Jäger
High Performance Spindles

Alfred Jäger - The right choice

High Frequency Spindles for Micro-Precision cutting of brittle hard materials

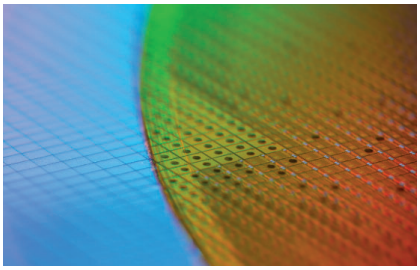
High-performance materials such as silicon and ceramic materials have special material properties.

In particular, they stand out through a high level of hardness, a high modulus of elasticity, low density and extensive insensitivity to chemical substances.

The high hardness of the ceramic materials favors their use for components that are exposed to high levels of abrasive wear are.

Ceramic materials are increasingly being used for technical components and implants. The ceramics are used in medical technology, e.g. for artificial dentures.

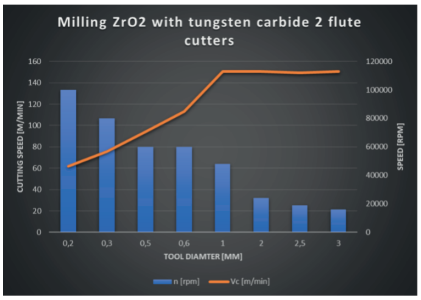
Semiconductors made from Silicon wafers have become indispensable in our digitized world.



Silcion wafer with mechanically drilled holes

Machining of brittle materials - requirements for the spindle

The spread of tool diameters used in Micro-precision cutting can be considered between 0,2 mm and 3 mm.



Typical parameter for milling of zirconia (Dental industry)

Either milling of brittle hard materials with geometrically determined cutting edges (limited to machining zirconia) or grinding with geometrically undefined is a challenge compared to machining of metal.

The great hardness and lack ductility of high-performance ceramics lead to low tool life, low material removal rates and poor surface qualities. As a rule, an increase in the cutting speed leads to an improvement in the surface finish achieved.

The reason lies in the reduction of the mean chipping thickness (more cutting edges per unit of time in the cutting process), with a decrease in the grinding forces (reduced stress on the individual abrasive grain) and as a result improvement of wear behavior.

However, the thermal load increases of tool and workpiece. The reduction in peripheral speed results, usually due to opposed processes, to a reduction of the surface quality. [Holzhüter02]

When the grit cutting edge penetrates the material, brittle material machining causes grit radial and lateral cracks in the workpiece material. The actual chip removal occurs through the lateral cracks that cause the chipping of the material. [Klocke18_1].

In contrast to metal processing, ceramic processing fundamentally occurs increased process forces, especially in the normal direction [TIO90].

These forces must be compensated by correspondingly stiff machines and spindle systems. Otherwise, systems that are too soft and yielding lead to reduced dimensional and shape accuracies of the generated functional surfaces. [Klocke18_2]

Consequently the spindle must offer good stiffness characteristics in radial and axial direction and must have on the one hand a speed of 100.000 rpm on the other hand enough power/torque for the roughing of the work piece with a 3 mm tool. The comparison to plowing a field with a Porsche suggests itself. The 5-axis machining of dentures makes it necessary to design spindles with considerable long overhanging spindle shaft noses and makes it obligatory using long tools. Rigidity and long tools/long spindle noses are diametrically opposed requirements and make compromises in terms of productivity necessary.

Various Dental tools with 3 mm shank diameter for dentures - Photos property of HPTec

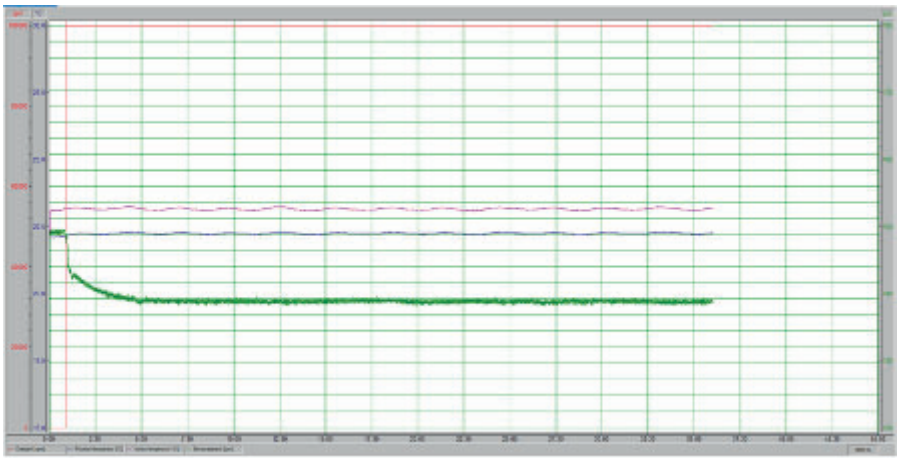
Powerful - Compact and light weighted as well as thermally constant for a demanding application

Alfred Jäger designs and manufactures the motors she uses in her high frequency spindles herself. By doing so **Alfred Jäger** can design the motor to that very purpose – small and compact on the one hand, sufficient power for the challenging roughing on the other hand. Combined with the motor design focus on having the lowest temperature losses **Alfred Jäger** spindles are the perfect match for this demanding application. The geometric accuracy requirements on workpieces made of brittle hard material is usually outstanding high. A thermally expansion of the spindle shaft is undesirable and the heat input of the spindle into the machine as well.

The spindle has to be thermally saturated as quick as possible due to productivity reasons and has to be constant during the operation in order to limit the thermal impact to the accuracy to a minimum.

To achieve such a thermally constant spindle an extraordinarily effective motor design and an outstanding cooling concept must work together here.

Milling of Zr02



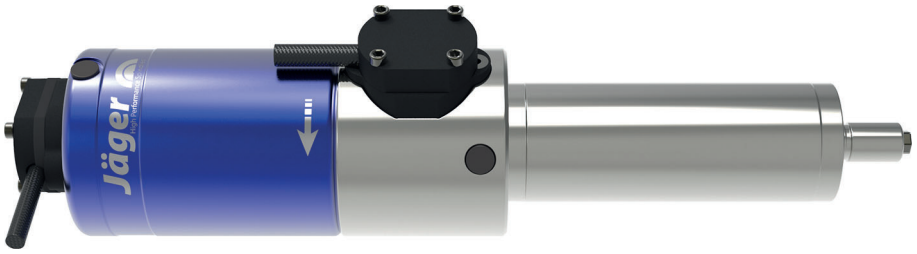
Z33 @ 100.000 rpm thermal behavior saturated after minutes, constant within 1 µm derivation > 30 minutes

Greased for life - The best matching bearing lubrication principle for sensitive parts

When machining silicon and ceramic materials which, for example, have hygroscopic properties in the unsintered state, as well as in medical applications, the grease-lubricated spindle is often preferred to the oil/air-lubricated variant. This prevents contamination of the workpiece which might be critical especially for implants. In addition to the cost aspect, other reasons for permanent grease lubrication are, for example, the reduction of the possibility of errors (e.g. due to improper handling of oil-air lubrication units, or the use of unsuitable or insufficiently pure oils).

The execution and accuracy of the tool interface is decisive for the achievable accuracy

The fewer interfaces between the tool and the spindle, the higher the achievable clamping accuracy. Alternative clamping systems for micro-machining of brittle hard materials are the HSK taper, preferably with a heat-shrink connection or the polygon clamping principle, or direct tool shank clamping. The disadvantage here is that all tools in the process must have the same shank diameter which in specific branches like the dental industry is state-of the art. In order to reduce the air consumption and consequently the CO2 footprint Alfred Jäger spindles can be equipped with an electrical release unit instead of a pneumatic cylinder.



Z33 spindle 100.000 rpm, 0,65 kW with electric release unit

Alfred Jäger product range – examples for products for the micro-precision cutting of brittle hard material:

Spindel Type	max. speed (rpm)	Tool interface
Z33	100.000	Direct Tool Shank Chucking
Denta Drive X.O	100.000	Direct Tool Shank Chucking
Z62 H370	70.000	HSK E 20
Z62 H460	60.000	HSK E 25
Z100 H540	40.000	HSK E 32
B150	26.000	HSK E 40

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