



National Aeronautics and Space Administration

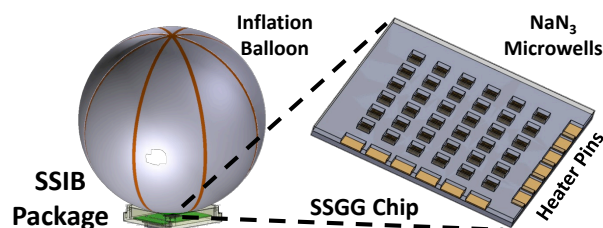
## Solid State Inflation Balloon Active Deorbiter

### Scalable Low-cost Deorbit System for Small Satellites

The goal of the Solid State Inflation Balloon Active Deorbiter project is to develop and demonstrate a scalable, simple, reliable, and low-cost active deorbiting system capable of controlling the downrange point of impact for the full-range of small satellites from 1 kg to 180 kg. The key enabling technology being developed is the Solid State Gas Generator (SSGG) chip, generating pure nitrogen gas from sodium azide ( $\text{NaN}_3$ ) micro-crystals. Coupled with a metalized non-elastic drag balloon, the complete Solid State Inflation Balloon (SSIB) system is capable of repeated inflation/deflation cycles. The SSGG minimizes size, weight, electrical power, and cost when compared to the current state of the art.

The SSIB system is composed of three major components: the Micro-Electro-Mechanical Systems (MEMS) SSGG chip, a balloon structure made of thin metallized polyimide films such as Kapton® HN composed of multiple lenticular gores which will form a spherical balloon, and an integrated package that can be interfaced with a small satellite. The SSGG chip is comprised of a MEMS array of wells where the  $\text{NaN}_3$  micro-crystals are selectively deposited using surface wetting properties of the well materials. The crystals are selectively activated by addressable resistive heaters using Metal-Insulator-Metal (MIM) diode networks designed for high temperature operations. Due to the parallel micro-fabrication of the  $\text{NaN}_3$  arrays, redundancy can be achieved with increased array elements while maintaining low mass (<1g) and volume (<1cm<sup>3</sup>). Reliability is achieved due to its solid state characteristics with no valves and/or tanks, in addition to low operating currents (~10mW). Safety with  $\text{NaN}_3$  is addressed by the segregated wells and the low total volumes of the active materials used. Active modulation of the balloon will be achieved by using the combination of the gas pressurization for inflation and biasing a voltage across metalized films of the balloon membrane for deflation.

Due to the recent proliferation of small satellites, and the expected future growth in this class of spacecraft, there is an urgent need for small-sized



*The system representation of the Solid State Inflation Balloon (SSIB) consisting of: 1) the Solid State Gas Generation (SSGG) chip, 2) the metalized non-elastic inflation balloon, and 3) the interface and packaging.*

deorbit technologies. The SSIB provides the low-cost technology for NASA to satisfy current regulations requiring low Earth orbit (LEO) satellites to deorbit after 25 years from mission completion in order to minimize orbital debris. The scalable SSIB can cover the entire small satellite range using the same design architecture, thus eliminating the potential need for tiered or custom deorbit system development. In addition, it will allow low Earth orbiting satellites to operate at higher altitudes (up to 1000 km) while satisfying deorbit lifetime requirements. By accessing higher orbits, this technology enables more variety of science and technology demonstrations, increases launch opportunities, and minimizes collisions by reducing orbital conjunction probabilities with a larger operating space. The SSGG technology, by itself, provides small volume nitrogen gas delivery and control that is unparalleled with the current state of the art in volume, mass, and electrical power. It can enable compact fluid based systems such as spectroscopy, pneumatics, robotics, and spacecraft attitude control.

The SSIB is being developed through a partnership between the University of

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Arkansas in Fayetteville, Arkansas and NASA Ames Research Center in Moffett Field, California.

The project is funded through the SmallSat Technology Partnerships, a program within the Small Spacecraft Technology Program (SSTP). The SSTP is chartered to develop and mature technologies to enhance and expand the capabilities of small spacecraft with a particular focus on communications, propulsion, pointing, power, and autonomous operations. The SSTP is one of nine programs within NASA's Space Technology Mission Directorate.

**For more information about the SSTP, please visit: <http://www.nasa.gov/smallsats>**

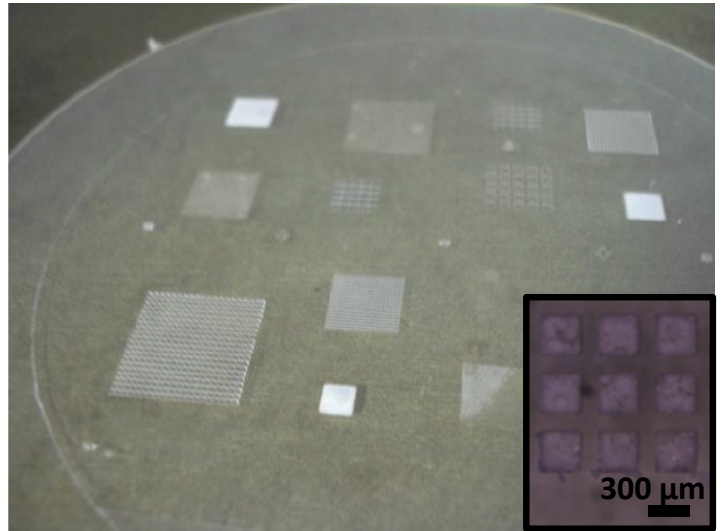
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*A variety of micro well arrays fabricated on 4 inch (100 cm) diameter borosilicate glass. The well material is made of photo-definable epoxy resin (Su8®). The inset shows a sub array with 9 filled sodium azide microcrystals in 300  $\mu\text{m}$  x 300  $\mu\text{m}$  square wells.*

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