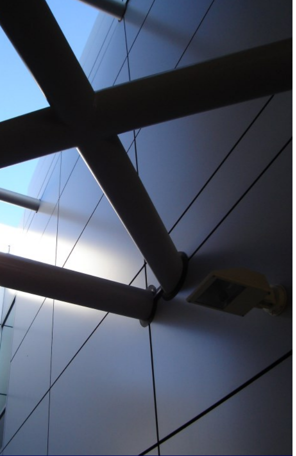

MECHANICAL ENGINEERING
DISSERTATION DEFENSE

The Department of Mechanical Engineering presents:

The Ph.D. Dissertation Defense of

Kendrick Mensink

Tuesday, May 28, 2019,
2PM in Bourns Hall A265

Laser Energy Interaction With Novel Fine-Grained Materials

Doctor of Philosophy, Graduate Program in Mechanical Engineering
University of California, Riverside, June 2019
Dr. Guillermo Aguilar & Dr. Suveen Mathaudhu, Co-Chairs

Laser irradiation is a unique technique used to process materials, it is “contactless”, rapid, and highly localized. The scope of this work is focused laser energy interacting with powdered materials that are in one case consolidated before, or in the second case, as a result of, laser irradiation.

Ultrafast laser pulses, pico and femtoseconds long, have provided new ways of processing materials due to either multiphoton absorption or lack of heat affected zones. However, pulsed laser incubation effects, in which the material is heated or ablated at lower laser energy density than expected, is not well understood. The first objective is to characterize the ultra-low laser density machining capability of a high repetition rate (55 MHz) femtosecond laser. The laser energy density ablation thresholds were found for several materials to be two orders of magnitude below single pulse thresholds. Results focus on binderless tungsten carbide, which is ultrahard and difficult to machine, especially without the metal binder phase. This relatively unexplored regime of laser ablation is found not ideal for precise machining of ultrahard materials due to the heat affected zones and relatively slow removal rates, however, it forecasts promising ultrafast laser micro-machinability at repetition rates below heat accumulation, which depends on the thermal relaxation time.

In the second case, more commonplace continuous wave laser heating is applied to loosely packed ball-milled metal powders to investigate their usefulness in additive manufacturing. The milled powders are compared to industry-standard atomized powders and are found to be feasibly additively manufactured in terms of size distribution, flowability, and potential grain boundary pinning precipitate benefits. However, questions remain regarding the sintered density and scalability to parts larger than laboratory test dimensions.

The findings forecast ideal repetition rates for ultrafast ablation to be hundreds of kHz, depending on thermal diffusion length and time constant, and that milled powder approaches for additive manufacturing are feasible and could help overcome some of the challenges related to alloy design and residual porosity in atomized powders.