# SiC Fibres: the Key to Meeting the Highest Requirements for Energy Efficiency and Environmental Protection

**Technical megatrends in high-temperature applications with regard to energy efficiency, lightweight engineering and environmental protection ask for new materials and systems. New fibre-based ceramic components can be the solution for high-temperature applications.**

*Fig. 1*
*Prof. Dr Hubert Jäger*

BJS Ceramics GmbH/DE was founded in autumn 2014 by Prof. Dr Hubert Jäger (HJ), Professor of Lightweight Systems Engineering and Material Design at Dresden University of Technology/DE (Fig. 1). The company is engaged in the development, production and sale of non-oxide high-performance ceramic fibres as well as precursor and derived products on SiC basis, especially for high-temperature and high-corrosion applications. In February 2015, MT Aerospace AG, an aerospace company based in Augsburg, sold its Ceramic Composites Division to BJS Composites GmbH which was founded in the process. BJS Composites is a company set up for the development and production of ceramic fibres and composites. BJS took over the buildings and facilities at the Gersthofen site as well as the patent and brand rights. BJS Composites is a subsidiary of BJS Ceramics GmbH. The BJS companies collaborate with the leading companies in these industries and the relevant scientific centres of expertise.

***CA:*** *The range of activities of the companies you have founded includes the further development of fibre materials as well as their sales and marketing. What was your motivation to concentrate on this segment of technical ceramics?*
**HJ:** From my long industry and research activities I know that the technical megatrends in high-temperature applications with regard to energy efficiency, lightweight engineering and environmental protection cannot be addressed based on the optimization of existing systems. We have to introduce new materials and systems into industrial application. By way of example, I should like to mention the challenges for aircraft engines with the following goals by 2020: noise: –50 %, $CO_2$: –50 %, $NO_x$: –80 %, which are to be combined with an improvement in efficiency. In this context, the topic of lightweight engineering becomes important. Turbine components for aviation are typical components that we can apply in other applications in energy engineering. Our ceramic composites enable a reduction in noise and pollutant emissions and an increase in energy efficiency.
Ground breaking for our production concept are procedures that have been realized in the field of carbon fibres or carbon composites and are therefore valuable as a guide.
In Germany we have shown repeatedly that we are leading in basic development, which is supported with extensive, public funds. The industrial application of such know-how, however, is often realized abroad because there is funding gap when it comes to getting such valuable findings verified in pilot plants and introduced in industrial application. We are talking here about investments in the order of more than EUR 10 million that cannot be financed by industry in advance as these new technologies are still associated with technical risks and need further development.

***CA:*** *In what industrial applications are fibre-based ceramic components used? Where do you expect the biggest growth rates?*
**HJ:** Besides aerospace engineering as well as energy and environmental engineering, markets for anti-corrosion and high-temperature materials naturally include, for example, the iron and steel industry, the automotive industry, mechanical engineering and the chemicals branch. The SiC fibre market is currently dominated by Japan (Fig. 2). In a first approach, it is important, however, to bring to the market an integrated

concept that meets the highest requirements, from which the results can be quickly derived for other applications.

An important project is the air turbine, where materials have to be selected to accommodate the temperature load and ensure the necessary creep resistance. To design the turbines to be more energy-efficient, metal-based components have to be replaced. SiC/SiC fibre materials are predestined for the high-temperature range (1100–1500 °C). In the cooling zone below 1000 °C, oxide-based fibre materials or CMC can be used. Special alloys (1000–1200 °C) reach their limits with regard to temperature stability, even if great effort is made with cooling systems, as these are highly temperature-sensitive.

***CA:*** *Does the topic of carcinogenicity have to be addressed when it comes to the production of materials or the installation of components in modules for industrial use?*

**HJ:** SiC fibres are isotropic, and for that reason there is no risk of them breaking into particles with a critical aspect ratio (length/diameter >5). For this reason, this problem is not conceivable.

***CA:*** *What market position does Europe/Germany hold in respect of the development situation and industrial application in fibre-based ceramic applications?*

**HJ:** At this point, I can only refer to my words on my motivation in founding BJS. We have to extract ourselves from the dilemma of leaving good research findings unutilized in the final reports of the publicly funded projects. With Fraunhofer, we have in Germany one of the most important research organizations for applied industrial research in the world. Together with Fraunhofer ISC Würzburg and Fraunhofer HTL Bayreuth, we are seeking possible solutions to set up SiC fibre production on pilot plant scale.

According to our investigations, the market demand is something over 20 t/a, this demand will, however, increase substantially in the next few years, especially when other applications, e.g. for the aircraft turbine, are developed. The pilot plant in Bayreuth at Fraunhofer HTL is to be designed for 5 t/a in development operation. BJS wants to achieve sales of a total of 3–4 t/a by 2018. In the years following, these are to increase to 5 t/a.

***CA:*** *Besides technical property profiles, market success is heavily dependent on the kilo price of the materials. What are the orders of magnitude for the material groups from today's point of view? Can the market price be lowered so far based on an increase in volume that the materials are no longer reserved for "premium applications"?*

**HJ:** For high-quality SiC fibres for application temperatures above 1100 °C, the kilo price is above EUR 5000. In comparison with this, $Al_2O_3$ fibres: EUR 260–900, carbon fibres depending on type: EUR 20–80 (HT), EUR 80–500 (HM), EUR 500–1000 (UHM).

The prices of SiC fibres are determined largely by the raw material price, which is tied to the property profile of the fibres to be produced and naturally the process costs of the fibre production. The production costs can be minimized with increasing volumes, e.g. with automation measures. The cheaper raw material costs can only be achieved with further development measures, which must be financed based on a distribution of the technology.

***CA:*** *These processes have to be supported by industry-oriented R&D activities. What R&D networks do you see besides the activities you have already mentioned?*

**HJ:** Back in 2007, Carbon Composites e.V. (CCeV) was founded. That is an alliance of companies and research institutes covering the entire value-added chain of high-performance fibre composites in Germany, Austria and Switzerland. In the meantime, this association has 280 members, 80 % of whom come from industry (users, suppliers). Joint projects bring together the members of the Carbon Composites network on key topics in the sector. Regional and supraregional projects are initiated with which the future of carbon and ceramic composites is being shaped, the CC Ceramics group has stewarded the further development of high-performance ceramics.

***CA:*** *High-temperature lightweight engineering is important to you. How can fibre-based ceramics, here in competition with "superalloys", be seen?*

**HJ:** I am an advocate of hybrid approaches because we in ceramics have to understand the other materials (alloys, composites) so as to enable continuous benchmarking. Only in this way can we achieve the best solution in economic and technical terms.

I also see potential for development in SiC fibres with regard to higher creep resistance based on optimization of the crystal structure. This further development depends on us precisely analysing the required property profiles of the components and adapting the materials to these.

***CA:*** *Can additive manufacturing be used for fibre-based ceramics?*

**HJ:** It is important for us to look at this as it will be vital when we need bionic structures. As additive manufacturing is neutral in terms of unit costs, it will be too expensive for simple shapes or high unit numbers. Complex shapes have to be individually analysed with regard to system costs.

***CA:*** *Thank you for talking to us.* KS

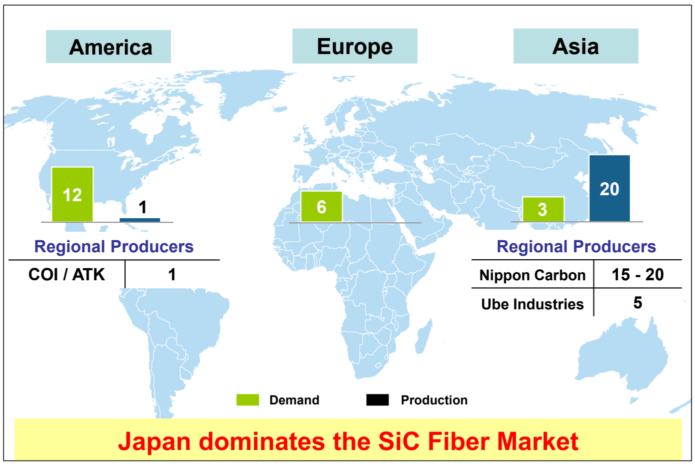


*Fig. 2*
*SiC fibre markets*