In certain cases the thermal conductivity is not below stationary air, which removes the main strength as a super-insulator.
Opportunities	**Threats**
• The development in adding value to products away from blankets and panels such as coatings, paints, gypsum boards and concrete blocks are currently inaccessible to more expensive processes. • Main market players will be expanding production capacity faster than the granule manufacturers. Increasing supply and prominence as well as reducing cost.	• The development of advanced manufacturing procedures for granules could reduce the cost gap. • Alternative products (such as fumed silica) remain very cheap and prominent within many products.

Source: www.jiosaerogel.com

Antennas – Polymer Aerogels

The role of aerogel based RF antennas has been extensively researched by NASA. Upon licencing of their polyimide aerogel to FLEXcon and its affiliate, Blueshift international Materials, research has extended into antenna applications. This is particularly focused around the role in aerospace for the lightweight advantage, a typical commercial or military aircraft could have as many as 15 to 100 antennas, and improved bandwidth.

These antenna are essential for communication (voice, internet, data etc) and navigation (GPS) in aeronautical situations, but can also be used in electronic circuit boards or land based communication. The technology is mainly centred around printed circuit patch antennas, which are printed onto a specific substrate. Monolithic silica aerogels have previously been studied for this substrate role and the dielectric properties vary linearly with density, but the brittleness of the surface makes them impractical.

Polymer aerogels, and in particular polyimides, with different backbone chemistry have been investigated for the combination of low dielectric constant, strength/robustness, flexibility and low density. Fabrication was possible by either e-beam evaporation or ink-jet printed techniques. These polyimide substrates gave advantages (compared to PTFE laminates) of mass, bandwidth and gain. These were tested to support digital communication links in a range of aerospace platforms including UAV, commercial aircraft and cubesats.

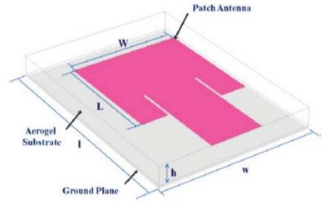


Figure 5.—Schematic of printed circuit patch antenna on an aerogel substrate (Ref. 1).

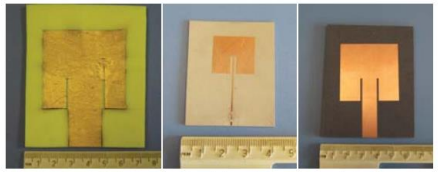
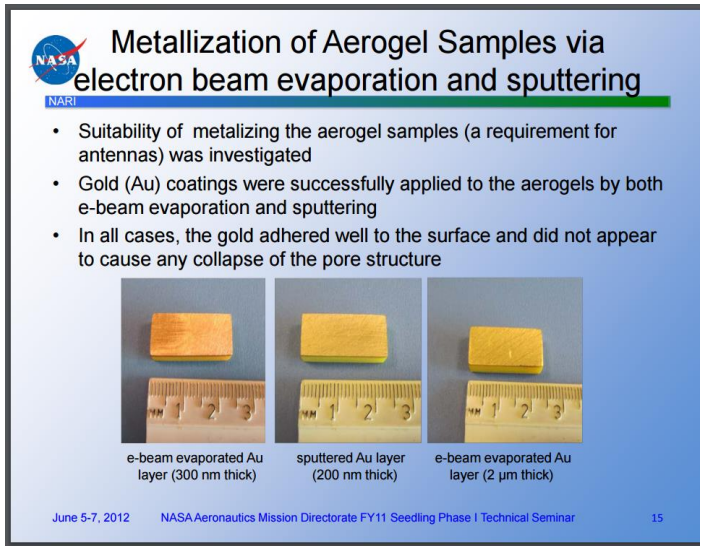


Figure 6.—Photograph of patch antenna on polyimide aerogel substrate (left), Rogers Duroid 6010 (ε_r = 10.2) (center); and Rogers Duroid 5880 (ε_r = 2.2)(right) (Ref. 1).



IDTechEx were told by Blueshift International Materials that they have a lot of interest in the use of the polyimide aerogel for antenna applications. They have many large projects in place that would not, at present, be disclosed. This includes work being carried out in conjunction with the ministry of defence. Blueshift can manufacture thin polyimide films in a roll-to-roll fashion.

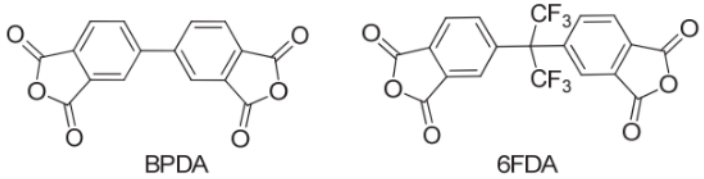


Figure 10.—Dianhydrides used in study.

Source: www.nasa.gov

1.8. JIOS Aerogel

Profile Type	Full Profile
Last Updated	08 Nov 2016
Ownership	Private Ownership
Interviewee Details	Patrick Stobbs 15642 Sand Canyon Ave #51537 Irvine California 92619 United States Contact us for more contact details
Interviewer Details	Richard Collins Email: r.collins@idtechex.com
IDTechEx score	7.8/10
Type of Business	Material Supplier
Product/Technology Category	Lightweighting
What they do	Manufacture powder silica aerogel products

Company Description

History

JIOS formed in 2010 after an innovative methodology for aerogel synthesis was established in a government funded lab in Korea.

The first 3-4 years we spent making the processes scalable and securing the relevant IP. This was then followed by business development, which involved setting up offices in California in 2013. The capacity production has developed over this times from 5 to 22 to 55 and currently 120 tonnes/year. There are plans in place to develop a 300 tonnes/year and 1000 tonnes/year plant.

Technology

JIOS produce a powder silica aerogel called AeroVa. This is manufactured in a fast, cheap continuous flow process. This begins with waterglass (sodium silicate) as the starting material, which is cheap and ubiquitous and the total process takes approximately 2 hours. The final product has trimethylsily end groups that provides the important hydrophobicity. This is done at ambient pressure and temperature.

AeroVa is formed in 3 grades: D20, D10 and D5. The number stands for the particle size in microns. The properties are included in the table below.

JIOS have also developed proprietary technology for a composite blanket. Here the AeroVa powder is liquefied and injected into the blanket.

Business Model & Market

The main market for AeroVa is to reduce the costs, and as a result increase the applications, of silica aerogel products. IDTechEx were told that Cabot granules are approximately $80-100 and that the final pricing of AeroVa is approximately half to a third of this. JIOS expected this to be half this value again in 5 years and in the future only $5-10 / kg. This low cost will allow it to compete with fumed silica and other conventional insulating products.