# Defining Ceramics

# 1. Advanced Ceramics

What would the ancient China have been without china? Imperfect! What would be the life of today without dental prostheses? Painful! What would be the space shuttle without thermal tiles? Disastrous! What would be the daily communication without mobile phones? Unimaginable! Is it thus carrying things too far that ceramic materials are objects of technologies of the past, the present, and the future? No way! But what are ceramic materials actually? Which structure do they have? How are their properties related to their structure? How are these manufactured? How are these modeled? Going somewhat beyond the conventional textbooks and the conventional monographs on modern ceramics, in the chapters that follow, an elaborate picture of modern ceramics is developed.

Going beyond the hellenic word *keramos* ("fired soil"), on the one hand, *ceramics* is defined as a name for products made out of non-metallic inorganic substances, and on the other hand, *ceramics* is defined as the art and science of making materials and products of non-metallic inorganic substances [28]. Naturally, following the standards of modern physics and modern chemistry, we want to associate the notion *non-metallic* with non-metallic energy band structures and their dependence on further constraints such as temperature and pressure, and we want to associate the notion *inorganic* with substances not showing the chemical structures of hydrocarbons. Certainly, we want to appreciate *conventional ceramics*, but we want to focus on *advanced ceramics*. We here compare with Figure 1.1, which shows the classifications, the definitions, and the terminology used in this book, and we here compare with Figures 1.2–1.13, which show some selected starting materials as well as some selected products of various branches of the ceramic industry.

We should already here appreciate that advanced ceramics meets the highest demands of present technologies. For instance, many ceramic materials are extremly resistant against abrasion! For instance, many ceramic materials are extremly resistant against heat! For instance, depending on further constraints such as temperature and pressure, ceramic materials can be insulators, ceramic materials can be conductors, and ceramic materials can be semi-conductors. Dear reader, ceramic materials even can be ferroelectrics without which the performance of present communication technology would be more than poor. Dear reader, the hip joint endoprostheses that are shown in Figure 1.10 are implants meanwhile doing their job in hundreds of millions of human bodies worldwide! Isn't this a feat?

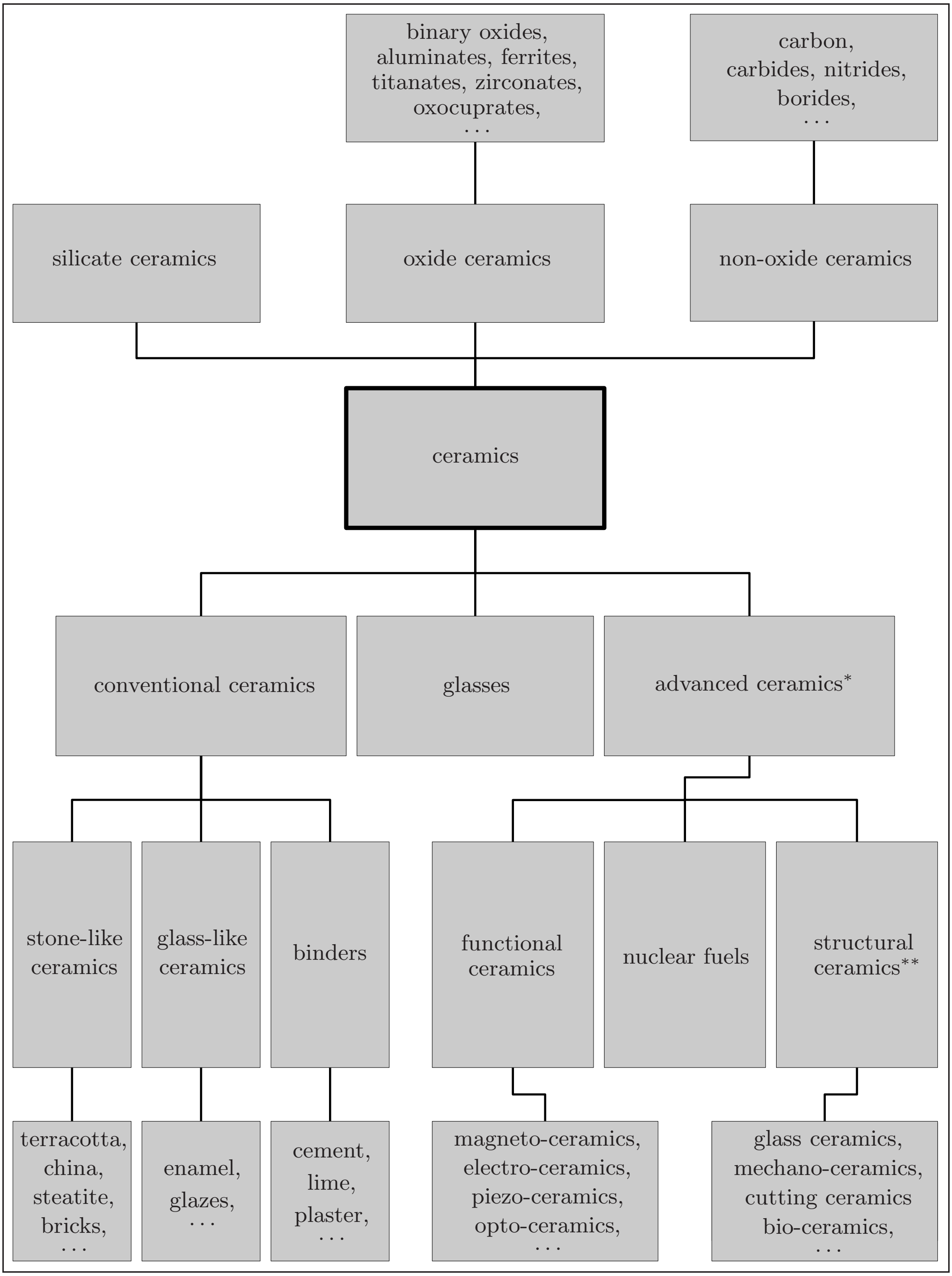
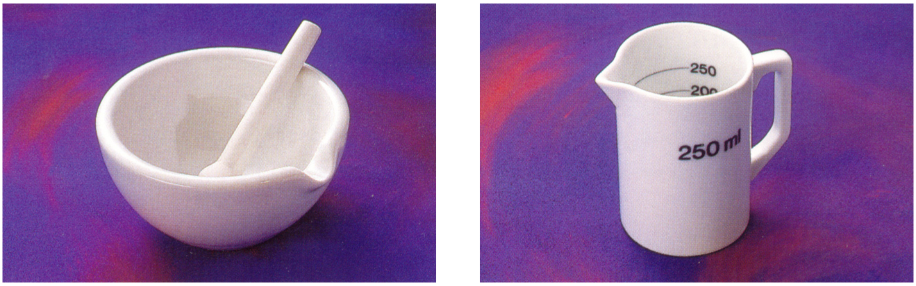



**Figure 1.1.** Classifications, definitions, and terminology. * frequently noted as "fine ceramics" (Japan) or "Hochleistungskeramik" (Germany). ** frequently noted as "engineering ceramics" (USA, GB) or "Ingenieurkeramik" (Germany).


**Figure 1.2.** Mineral stones and powdered artifical non-metallic inorganic materials.




aluminium oxide ($Al_2O_3$)

**Figure 1.3.** Laboratory ware.

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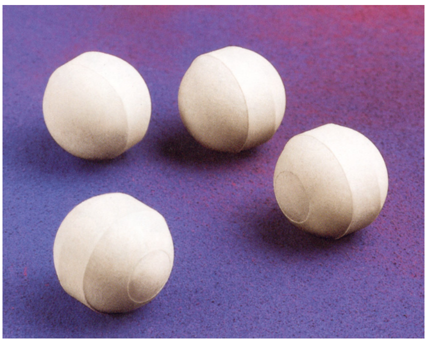
magnesium silicate
($Mg_3Si_4O_{10}$ hydroxide: steatite)



aluminium oxide ($Al_2O_3$)

**Figure 1.4.** Grinding balls.

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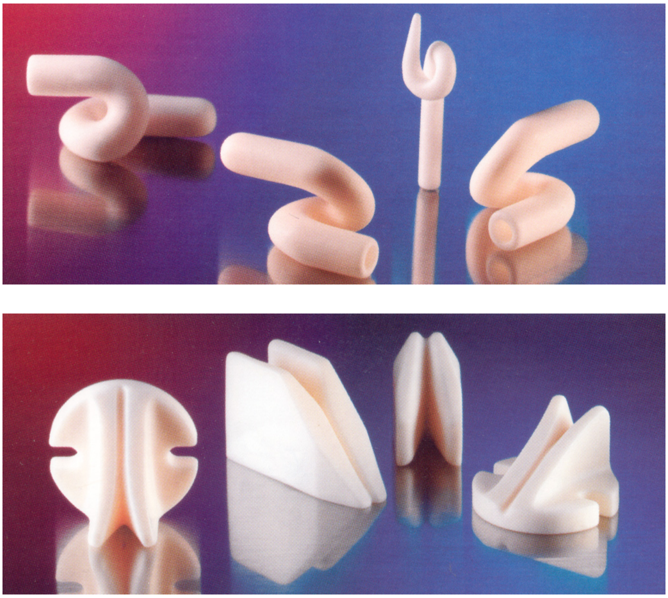

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**Figure 1.5.** Textile machinery components. Pigtails (top) and oiler guides (bottom).

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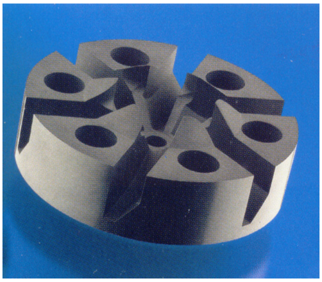
**Figure 1.6.** Ceramic cutters. Scissors (top) and knives (bottom).



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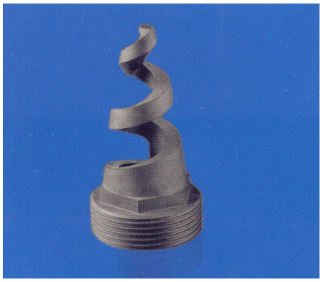

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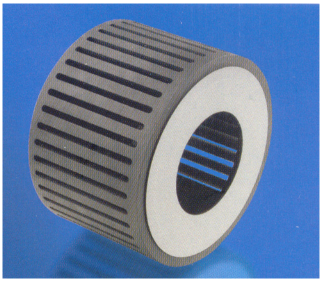
silicium carbide (SiC), SSiC or SiSiC



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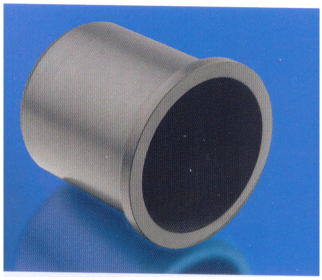
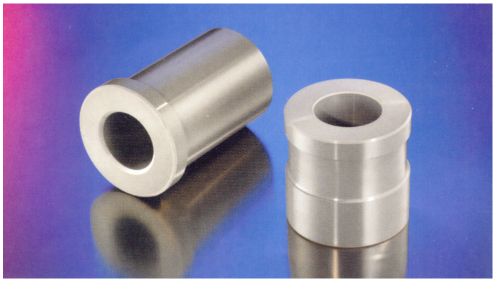


**Figure 1.7.** Components for industrial machinery and industrial facilities. SSiC: sintered SiC. SiSiC: Si-infiltrated SiC.



silicon nitride ($Si_3N_4$), $Y_2O_3$ stabilized

SL 200 BG
(CeramTec)

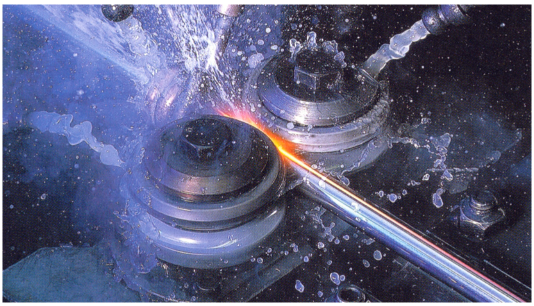


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**Figure 1.8.** Welding rollers (top) and their application (bottom). The lower picture shows a facility for pipe welding.

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liquid-phase sintered
silicon nitride ($Si_3N_4$)

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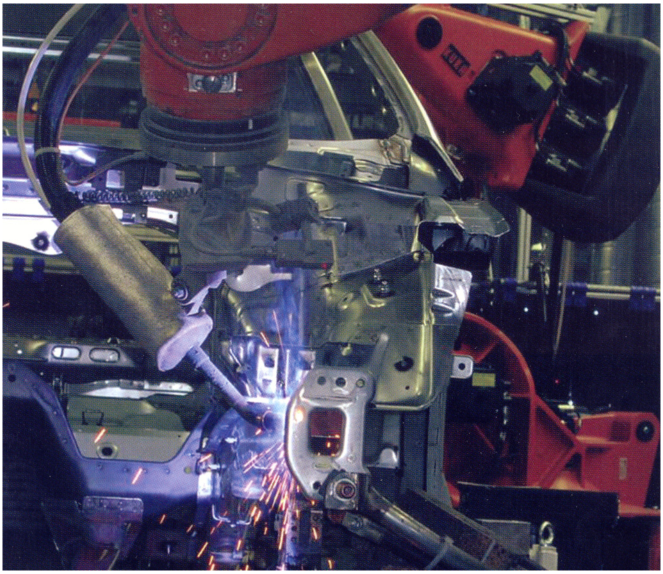

**Figure 1.9.** Centering pins for welding processes (top) and their application (bottom). The lower picture shows a facility for metal active gas welding.


**Figure 1.10.** Hip joint endoprosthesis (top) and its application (bottom).

image kindly provided
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**Figure 1.11.** Ball (roller) bearings.


images kindly provided by SGL Brakes GmbH

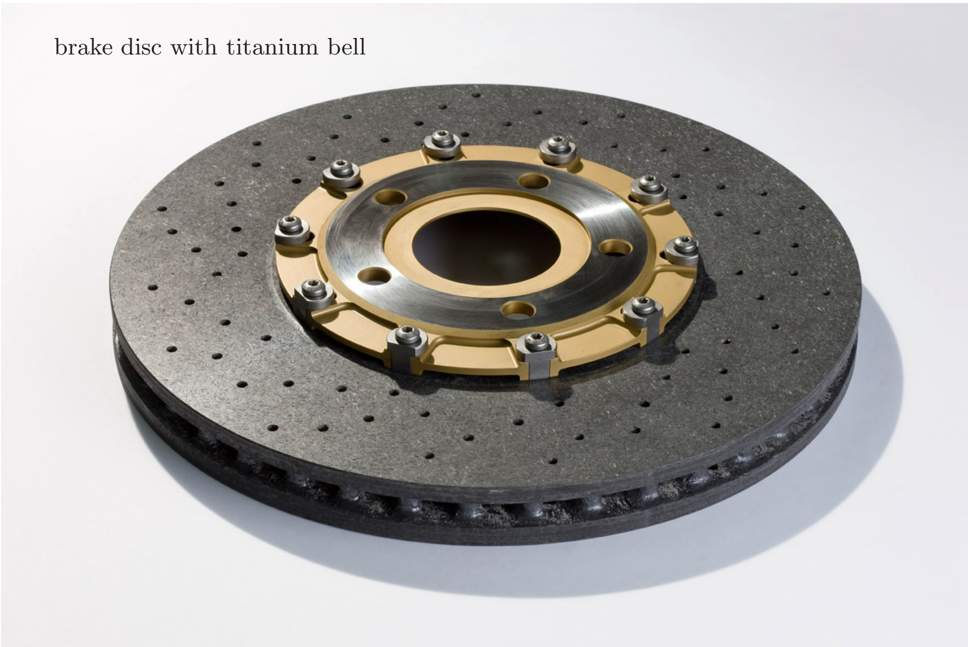


**Figure 1.12.** Ceramic (carbon) brake discs.

taken from the VAWsc picture archive

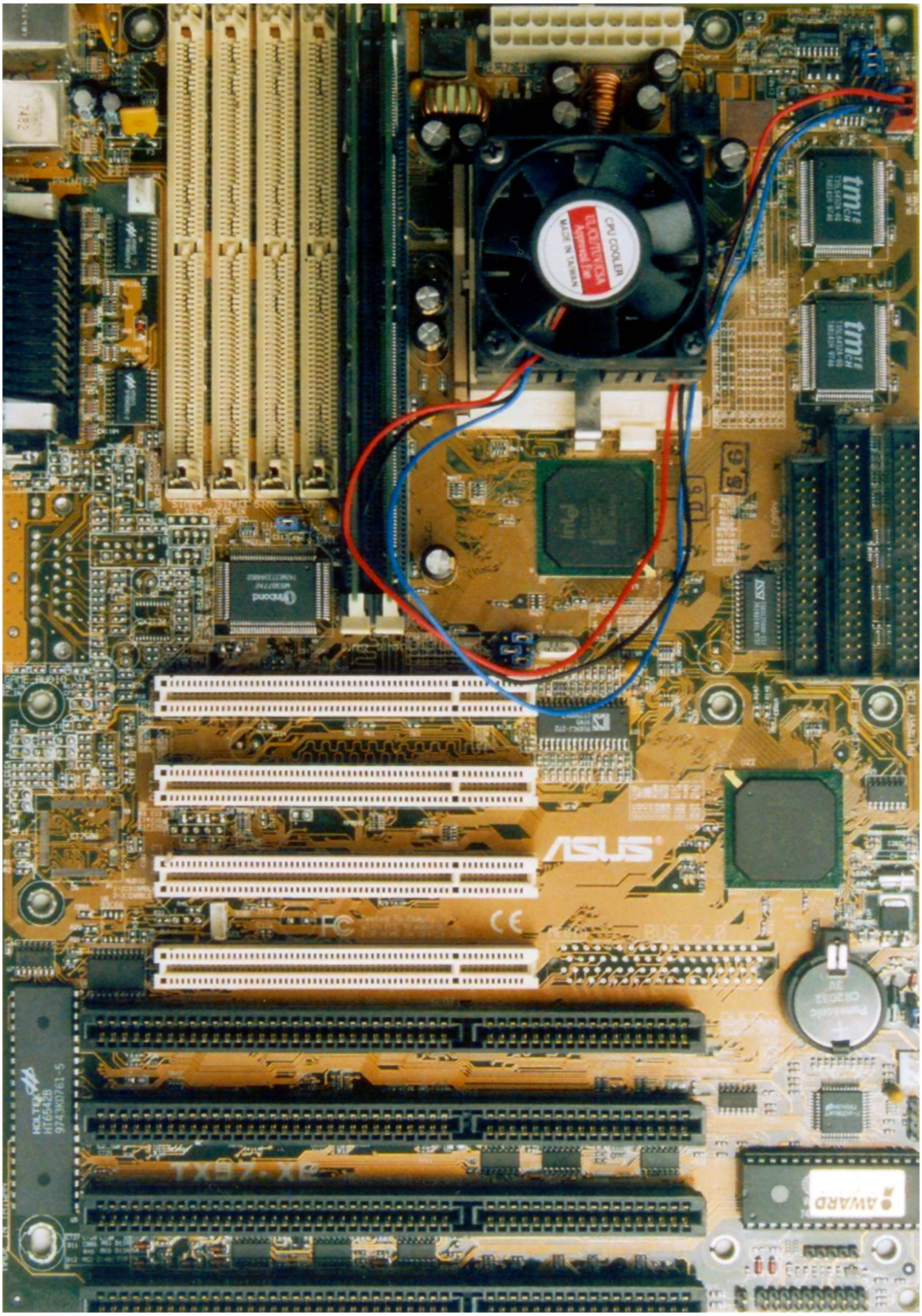


**Figure 1.13.** PC motherboard with chip carriers.

Going beyond advanced ceramics, in the final Chapter 5, first steps towards new fields of materials research are carried out. The following first introductory remarks already here should be useful. On the one hand, a branch of research is started up dealing with the question “How must materials be structured and how must their technical environment be structured that these can be used as the material basis for an oscillatory system generating a measurable oscillatory gravitational field, so to speak, as the material basis for a gravitational laser?” On the other hand, a branch of research is started up dealing with the question “How must materials be structured and how must their technical environment be structured that these – fundamentally going beyond nuclear techniques and matter–antimatter destruction – can be disaggregated into radiation, which in turn can be used as starting point for new types of energy plants, new types of spacecraft propulsions, and new types of matter conversion techniques?” For this purpose, a self-consistent network of model conceptions is launched, which some colleagues may consider as a direct extension of the Ginzburg–Landau theory of superconductivity [20] or as a semi-classical approach to quantum systems comparable to the Wunner–Main approach to quantum systems [34, 35, 64], however, which could turn out to be the true nonlinear extension of conventional quantum mechanics [63], on all accounts, which works without any known restrictions, and which firstly can supply us with much more information about the principles that govern the constitution, the stabilities, and the instabilities of materials than the methods of thermodynamics and the methods of quantum mechanics can do, and which secondly can supply us with paths to these new fields of materials research. Certainly, it goes far beyond the scope of this book to develop these new fields of research in great detail already here. However, the first steps towards this goal indeed are taken here.

Why do we think that a book about advanced ceramics is the adequate place for such first steps? Well, on the one hand, in the framework of advanced fuels such as nuclear fuel rods, ceramic materials play an important role so that we expect that ceramic materials will also play an important role in our more advanced context. Well, on the other hand, wanting to gain an access to artifical gravitation, it should not be the worst choice to depart from materials with a relatively high mass density and a relatively low free charge carrier density, promising us high gravitational radiation and low electromagnetic radiation, as it is the case for a lot of ceramic materials. Anyway, departing from advanced ceramics of the past and the present, let us also point into the future of materials.