Dissertation title:

Manufacturing of Injection molded Ceramic Nanocomposites for Biomedical Applications

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Commercially spread metallic prostheses have only a limited lifespan and high-end ceramic prostheses are too expensive for a vast number of patients. To overcome high cost related with the conventional manufacturing technologies used in manufacturing ceramic femoral head components, a new mass production approach such as ceramic injection molding was developed and the feasibility of manufacturing ceramic hip implants by injection molding will be considered and studied. Such an approach required the development of the integrated production process, reaching from conditioning of the raw materials to the final component. This process has been optimized with regard to cost targets and requirements to quality.

In order to achieve this aim, the complete processing chain from the selection of suitable raw materials, compounding of thermoplastic feedstocks, design and evaluation of a suitable injection mold, mold filling simulation and the parameter setup of the injection molding process had to addressed. Finally the thermal treatment including debindering and sintering was addressed with the aim of obtaining ceramic components with a high dimensional accuracy, microstructural quality, mechanical properties and low temperature degradation resistance.

ZTA materials were developed with the aim of enhancing the mechanical properties and ageing resistance to ensure a long lifetime and safe application of ceramic prosthesis. Addition of platelets and adjustment of zirconia content resulted in improvements in fracture toughness and strength. Predictions made by the mold filling simulation were helpful in designing and modifying the mold as well as understanding the experimental results.

Certainly the newly developed ZTA hip implants by injection molding are not ready for implantation in the near future. However it is obvious that this work founded a strong base for future work regarding the development of ceramic injection molding; not just for hip implants but also for other biomedical applications (material and manufacturing process). The study has clearly pointed out the potential but also the limitation of ceramic injection molding as a manufacturing process for biomedical implants. The basic recipes may be transferred to other e.g. engineering applications. The expertise collected in the field of mold filling simulation and mold design are valuable for the setup of ceramic injection processes for different kinds of components.