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Giant and Tunable Mechanical Impulse of Energetic Nanocrystalline Porous Silicon

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In this paper, a nanocrystalline porous silicon-based propulsion system is designed, and its explosion impulse is tuned by varying the propulsion design parameters and etching duration. The porous silicon is ignited by an electrical current passed through 100-nm-thick aluminum film deposited on the unpolished side of the wafer and the ignited porous silicon caused strong explosion, which destroys the chip into tiny fragments. The explosion impulse in the system can reach about 0.14 N·s

0.14 N·s at optimal conditions, which is two orders

stronger than the impulse produced by conventional propellants (Zakar, E., , “Technology Challenges in Solid Energetic Materials for Micro Propulsion Applications” U.S. Army Research Lab. Rept. ARL-TR-5035, Nov. 2009). It is also shown that, by varying the etching time, which is an important factor that determines the porous layer thickness and the volume of nanocrystallite, the strength of the impulse can be tuned. Furthermore, a linear increasing trend of the explosion impulse with etching time is observed, which can be explained as the results of heat trapping, materials confinement, and the increasing number of reaction centers.

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