Midlands Industrial Ceramics Group

Midlands Advanced Ceramics for Industry 4.0

# CASE STUDY

REF No: 2411001

## WS7 - Scale up and Commercialisation

## XENON FLASH LAMP SINTERING

MODELLING & DESIGN | RAW MATERIALS PROCESSING | FORMING | DRYING & SINTERING | ANALYTICAL

## INTRODUCTION

Methods that can provide targeted direct high temperature heating, without requiring contact to the sample, are in demand for ceramic sintering applications. These applications include sintering fragile structures such as films, parts which are prohibitively large to heat, or are layered structures with thermally sensitive layers that cannot withstand typical sintering temperatures. These applications include critical devices such as solid oxide fuel cells (SOFCs), solid state batteries, ceramic matrix composites (CMCs), and environmental barrier coatings (EBCs). For many of these applications new sintering methods are not just reducing costs and enhancing productivity but are key to enable manufacturing in the first place.

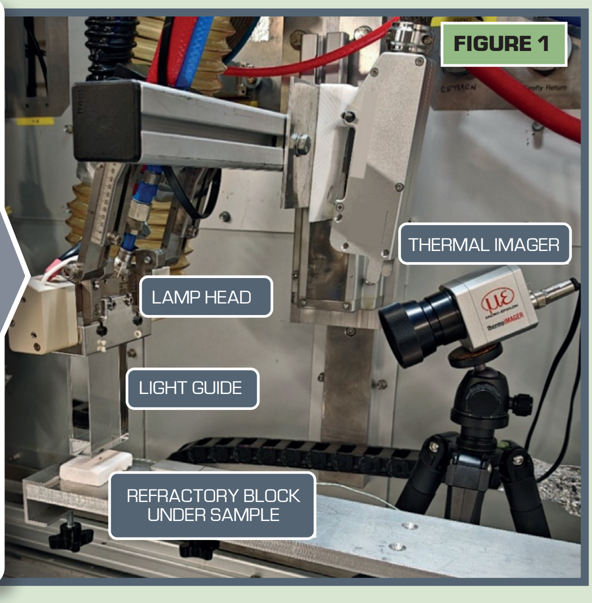
Xenon flash lamps with a broad emission range (Ultra Violet to Infra Red), also known as xenon flash, have considerable potential thanks to their large heated area size (> 25 mm to over 300 mm possible) with only limited academic investigation to date [1]. This case study outlines the trials that were carried out to validate the positive results demonstrated in literature, while also investigating the potential for sintering higher temperature non-oxide ceramics and identifying potential challenges for industrial implementation of xenon flash sintering of ceramics.

**The materials tested were:**

- **Cerium oxide**
- **Yttria stabilised zirconia**
- **Silicon carbide with a liquid sintering aid**
- **Silicon carbide with a solid-state sintering aid.**

## CASE STUDY ACCOMPANYING DIAGRAMS

Figure 1- Illustrated Image of Experimental Setup at Excelitas® (Cambridge UK)



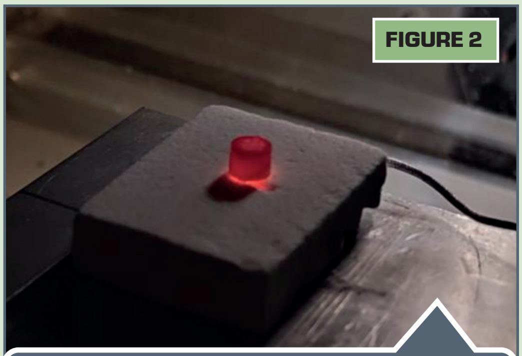




Figure 2 Hot Silicon Carbide sample glowing, during cooling, after exposure by xenon flash lamp was turned off.

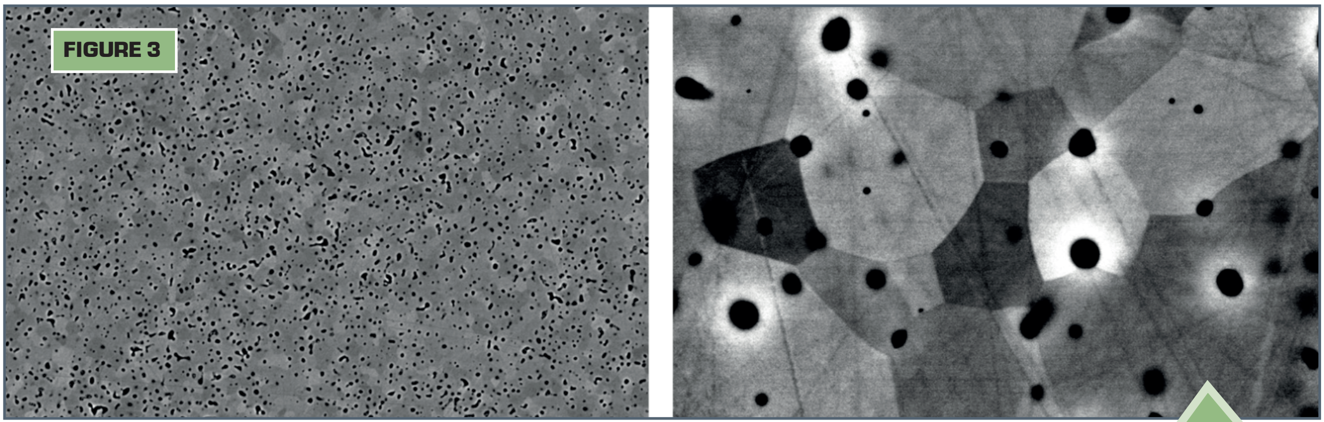



Figure 3 - SEM Images at 2000x and 15000x magnification showing dense microstructure of 8YSZ sample after only 15 mins of exposure. Some of the residual porosity may be due to incomplete binder burnout.

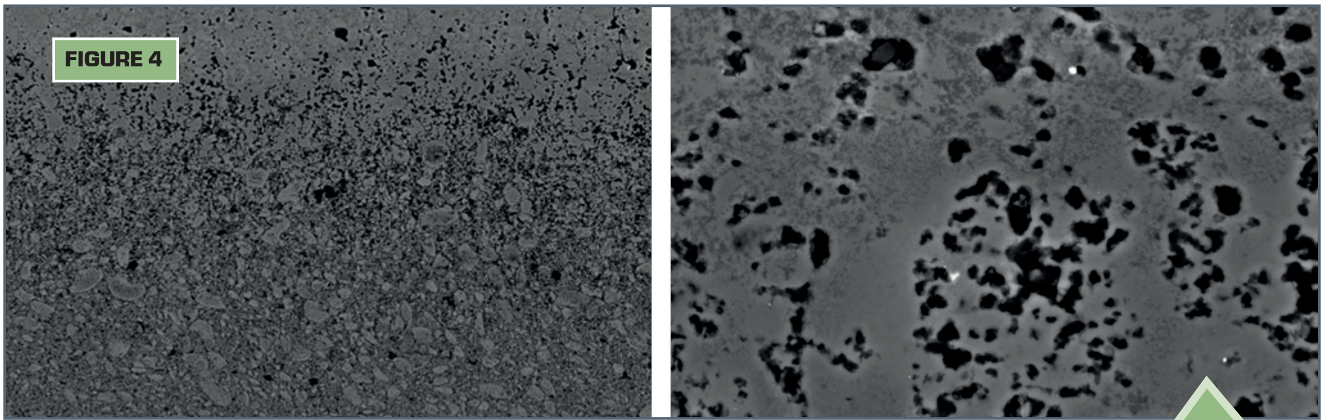



Figure 4 - SEM images at 300x and 2000x magnification demonstrating surface densification achieved of SiC sample.

## CHALLENGES

The xenon flash lamp  sintering method shows great promise with rapid sintering of several of the samples with very little parameter optimisation. Bulk sintering of yttria stabilised zirconia was observed and significant densification of the top surface of silicon carbide pellets with a liquid sintering aid. However, some potential challenges related to high temperature rapid sintering of ceramics were identified for further investigations.

These are:

- **Difficulty in measuring the exact temperature of the sample during sintering.**

  Solvable by use of high temperature range pyrometers and thermocouples (embedded below the sample). Melting point standards may also be useful in defining exact temperatures reached.

- **Some cracking of samples observed during rapid heating and cooling.**

  This may be solved by a mixture of binder burnout prior to heating and slowly ramping the power dissipated during both the heating and cooling segments. The severity of thermal shock will vary depending on the material and geometry.

- **Oxidation of non-oxide surfaces..**

  This could be solved by placing the substrates inside an Argon filled processing box or using a more localised argon hood.

## OUTCOMES

The **Strength in Places Fund (SIPF) programme** has been instrumental to support the collaboration between Excelitas® and their expertise in the equipment and Lucideon bringing their ceramics knowledge. It enbled the team to pioneer **xenon flash lamp sintering of ceramics** and demonstrate the **first-ever application of this technique to silicon carbide**. These trials serve as a foundational milestone for future collaborative efforts between industry and academia.

**Key achievements include:**

**Rapid densification** of zirconia pellets in just 15 minutes.

**Surface densification** successfully demonstrated on non-oxide ceramics.

Identification of **key challenges** alongside **potential solutions** for optimization.

Compelling evidence suggesting this process warrants further exploration and development for ceramic applications.

This work laid crucial groundwork to propel innovative sintering techniques, with vast potential for industry-wide impact.

**Contact Details**
**Dr Gareth Jones**
Senior Scientist -
FES Technical Lead (UK), Lucideon
Gareth.Jones@uk.lucideon.com

**In partnership/ collaboration with...**



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