Investigating Design Constraints for Indirect Selective Laser Sintering of Alumina

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Abstract:

Additive manufacturing (AM) technologies are increasingly being utilized by industries including aerospace, automotive, and medical device. The nuclear industry is following suit, launching research missions to identify how additive manufacturing can streamline innovation in the field. One concern of the nuclear community is how these modern manufacturing techniques could enable a nuclear proliferator. The research presented investigates the design constraints of ceramic parts fabricated by the indirect selective laser sintering additive manufacturing process. This is of interest because the most common nuclear fuel, uranium oxide, is a ceramic. Alumina is used as a uranium oxide surrogate throughout this work.

Selective laser sintering (SLS) uses a laser as a heat source to sinter together a 2D region of a polymer powder bed. When done on a layered basis, a three-dimensional part can be fabricated. SLS is one of the most popular AM techniques to create polymer objects, as it produces parts with high density and geometrical accuracy. The SLS process can be tailored to produce ceramic parts by using a sacrificial polymer binder that is removed after SLS. This process is known as indirect SLS and requires a ceramic-polymer composite powder be prepared. This research utilizes thermally induced phase separation (TIPS) as a method to produce almumia-PA12 composite powder. The TIPS process employs a solvent and a polymer that are insoluble at room temperature, but soluble at higher temperatures. When the solution is cooled back below the solubility point, the polymer precipitates out of the solvent and coats the ceramic. It is shown that the TIPS process produces powders that are suitable for the indirect SLS process. The produced powder will be used to fabricate metrology pieces to study design constraints for ceramic parts manufactured using indirect SLS. This will establish the ceramic fuel geometries that can be produced using indirect SLS. Once complete, design projects can be launched investigating how indirect SLS could be leveraged to gain a proliferation advantage over traditional methods.