Post-doctoral position on flash sintering

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Title: Controlling the flash sintering process during microwave sintering and spark plasma sintering, a coupled approach between sintering experimentation, processing and simulation.

Starting: September 2020.

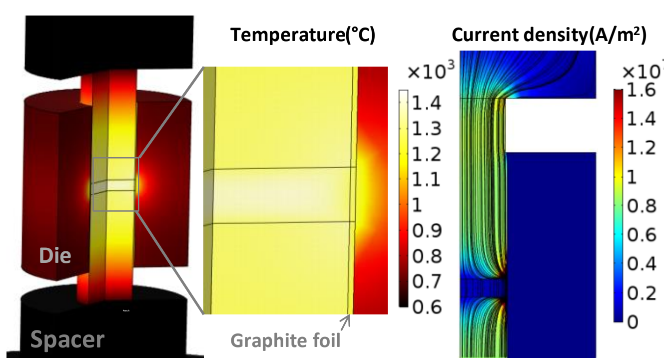
Location: CRISMAT laboratory.

Gross salary: about 2643€.

Duration: 2 years depending on the candidate experience.

Flash sintering context: In 2010, a research group lead by the Professor Rishi Raj at Colorado University (USA) discovered a new sintering approach enabling to sinter materials in a few seconds compared to several hours in conventional processes[1,2]. This process, called "flash sintering" (FS) or "ultra-rapid sintering", consists in a pressure-less field assisted method and was first applied on zirconia. They found that the Negative Temperature Coefficient resistivity (NTC) behavior of zirconia induces an abrupt electrical current/temperature raise accompanied by a very fast densification process (taking only a few seconds). Current research focuses on combining high pressure, pulsed current or electromagnetic fields for decreasing the sintering temperature[3,4], stabilizing this abrupt sintering process and providing a better control of the final microstructures[5].

Approaches and issues. The impact of such a potential technology lends impetus to the adaptation of initial "flash sintering" technology to advanced sintering processes such as spark plasma sintering or microwave sintering. The "Flash Spark Plasma Sintering" process (FSPS) has demonstrated its interesting capability for large scale sintering of ultra-high temperature materials such as SiC, ZrB_2[6]. In the FSPS configuration, a hybrid heating of the powder is applied through a lateral graphite foil (or felt) which can raise the specimen temperature therefore its electrical conductivity (like 3Y-ZrO_2, SiC etc)[7]. Consequently an abrupt current flows through the sample and activates the onset of the "flash event". Using an electrically/thermally/mechanically confined FSPS configuration (see next FSPS simulation), we recently showed that ultra-rapid sintering can be applied to electrically insulators materials and to metals (like Al_2O_3, Ni) [8]. However, this "all materials inclusive" method is still limited to small sample size (<10 mm) as heating diffusion in dielectric powders takes more than a few seconds to diffuse from the edges and surfaces to the core (for indirect heating configurations). To overcome this scalability problem, "Microwave Flash Sintering" (MWFS) represents a potential solution owing to the volumetric heating feature of this technology[9]. By using high microwave fields in resonant conditions, even high resistivity dielectric materials, like pure alumina, can be rapidly heated[10,11]. In

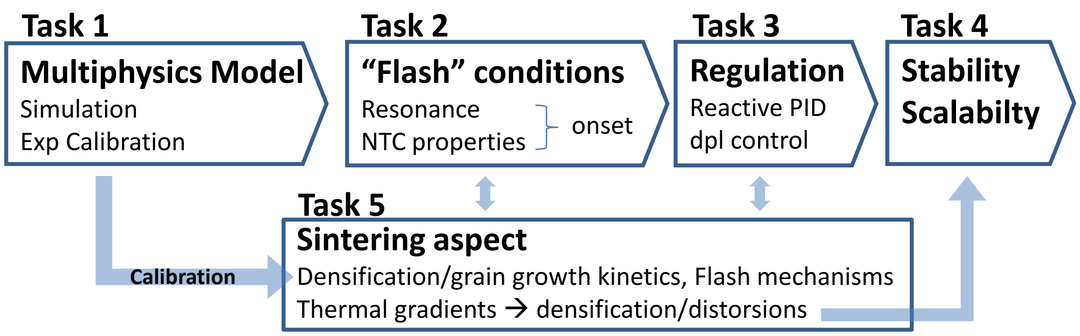


Flash Spark Plasma Sinteringmultiphysics simulation

another recent study, we also demonstrated the possibility of applying flash microwave sintering on metals via activated resonance phenomena[12]. However, the inherent instability of direct microwave heating of metals or dielectric materials is still a great challenge. The interaction between the coupled Multiphysics parameters and the resonance phenomenon contributes to the process instability and many side effects may appear: hot spot formation, porosity, specimen distortions and an intrinsic difficulty to reproducibly regulate this ultra-rapid process[13–16].

In this context, the project objectives encompass two main axes: (i) the **understanding** of the main Multiphysics aspects involved in flash sintering and the underlying sintering mechanisms (ii) the establishment of **stable and scalable ultra-rapid sintering conditions** for a wide range of materials. Zirconia will be used as initial classical material, then electrical insulators and metallic materials like alumina and nickel will be investigated. The spark plasma sintering (FCT hpd25) and microwave sintering (2450/915 MHz Sairem) will be the preferred approaches for, respectively, conductive and dielectric materials. In the same way, metal inductive sintering could also be investigated[17].

Methodology. Attaining the project objectives requires a coupled approach between the **Multiphysics simulation** for the **different ultra-rapid sintering approaches** and the **experimental calibration/verification** of the developed model/approaches. This study is organized in 5 tasks (see below).



Candidate profile: We are looking for a candidate having a strong background on sintering. We are interested in priority by young researcher (1 or 2 years after PhD) with a formation on materials science and/or mechanical & engineering science.

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