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Assessment of Zr-V-Fe getter alloy for Gas-Gap Heat Switches

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Gas-Gap heat switches are devices used to thermally connect and disconnect two objects by filling and emptying the volume between their two surfaces with a gas. The change in pressure in the gap is equivalent to the change in number of molecules available to transport heat from one surface to the other. Minimal size and mass for a gas-gap switch can be obtained through the use of a solid that reversibly absorbs and desorbs this gas. The primary requirements of a gas used in this type of a gas-gap heat switch are a high thermal conductivity and its ability to react reversibly with the solid in an actuator. Hydrogen is the gas with the highest thermal conductivity and can be reversibly stored in various metal systems. The physical dimensions of the gap and the properties of the surfaces determine the required ON (i.e., conducting) and OFF (i.e., insulating) state pressures of the switch. The present application (i.e., hydride compressors in closed-cycle Joule-Thomson sorption cryocoolers) for which a commercial Zr-V-Fe alloy has been assessed will impose an ON state pressure above 670 Pascal and an OFF state pressure below 0.13 Pascal. Furthermore, a fast switching time (i.e., < 100 s) between the two states is also required.

The Zr-V-Fe system is being considered as a promising candidate for these gas-gap actuators due to its fast kinetics of hydrogen absorption and its robustness towards contaminants. The Zr-V-Fe alloy manufactured by SAES Getters (St-172) was developed as a chemical getter to maintain vacuum in sealed volumes. There is very limited information on the properties of this hydrogen- Zr-V-Fe system for high hydrogen concentrations where alloy embrittlement severely limits its use for most getter applications. Consequently, the pressure-composition-temperature isotherms for high concentration have been determined for the SAES St-172 material to determine the baseline performance at the hydrogen concentration useful for the heat switch actuators.

Two gas-gap actuators containing the SAES St-172 material were built and they have been thermally cycled for more than 5,000 cycles to evaluate the character of degradation in the performance of the metal hydride system under conditions simulating heat switch operation. These tests are still in progress and the life study results will be compared to similar evaluations performed on gas-gap actuators containing ZrNi and uranium metal.

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