

Themes for Master of Science Diploma Theses in Ceramic Technology 2003

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In ceramic technology and in powder metallurgy the components are produced by sintering a powder and it is well known that forming is a key issue in the production of these materials. SCI has a long tradition and worldwide reputation in the field of colloidal processing of ceramic materials and possesses equipment for most existing forming and sintering methods. During the past few years, the research has more and more been directed towards the development of materials for specific and often very demanding applications.

- 1. Development of Commercial Si_3N_4 Powder**
- 2. Powder Suspensions with Extreme Solids Loading**
- 3. Shaping Methods for Components of Complex Geometry**
- 4. Formation of Multilayer Structures**
- 5. Functional Films, Surfaces and Materials**
- 6. Corrosion-resistant materials in the processing industry**
- 7. Exam work at ceramic industry or institute in Japan**

1. Development of Commercial Si_3N_4 Powder

The objective of this diploma work is to develop the properties and processing of the commercial silicon nitride (Si_3N_4) powder SicoNide from Permascand, in order to meet demands of the costumers and the manufacturers of Si_3N_4 components. Si_3N_4 is the more important ceramic material for structural applications (ball bearings, wear and engine parts) and the manufacture of components is based on powder processing and pressing as the major shaping technique. To further strengthen the position and broaden the field of applications, it is desirable to make cheaper powder and processing available. More refined products that minimise the need of equipment and know-how at the component manufacturer are also in demand. Various pre-treatments of the powder, different sintering aid compositions, pressing aids, granulation techniques etc will be evaluated in close collaboration with Permascand, a Swedish manufacturer of Si_3N_4 powders and with some of its international costumers. Materials will be shaped, sintered, mechanically tested and microstructurally characterised. The aim is to achieve adapted powder concepts that can be provided by the powder manufacturer to the component manufacturer resulting in an overall market increase for Si_3N_4 .

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2. Powder Suspensions with Extreme Solids Loading

The objective of this Diploma work is to evaluate and develop dispersing concepts for extreme solids-loaded powder suspensions. This is crucial for shaping ceramic components, especially when utilising tape casting and direct casting. Tape casting is frequently used to produce substrates for electronic circuits, piezoceramics etc as well as solid electrolytes for fuel cells. Direct casting is the common name for a group of novel shaping techniques (gel casting, freeze forming, direct coagulation casting etc.) with the potential of broadening the use of ceramics in various applications. Water-based and solvent-based systems together with various processing additives (dispersants, binders, consolidators) will be evaluated. Surface-chemical characterisations, rheological studies and shaping tests will be the most important experimental tools. Sintering and evaluations of ultimate material properties will also be included.

There is a great industrial interest for new shaping technologies with possibilities of simplifying the fabrication of component prototypes as well as large-scale production of advanced ceramics (Al_2O_3 , ZrO_2 , Si_3N_4 , SiC etc). This work will be conducted within a member program sponsored by a group of Swedish companies (Volvo Aero, Volvo Materialteknik, Scania, Nobel Biocare, Sandvik Coromant and others) and presented at meetings with these companies.

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3. Shaping Methods for Components of Complex Geometry

Direct consolidation is a technique in which a ceramic suspension transforms from a liquid state to a solid body without any removal of water. The consolidation can be achieved by the formation of a gel network in the water by polymerisation of a monomer or by using polysaccharides. The ceramic particles are then immobilized in the gel, which is an advantage of this technique as it improves the homogeneity in the shaped component and thus also the dimensional control during sintering. Another advantage is the fact that you can prepare more complex-shaped components than when using other methods like pressing or slip casting. These advantages are the reason for the industrial interest, which includes both medical and technical applications.

The aim of the project is to evaluate and further develop a suitable direct consolidation method that can be used in combination with freeform-fabricated moulds. The project will include both ceramic processing, preparation of freeform-fabricated moulds and evaluation of the prepared materials.

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4. Formation of Multilayer Structures

Tape casting and lamination are generic techniques for the manufacture of components for a number of applications within the ceramic field. Multilayer circuit boards, actuators, sensors, membranes, structural laminates, gradient material, catalysts and fuel cells are just some examples. SCI has for many years been working on this technique, primarily focusing on the development of more healthful aqueous-based tape-casting systems. However, so far the prevailing system for producing tapes commercially is still based on organic solvents. For this reason, we will make a detailed comparison study of the two systems to find out where the differences lie from the manufacturing and quality point of view. Another objective of gaining knowledge of an organic system is to master a commercial method that will make it possible to produce larger quantities of high-quality tapes for our industrial clients.

You will take direct part in the project described above and learn all about the growing market of tape casting and lamination for the formation of advanced ceramic multilayer structures. Especially for your work, we will focus on a selected component to be manufactured and evaluated. The thesis will be presented on special meeting occasions at which representatives from all of our industrial member companies will be present. We shall be glad to hear from you.

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5. Functional Films, Surfaces and Materials

Mesostructured composites constitute a new class of materials that is formed from an inorganic precursor and a surfactant by self-assembling. The so formed material has an ordered hybrid structure with a length scale of 2-50 nm. The inorganic substance which commonly is ethyl silicate or an alkoxide is templated by liquid crystal block co-polymer molecules. The structure is heated to form silicates or other ceramic materials and the surfactant is pyrolysed leaving a highly structured mesoporous inorganic material. The mesoporous ceramic material can be impregnated with organic substances to create new types of functionality. There are several potential applications such as slow drug release, functional coatings, various optical applications, in fuel cells, for lab on a chip or applications in analytical chemistry.

The thesis is part of a project with the objective to develop new applications and processing methods for mesoporous materials. Dispersion studies, rheological measurements, screen-printing, solid freeform fabrication and material characterization will be included in the work.

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6. Corrosion-resistant materials in the processing industry

The area includes applications in which the primary mechanism of degradation is based on chemical attacks. The fields of application involve masses/monolithics within the chemical industry and other processing industry such as soda recovery boilers or cracking plants where the material is exposed to a chemically aggressive environment at room temperature or above.

First, the work includes the collection of comparative data for selected existing material candidates that, from the chemical point of view, are expected to possess low reactivity and to show low wettability in a given corrosive environment, within a temperature region of interest from the process point of view. Both porous and dense materials, primarily oxidic, will be considered. In applications involving severe attacks, particularly in a reducing/inert gas environment and at high-temperatures, non-oxide materials based on silicon carbide, sialon or silicon oxynitride can be evaluated if feasible from the economic point of view. At a later stage, the selected materials will be tested concerning their product properties in collaboration with the industrial producers (IFÖ Ceramics AB, Lafarge Svenska Höganäs AB, and Permascand AB).

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7. Exam work at ceramic industry or institute in Japan

The Swedish Ceramic Institute has good contacts with companies, institutes and departments within the field of ceramics in Japan. Every year The Gadelius and The Sasakawa Foundations give a number of scholarships for project work in Japan. If you are interested in doing your diploma work in Japan, please contact a researcher at SCI. We will then contact different companies in Japan and, if we get a positive answer, a project plan will be made and sent to the Gadelius and Sasakawa Foundations. The last day of applying for the scholarships is 1 March, 1 September or 1 December every year. If you are interested, please contact us as soon as possible before the deadline.

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