LUCIDEON
insight creating advantage

FLASH SINTERING TECHNOLOGY

WHAT IS IT?

Flash Sintering (FS) technology is the application of a direct electric field via bespoke electrodes to a material body during the sintering process. Incorporating FS into the material processing route can dramatically reduce the energy consumed during product manufacture. The FS process has also been proven to improve material properties for certain applications. The technique has recently attracted attention in a variety of applications from electroceramics to biomaterials and from defense to traditional tileware, with improved ceramic properties for novel applications being realized.

THE BACKGROUND SCIENCE OF SINTERING

Ceramic bodies are produced by sintering formed parts at high temperatures. During the sintering process, different material transportation mechanisms occur for which heat is the primary source of energy. Sintering happens in multiple stages; the driving force for diffusion is the reduction of surface-free energy. Diffusion can occur at a surface, grain boundary and within the volume of a grain, as contacting particles bond together and the pore size of the interconnecting porosity is decreased. During the densification process, the material grain size generally increases. FS has been shown to drastically enhance the sintering rate, which can affect the sintered microstructure final grain size. Full sintering can occur in seconds and at significantly lower temperatures than for conventional sintering processes. However, the mechanisms responsible for such extreme densification rates remain a matter for debate.

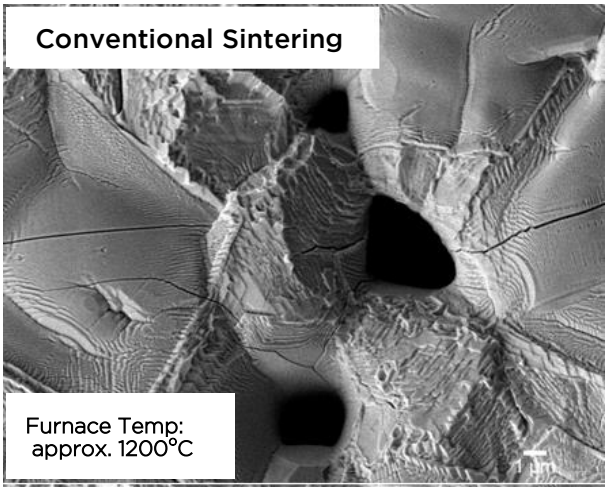
WHAT ARE ITS BENEFITS?

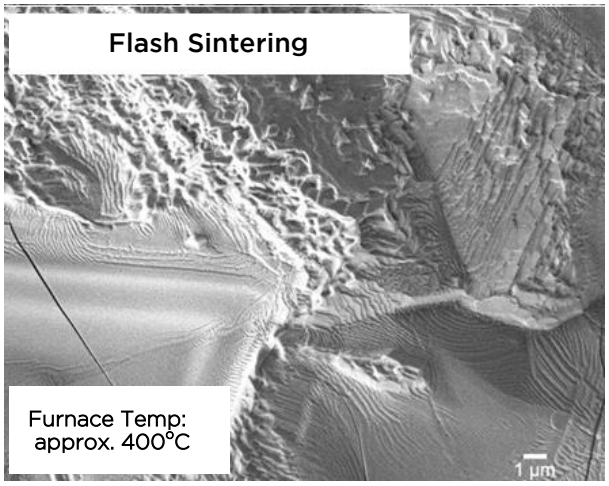
The manipulation of the sintering mechanism and control over the sintering rate enables, a) ceramics to be produced with reduced energy consumption and cost, and b) a change in the properties of the fabricated material. For example; grain size affects the density and mechanical properties of the material. This is an opportunity to develop new products, improve performance and increase profitability.

APPLICATIONS OF FLASH SINTERING TECHNOLOGY

ELECTROCERAMICS

Electroceramics are ceramic materials which are used in a wide variety of applications due to their electrical properties; cobalt manganese oxide present within Solid Oxide Fuel Cells (SOFC) being a good example (see images to left). Interconnects are an important component in SOFCs. They are placed between the cathode and anode of adjacent cells, thus carrying current through the stack. SOFCs are used to produce energy at high efficiency and without pollution. A major setback to this green technology is the high sintering temperature required to produce dense ceramic materials. FS technology has been used to produce dense materials at lower sintering temperatures, as illustrated in the SEM images above (work carried out by collaborators). Moreover, control over grain size in turn will have an effect on the material's electrical conductivity.

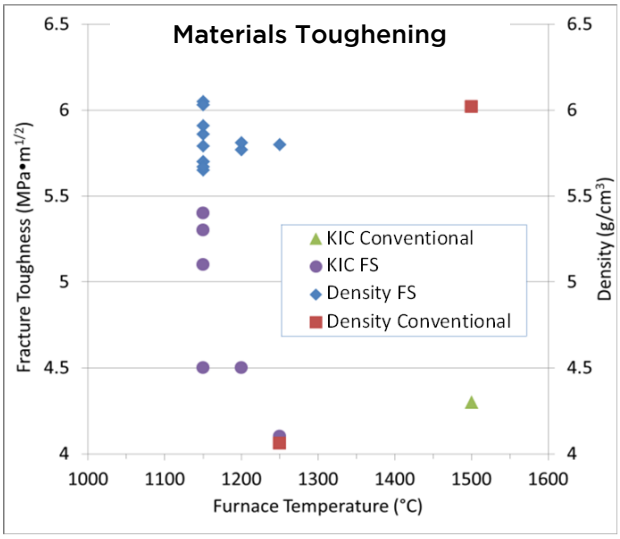




BIOMATERIALS

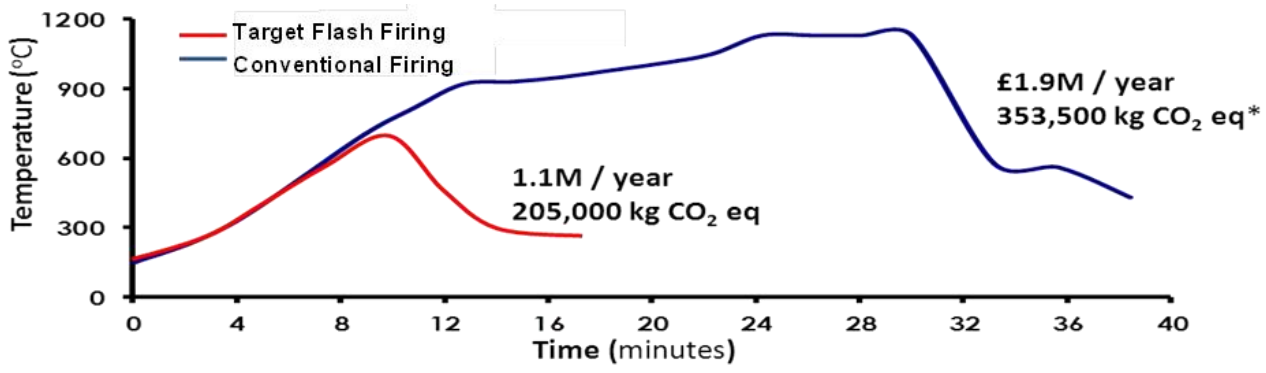
High mechanical strength and fracture toughness are examples of properties which are required in bio materials for certain applications. To achieve these properties, ceramic materials need to be sintered at high temperatures for a considerable amount of time. By applying an electric field across the material, it is possible to sinter ceramics to produce highly dense structures with limited grain growth at low temperatures.

The graph titled Materials Toughening shows that the fracture toughness (K1c) of Zirconia material using FS, has been increased by approximately 25%! The firing time has been reduced by approximately 50% at a reduced furnace temperature (1150oC), in comparison to conventional methods (1500oC). The density of conventional to FES samples has also been matched.



TRADITIONAL CERAMICS

The ceramic industry is highly energy intensive and the energy used can account for up to 30% of the manufacturing costs (The European Ceramic Industry Association). To reduce the environmental impact of the energy use and ensure cost savings to the industry, both the temperature and time at which the ceramic materials are sintered need to be reduced. FS technology enables us to sinter whiteware bodies at much lower temperatures and shorter times than conventional sintering. Our Regional Growth Fund Project on Low Energy Firing is currently on-going with commercial prototypes being tested for implementation of flash sintering into the whitewares industry. The figure below illustrates the savings which could be made in this sector from the FS technology.



(*Estimated example Costs relating to one tile factory manufacturing 15,000 m²/day.)

WHY LUCIDEON?

The equipment designed and installed at Lucideon for flash sintering development is completely flexible in its ability to study materials of varying compositions and in different applications. The expert team and equipment at Lucideon are specifically selected to give a commercial output on projects, directly addressing the client's needs for the fastest route to solutions.

To find out more about our Low Energy Firing project, visit www.lucideon.com/low-energy