SAND2023-05278C

Hybrid Metalized Polymer Core Hardware Design & Initial Results for Prototype Mass Optimized Pulsed Power Hardware

Critical author list:
Charles, E, Rose. Shaun, R, Whetten. Michael, R, Kracum. Jacob, T, Mahaffey. David, j, Saiz. Joseph, A, Padilla. John, Cochrane. Raymond, V, Puckett. Brian, T, Hutsel.

Stockpile stewardship, being one of the main thrusts of Sandia National Laboratories (SNL), requires the worlds most advanced test beds which rely on accurate and predictive models of high energy and density environments (HED). Generation of such extreme environments is both incredibly difficult and profoundly necessary, especially for the design of next generation pulsed power (NGPP). Traditionally, power flow equipment is machined from large blocks or forged ingots with undesirably large amounts of waste material given the current classical reductive process. Further, some power flow hardware cannot be classically machined, and hardware overall is becoming increasingly complex. Couple this with the fact that experimental time on NGPP will be more expensive, central section hardware activation is likely, and post shot debris is expected to scale with increased load current, and a new paradigm for power flow hardware becomes paramount. Therefore, new directions are necessary, and this paper describes recent results of our investigation on the limitations/capabilities of our novel hybrid metalized polymer core (HMPC) concept. Notional design approach and manufacturing details are presented, but essentially can be summarized as metal coated polymer shot hardware. Key pitfalls and limitations of this process have been identified, investigated, and are enumerated including mechanical/vacuum performance, production of internal features, and impacts due to a-symmetry to name a few. Four unique pieces of power flow hardware, both up and down-stream of the experimental region, were manufactured with a metallic skin depth between 200 µm to 1 mm and successfully fielded on the Mykonos accelerator at SNL. Initial results show no obvious power flow differences given an apples-to-apples comparison of like kind shot conditions and hardware topology propagating > 400 kV at > 600 kA while maintaining a ~ 3X mass reduction. Future work is necessary, but we are happy to report HMPC power flow hardware works as intended and is believed to be a viable candidate for NGPP debris mitigation. Further, given our ability to dramatically mass optimize hardware, this technology could have a significant impact on HED and fusion applications. For example, building complex light weight, yet large components or taking advantage of the economy of scale, intrinsic to 3d printing, dramatically reducing the cost of power flow hardware.

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology & Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.