Industrial Solutions
Process Technologies

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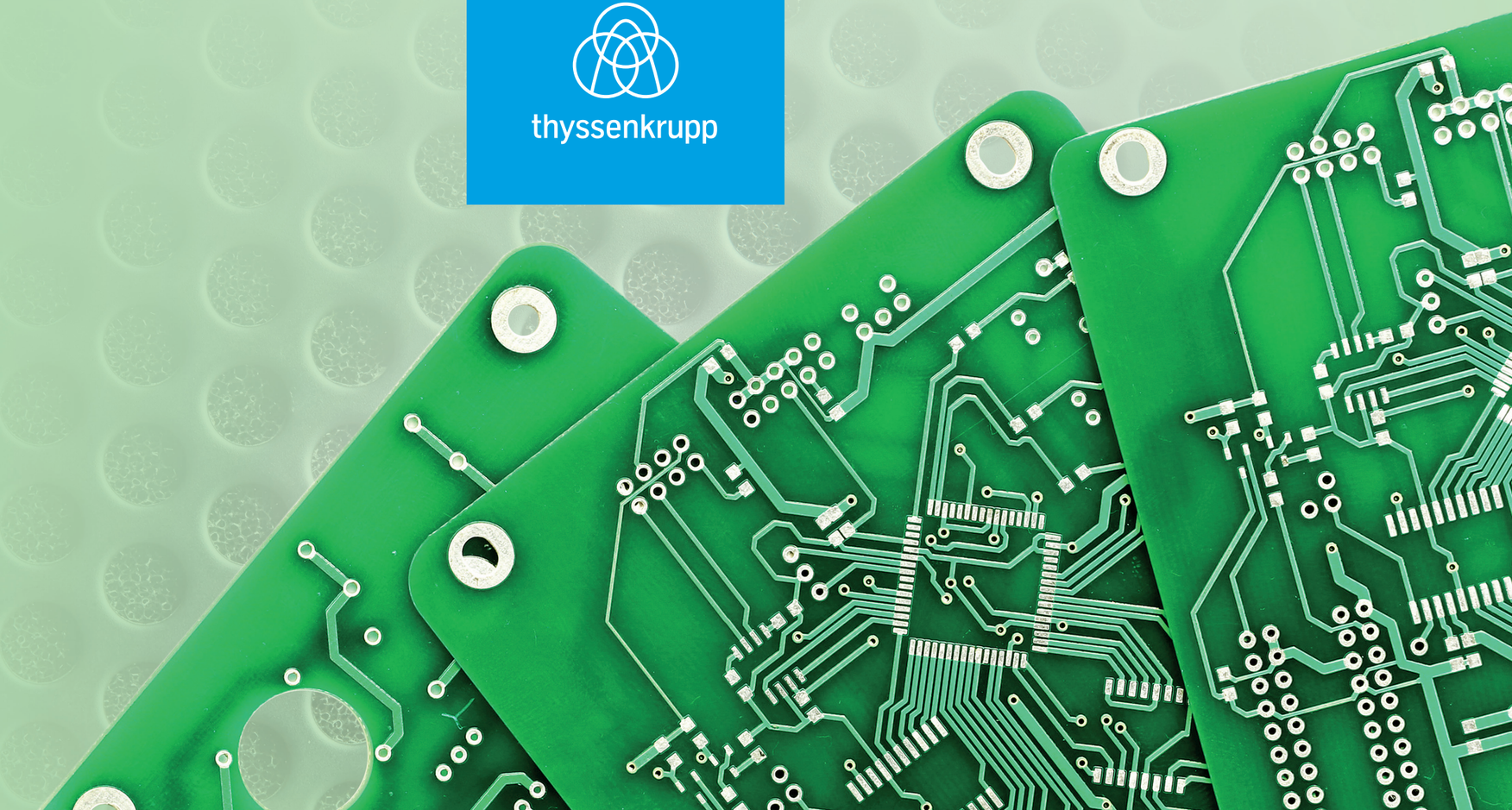
Industrial Solutions

Shaped materials

Aerogels

thyssenkrupp



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Supercritical treatment of shaped materials

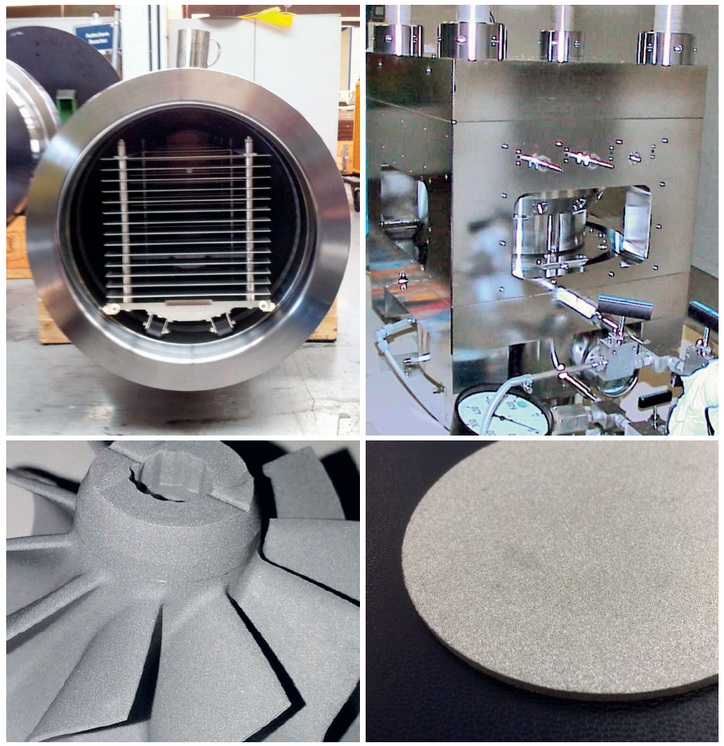
The treatment of shaped solid materials with supercritical CO_2 ($scCO_2$) has moved in the area of interest during the last few years. Not only is it useful with regard to cleaning complex structured materials but also in some production steps it can be used for removing unwanted process reactants. Since being an inert gas and readily available, CO_2 supercedes traditional cleaning agents in many ways.

Debinding of components / parts

The powder injection moulding process is an easy way of producing very complex shaped components with different kinds of properties depending on the powder used for the fabrication. However, in this process the binder has to be removed after the process and before the sintering process. This can be achieved by extraction using supercritical CO_2 as extraction agent. The binder can be retrieved in a separate vessel after expansion of the CO_2 and can thus be reused in the process.

Cleaning process using silicon wafers as example

Silicon wafers are used for electronic compounds like storage media, processors, etc. For these areas of application the wafers have to be free of contaminants. Therefore, after the creation of the wafers, an additional cleaning step is introduced. This cleaning can be done using supercritical CO_2. Besides being able to remove the contaminants from the wafer no solvent or other contaminant stays on the material, since after the relaxation step the gaseous CO_2 can be removed easily. The advantage of using $scCO_2$ in this process is found in its low surface tension which leads to a fast diffusion inside the material.



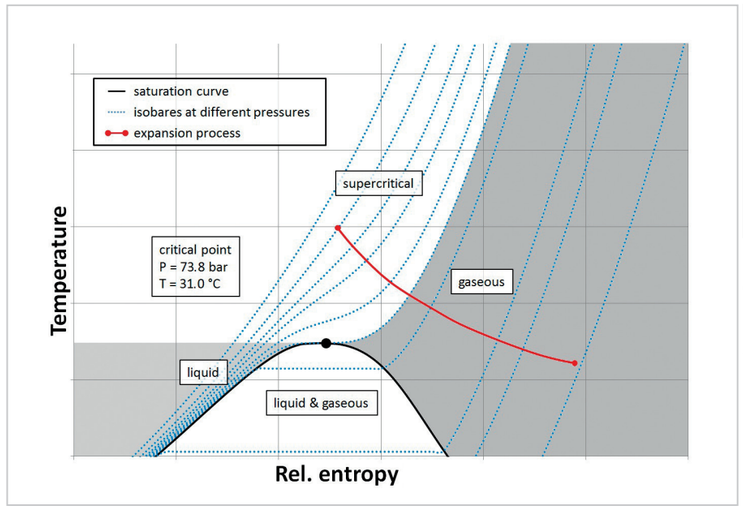
Picture top left: special handling designs in the autoclaves for different applications

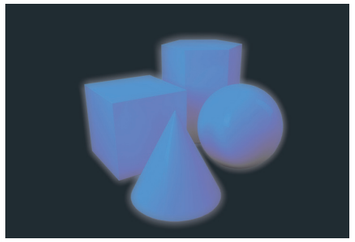
Picture top right: high pressure equipment for cleaning of wafers

Picture bottom left: metal turbine part used e.g. in vacuum cleaners

Picture bottom right: sintered metal plates used for special sieving operations

Drying process of aerogels using supercritical CO_2





Picture top: aerogels for industrial applications used especially as insulation material

Picture left: expansion process of the areogel drying process shown in a simplified T-s-diagram avoiding the two-phase region liquid-gas

Aerogels - high performance insulation materials

Aerogels are products either in shaped form or as small particles which show several outstanding product characteristics. The most important ones being

- High stability
- Non-flammability
- Low heat conductivity

In the former years these materials have drawn attention as special insulation materials due to these properties. Since the heat conductivity is generally much lower than standard insulation materials, aerogels are of special interest in applications with small space requirements such as refrigerators, old-building renovation, planes and even space shuttles.

Aerogel production process

Aerogels are traditionally produced using the sol-gel-process, where a solution of a network building material (generally on silicate basis, but polymers are also possible) is used to form a fine porous structure. After the removal of the solvent from this material the aerogel is obtained. This process step is also the most critical, since a normal evaporation of the solvent would destroy the fine porous structure of the gel and thus leads to a considerable deformation of the product.

Aerogel drying process

An approach for the drying process is using supercritical CO_2 as drying agent to replace the solvent in the aerogel. Afterwards, the supercritical CO_2 can be expanded to the gaseous state preventing an unwanted phase change from liquid to gas.

Advantages of $scCO_2$ for the drying process

- No thermal stress which could damage sensitive material
- Solvent can be recovered purely for re-use
- Non-toxicity of CO_2
- Non-flammability of CO_2