Scalable Flat-Panel Nanoparticle MEMS/NEMS Propulsion Technology for Space Exploration in the 21st Century - Phase 2

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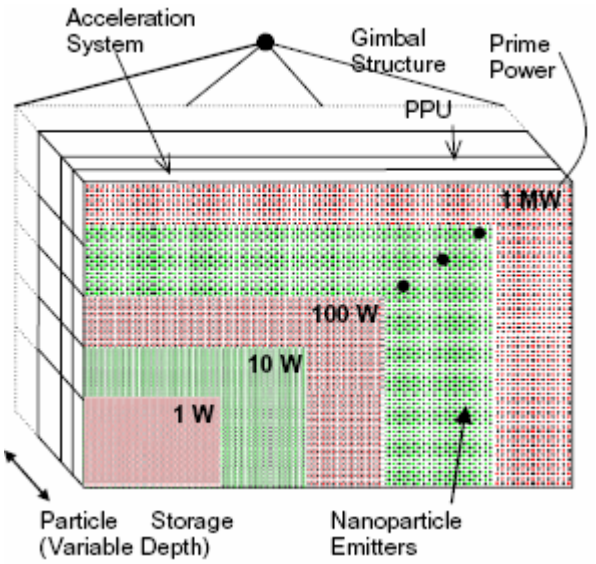

We have proposed and studied in Phase 1 a completely new style of charged particle space propulsion technology that uses *nanoparticles* and micro- and nano-electromechanical systems (MEMS/NEMS) technology. MEMS technologies are already being explored as a possible approach to achieve scalability and system simplification. Our Phase 1 results, which include scaled particle extraction *experiments* and modeling, have shown that the potential benefits we suggested in proposing Phase 1 were actually conservative! Specifically, we were able to determine that we can use nanoparticle field emission (extraction and acceleration) exclusively to cover an even broader range of performance than first thought (e.g., specific impulse covering 100 to 10,000 seconds). We believe the advantages include (1) operations at high power levels at substantially lower system level specific mass (kg/kW); (2) higher efficiency; (3) an order of magnitude increase in thrust densities over present-day ion propulsion technologies; (4) substantially simpler propulsion sub-system integration requirements on a spacecraft using "flat-panel" nanoparticle thrusters; and (5) substantial improvement in lifetime over state-of-the-art ion propulsion technology. We have also learned that (a) an operational range can be defined where particles can be extracted from a liquid surface and accelerated while avoiding the formation of efficiency-degrading Taylor cones; (b) low vapor pressure liquids can be used under high electric field conditions; and (c) there is already important research on-going with microfluidic transport of nanoparticles we can take advantage of in Phase 2.

Our refined vision after Phase 1 is that in 10- 20 years, modern electric propulsion systems will be heavily leveraging nanoparticle and MEMS/NEMS technologies to address everything from the movement of propellant using micropumps, integrated microsensors for performance improvement (e.g., health monitoring), and high levels of scalability and system robustness.