Advanced Thermoelectric Couples – Current Status. S.A. Firdosy[1], T. Caillat[1], B.C-Y. Li[1], C.K. Huang[1], V. Ravi[1], J. Paik[1], D. Uhl[1], S. Bux, K. Smith[1] and J.-P. Fleurial[1], [1] Jet Propulsion Laboratory/Caltech, MS 277-207 4800 Oak Grove Drive, Pasadena CA, 91107 818-393-0576, samad.a.firdosy@jpl.nasa.gov.

Introduction: Radioisotope Thermoelectric Generators have been successfully used to power spacecraft for deep space missions as well as for terrestrial applications where unattended operation in remote locations is required. They have consistently demonstrated their extraordinary reliability and longevity (more than 30 years of life). NASA's Radioisotope Power Systems Technology Advancement Project is pursuing the development of more efficient thermoelectric technologies that can increase performance by a factor of 2 to 4X over state-of-practice systems that are limited to device-level efficiencies of 7.5% or less, and system-level specific power of 2.8 to 5.1 W/kg. Over the last few years, under the Advanced Thermoelectric Couples (ATEC) task, several advanced high-temperature thermoelectric materials, including n-type $La_{3-x}Te_4$, p-type $Yb_{14}MnSb_{11}$, and n- and p-type filled skutterudites, have been developed for integration into advanced power generation devices at the Jet Propulsion Laboratory (JPL). The stability of their thermoelectric properties has been demonstrated for over 15,000 hours up to 1323 K, which is 50 K higher than planned maximum operating temperaturs. The key temperature dependent mechanical properties relevant to thermoelectric device fabrication and operation have also been measured. Suitable sublimation suppression barriers/coatings and stable skutterudite metallization have been successfully developed and their performance validated. JPL is now focusing on developing segmented couples based on these high-temperature materials, and demonstrating their reliable operation during extended performance testing.

A first iteration of spring-loaded couples composed of n-type $La_{3-x}Te_4$, p-type $Yb_{14}MnSb_{11}$ upper segments and skutterudite lower segments have been fabricated and tested in a vacuum environment for up to ~9,000 hours at hot-junction temperatures ranging from 973 K to 1273K. Test performance results have demonstrated 10 to 15% conversion efficiency values at beginning of life with couple cold- and hot-junction temperatures in the 423–473 K and 973-1273 K, respectively. When operating at a hot-junction of 873K and at a 473 K cold-junction temperature, ATEC "low temperature" couples operate at an efficiency of about 9.3%, about a 30% improvement over thermoelectric couples used in the Multi-Mission Radioisotope Thermoelectric Generator (MMRTG). Over the past couple of years, a number of such skutterudite couples were fabricated and tested in high vacuum conditions with minimal insulation and sublimation suppression packaging. So far they have displayed stable performance for more than 8000 hrs at a hot side temperature of 873 K. Lessons learned from the testing of these first iteration couples will be presented and discussed. Key fabrication challenges and degradation mechanisms identified from the initial testing are being addressed into a second couple iteration that is now nearly complete. Key couple configuration and packaging modifications that are incorporated into the second iteration will be presented and discussed.