PROPOSED USE OF PYROELECTRIC X-RAY FLUROESCENCE SPECTROSCOPY IN PLANETARY SCIENCE EXPLORATION. Christopher M. Heirwegh, Kyle Uckert, Robert Hodyss, Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California USA, christopher.m.heirwegh@jpl.nasa.gov.

Introduction: X-ray fluorescence (XRF) spectroscopy is a technique that NASA and the planetary science community have relied upon for decades to provide critical geochemical analysis of Mars and other extraterrestrial bodies. The two leading XRF technologies that have shown fidelity on past and planned missions include radioactive X-ray sources and X-ray tubes. A prime example of the former is ^{244}Cm source used in numerous Alpha-Particle X-ray Spectroscopy (APXS) systems including the recent Mars Science Laboratory (MSL). For the latter, only one example, the Planetary Instrument for X-ray Lithochemistry, has been implemented thus far and is intended for integration on the 2020 Mars rover.

Use of either technologies in planetary investigations can provide meaningful, high fidelity geochemical analysis but, both systems have challenging aspects both in design and implementation that warrant NASA's continued effort to develop and test alternative X-ray emitting systems.

A proposed promising alternative form of XRF technology is the pyroelectric X-ray emitter, which is a newer form of X-ray source technology that uses thermally cycled polarized pyroelectric crystals, held in low pressure air or vacuum. Thermal cycling generates electric fields between the crystals that discharge electrons, leading to bremsstrahlung X-ray production [1].

The **P**yroelectric **I**nstrument for **R**ock **Ana**lysis (PIRANA) testbed at the Jet Propulsion Laboratory (JPL) is being refined to commence a series of new tests that designed to meet project goals. Goals include enhancing the emitted X-ray flux, characterizing the vacuum pressure conditions and instrument 1- and 2-crystal designs that maximize flux, understanding conditions of operation stability over time and, determining how the maximum energy limit of the photons produced (E_{max}) is affected. To further examine fidelity of the prototype

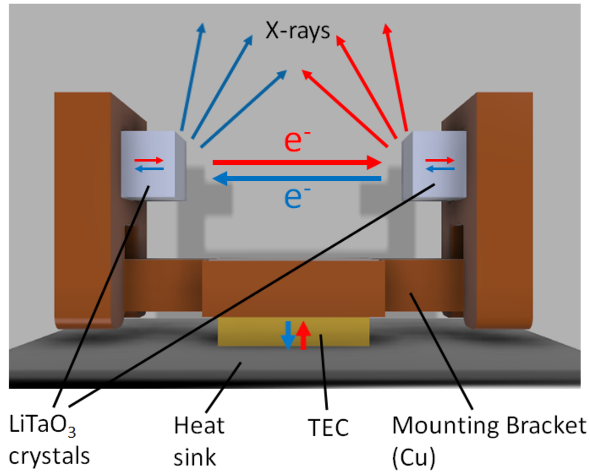

Figure 1: JPL's prototype PIRANA 2-crystal testbed design showing temperature change propagation leading to X-ray emission. Arrows on LiTaO3 crystals indicate polarization direction.

instrument, reconfiguration of the existing setup is being planned to allow measurement of a geochemical reference material (BHVO2 powder).

Efforts being taken by the instrument development team are intended to understand if pyroelectrics might provide a useful, high fidelity, low cost alternative to the leading technologies. The work presented will showcase some of the preliminary results from the first round of testing on the initial 2-crystal design (Fig. 1) and, further show new design configurations and measurement setup being planned.

Methods: The pyroelectric testbed consists of two opposite facing polarized lithium tantalite ($LiTaO_3$) crystals, mounted on a copper bracket, attached to a thermal electric cooler (TEC). The TEC is electrically driven between low and high temperature set-points and X-rays are generated as crystals experience strong temperature change (ΔT °C). The testbed was cycled in three different low pressure atmospheres (6, 16 and 26 mTorr) and three different separation distances (5, 7.5 and 10.4 mm).

Results: Cycling data indicated that certain conditions of pressure (ie. 16 mTorr) delivered superior stability of emitted flux when compared across multiple cycles within one experiment. Also, keeping separation distance at a minimum (5 mm) promoted greatest flux.

It was found that E_{max} was strongly affected by both variables in a less predictable pattern, indicating that more work is required to characterize operating conditions needed to model and predict the observed E_{max}.

Discussion: The flux observed indicates that room for improvement is needed to maximize this output. Future efforts will include new crystal holder design testing incorporating both 1- and 2-crystal setups, operation testing in pure vacuum environment (ie. 1E-06 Torr), operation of a new smaller holder design allowing improved control over delta T and, automatic operation of chamber cycling using the newly developed LabVIEW chamber operation software developed for this task.

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References: [1] Lang, S. B. (2005) *Physics Today 58*, 31 – 36.