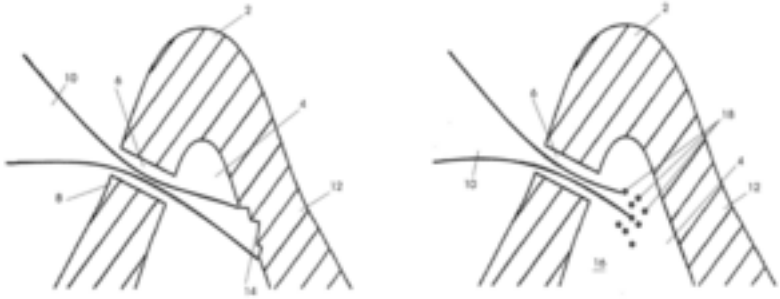
Absorbing nanoparticle-suspension for laser drilling

To protect the material at the backside of a workpiece during laser drilling or cutting, an absorbing material is used. Here a nanoparticle-suspension provides a particularly efficient protection with further advantages like cooling.

Challenge



Laser drilling without backing material damages the workpiece. A nanoparticle-suspension helps to prevent the damage. (Source: Patent application DE102013212665B4)

During laser drilling, material situated behind the bore can be easily damaged by laser radiation. A common problem, for example, during the manufacturing of injection nozzles. To prevent the damage, a material which absorbs the majority of the laser radiation is placed at the working side. The material can be a solid which typically absorbs almost all of the radiation but has the disadvantage that it cannot be used if the geometry of the workpiece makes it impossible to place a solid material behind the bore. Furthermore, the solid has to be replaced from time to time. Particle suspensions are a more flexible alternative. However, to achieve a sufficient absorption rate, the particle concentration has to be high. A high particle concentration leads to a very viscous liquid and thus the liquid flows slowly. In consequence, the risk that the liquid evaporates locally and the protection fails is increased.

Our Solution

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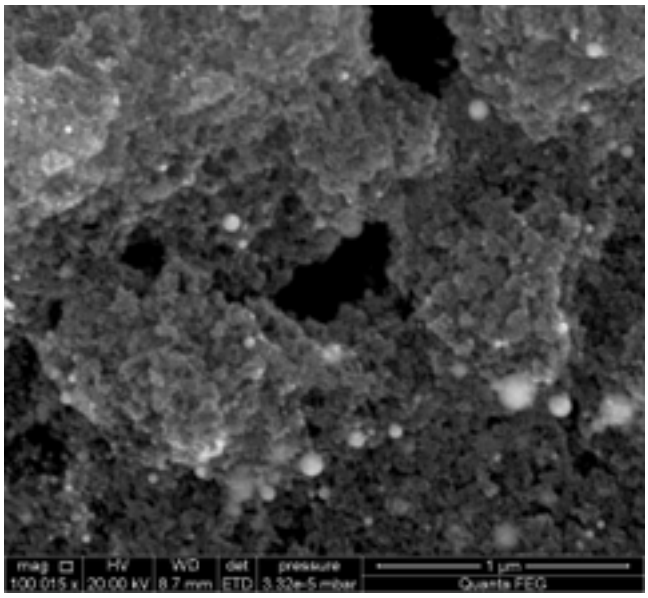

Abbildung 2: EM-Aufnahme: Gold- und Titanoxid-Nanopartikel

At the Laser Zentrum Hannover a particle suspension has been created containing nanoparticles which offers excellent absorption properties. The high shielding efficiency is caused by plasmon resonance which occurs for example if gold-nanoparticles are used. Due to their small size, the nanoparticles are not further fragmented by the laser radiation. The suspension can thus be used indefinitely. The suspension has a low viscosity and is thus also ideally suited to be constantly pumped through the working area. This flow offers the additional advantage of cooling and removes the debris caused by the drilling. Gold-particles with a diameter of 5 nm offer the best protection at a laser wavelength of 515 nm.In order to achieve better wavelength coverage, the concept has been expanded. The gold particles attach to the surface of the microparticles. Thus, absorption properties of the protective medium are extended to the range of 1064 nm. The Figure 2 shows the combination of gold and titanium oxide nanoparticles. Furthermore, the method can be combined with various nanoparticulate components, having absorbent properties, and with different microparticles. The solvents can also be varied (water, oils, organic solvents).

Advantages

- High absorption rate due to plasmon resonance

- Low viscosity
- Long service lifetime
- Debris caused by drilling can be removed
- Cools the working area

Applications

- Laser drilling
- Manufacturing of injection nozzles or turbine blades
- Cutting of tubes with small inner diameter (e.g. stents)

Developmental Status

The efficacy of the nanoparticle-suspenison has been demonstrated in several tests and experiments.

Patent Status

Granted German patent: DE102013212665B4
Granted German patent: DE102017116943B4
Granted Chinese patent: CN105339127
International patent: WO2019020741A1

Further patent applications in Brazil, Europe, India, Japan, Korea and the USA.

Applicants:
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(2) Robert Bosch GmbH

For BR, KR, IN and JP is (2) the only remaining applicant.

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