Micromachined Thermopile Arrays with Novel Thermoelectric Materials. A. -D. Brown[1], S. Aslam[1], E. M. Barrentine[1], V. Mikula[1,2], A. Schmidt[3], and E. Ziade[3], [1]NASA Goddard Space Flight Center, Greenbelt, MD 20771 USA, e-mail: ari.d.brown@nasa.gov; shahid.aslam-1@nasa.gov; emily.m.barrentine@nasa.gov, [2]Institute for Astrophysics and Computational Sciences, The Catholic University of America, Washington, DC 20064 USA, e-mail: vilem.mikula-1@nasa.gov, [3]Department of Mechanical Engineering, Boston University, Boston, MA 02215 USA, email: schimdt@bu.edu; eziade@bu.edu .

Introduction: Thermopile detectors are prime candidates for mid- and far-infrared (4.6-100 μm) instruments (e.g., a thermal mapper on the Europa Clipper or Saturn Probe missions) engaged in planetary and lunar thermal mapping because their specific detectivity D^* has been shown to exceed 10^9 Jones and, unlike competing Si bolometers, they can be passively cooled. We have fabricated and characterized novel thermopile detectors, which use micromachined 2μm-thick Si legs to thermally isolate the hot and cold thermocouple regions. A minimal thermoelectric model, coupled with measurements of the Seebeck coefficient and thermal conductivity (see Fig. 1) of various semimetallic thin films at 77 and 300 K, was used to guide the thermopile design to obtain predictions of D^*, responsivity, and time constant.

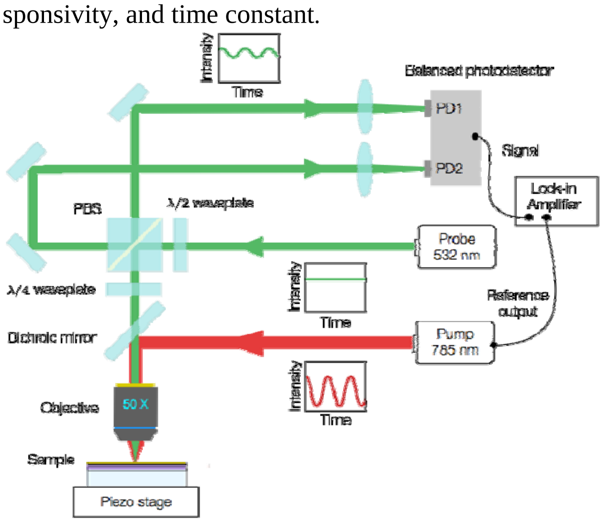

Figure 1: Laser thermoreflectance apparatus used to extract the thermal properties of thin films. This is a non-destructive process, which can be used to measure the thermal conductivity of sub-mm^3 sections of material.

Linear arrays of thermopile detectors, which consisted of semimetallic thermocouples contacting a semimetallic absorbing thin film, were fabricated with over 99% yield. The fabrication process allowed for evaluation of six different leg designs on a 4” Si wafer as well as realization of 1x64 linear thermopile arrays shown in Fig. 2.

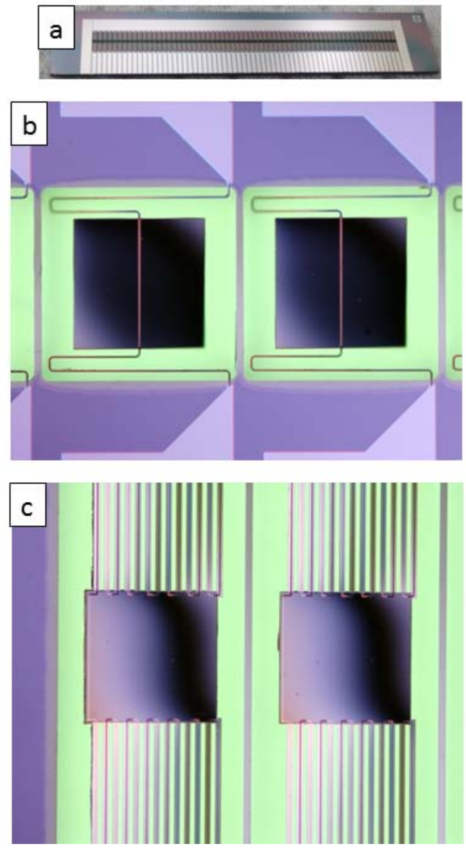

Figure 2: (a) Image of a fabricated linear 1x64 thermopile array. (b), (c) images of thermopile pixels. The pixel pitch is 500 microns.

This process also provides a template for the realization of high throughput thermopile arrays; we expect that thermopiles with competitive time constant, responsivity, and specific detectivity can be made when materials with high Seebeck coefficient are used.

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