PhD subject / sujet de thèse (2023)

Title: Selected laser sintering for lunar dust simulants

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Host Unit/ Unité d'accueil : ICube Laboratory (D-ESSP Department)
IPP team (Photonics Instrumentation and Processes)

Affiliate institution: University of Strasbourg / INSA of Strasbourg/ Icam site de Strasbourg-Europe

Collaboration(s) (if applicable): **ISU, Mines d'Albi – Institut Clément Ader**

Attachment to a program (if applicable):

Summary:

Nations with space capabilities are now in a race to build the first base on the Moon as launch pad to go to Mars. The European Space Agency is currently recruiting the next generation of astronauts that will go back to the moon on the *Artemis* project. Additive manufacturing using regolith, the main Lunar in-situ material resource, is offering a solution for long duration stay on the Moon or Mars. Appling Selective Laser Sintering (SLS) technology to build infrastructures or tools will reduce the space transportation efforts from Earth and lower the cost of the space missions. Furthermore, additive manufacturing will be a precious asset for compagnies looking into settlements for space mining of various resources such as water and helium 3.

However, many challenges still lie ahead to optimize the SLS process. First of all, the regolith composition is region dependent. Various simulant thus must be tested and their respective adequate experimental conditions for correct sintering compared. Furthermore, the mechanical integrity of the manufactured samples must match the requirements depending on the diverse applications.

Our research team has developed a powder bed SLS prototype using a 100 W 1090 nm CW laser and a galvo head for high speed and accuracy. The heigh and compression of the added layers can be controlled thanks to a Z-stage, a roller and a blade. Various lunar dust simulants were characterized by XRD and used (JSC-2A, LHS, LMS, and EAC-1). Specific care is taken when manipulating the nano-size powders. The experimental process is monitored by a pyrometer. The process conditions are optimized thanks to a numerical model developed on COMSOL Muliphysics. Nonetheless, the processing condition do not currently reflect those that will be met in space such as gravity or atmosphere. In order to recreate some of the conditions, a vacuum chamber with 10^{-2}mbar capacity is currently being refurnished. This chamber will host X/Y/Z/rotation stages. The outside will be adapted to fit the laser and galvo head to stir the beam. The PhD student will have to finish the instrumentation of the vacuum chamber.

The thermomechanical characterization of the samples will be made by the CGE team at ICube, Strasbourg, and the ICA, Albi.

The PhD candidate will work on three axis:

- The optimization of the process in the experimental powder bed SLS machine for various simulants ;
- The optimization of the process in the low atmospheric conditions ;
- The optimization of the numerical model.

The PhD candidate will work on three sites, Icam site de Strasbourg-Europe in Schiltigheim, and ICube and ISU at Illkirch.

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