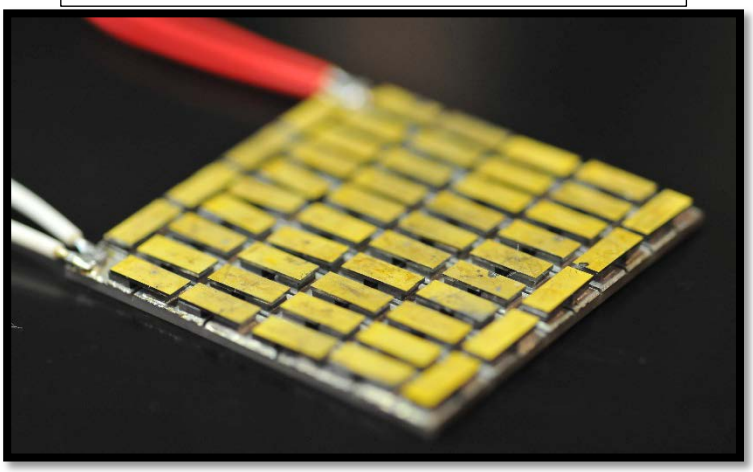
NETS 40-Watt Devices
for DARPA MATRIX

Specifications

Footprint	~ 40 mm x ~ 40 mm
Cold side temperature	125-150 °C
Thermal flux	~ 500 Watts
Efficiency	≥ 8%
Power output	≥ 40 Watts

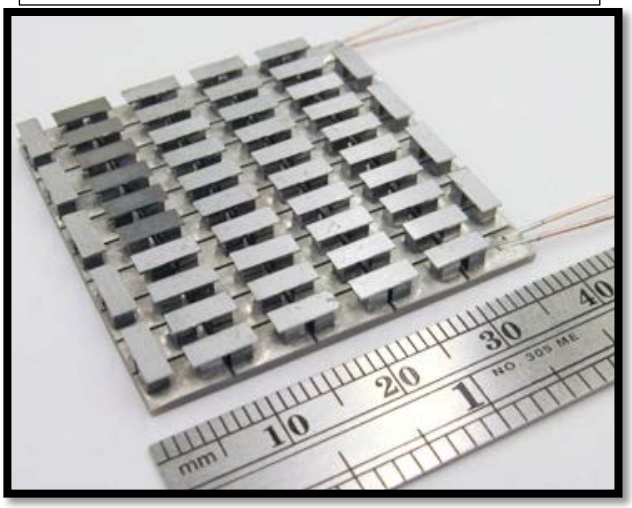
49-couple Skutterudite TE Device – Bottom Stage



Current Model Conditions

Cold side temperature	150 °C
Hot side temperature	600 °C
Thermal conductance	1.1 Watts/K
Thermal flux	504 Watts
Efficiency (de-rated)	8.2%
Power output	41 Watts
Optimum current	10-15 Amps

49-couple Half-Heusler TE Device – Top Stage



Current Parameters

Footprint	37.5 mm x 37.5 mm
Number of stages	2
Cold side substrates	1.0 mm AlN w/ 0.2 mm Cu
Hot side interconnects	Metallized molybdenum
Number of couples	49 in each stage
Leg lateral dimensions	2.35 mm x 2.35 mm
Fill fraction	39%
hH leg height	1.35 mm
Skutt. leg height	0.65-0.85 mm

Features

- ~ 3 W/cm^2 of output (higher than typical)
- Incorporating half-Heusler materials, which have improving ZT values
- Half-skeleton design minimizes thermally-induced mechanical stresses
- For time scale of testing, TE materials are air-stable in their respective operating ranges

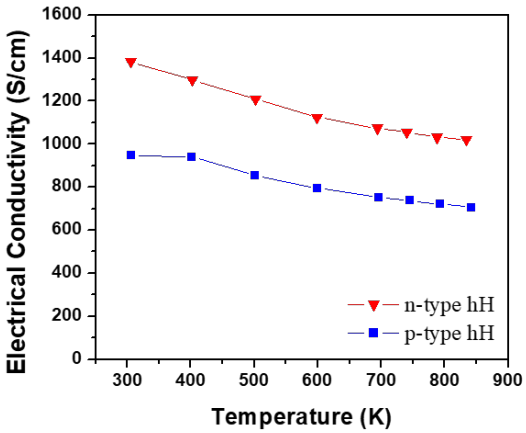
Planned improvement areas

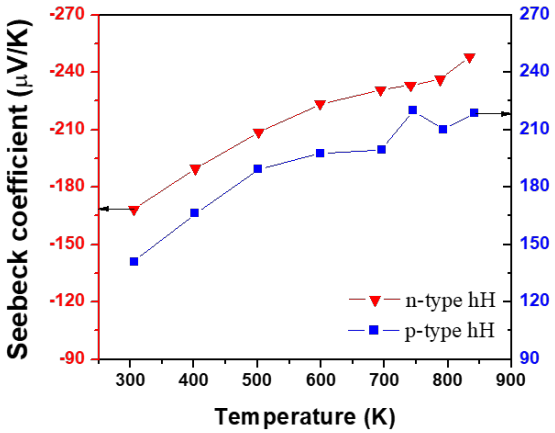
- Bonding method
- Possibly switch to segmentation to facilitate bonding and assembly process
- Coatings
- Process streamlining (between RTI and Marlow)

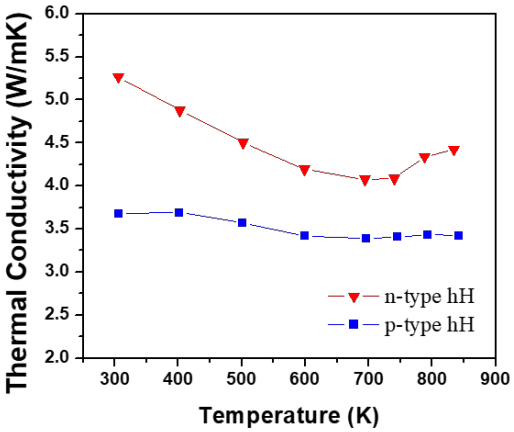
RTI INTERNATIONAL

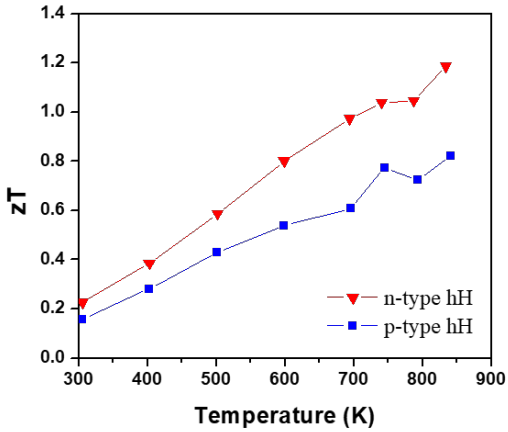
II-VI MARLOW

NETS Thermoelectric half-Heusler material

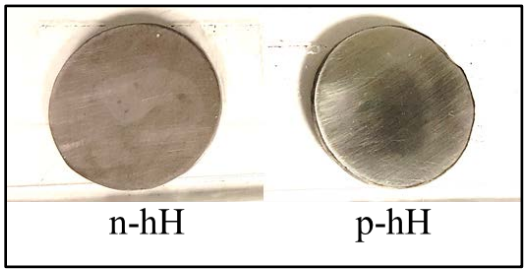






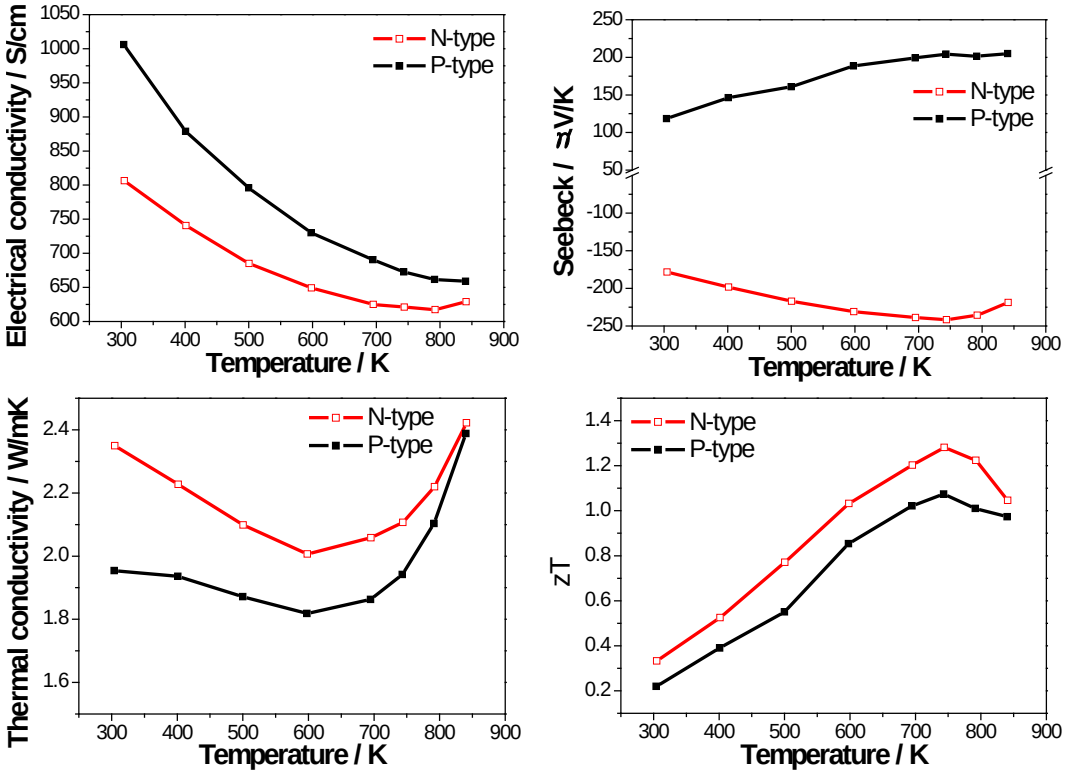


Materials	Temperature (K)	σ (S/cm)	S (μV/K)	κ (W/mK)	zT	zT_{avg}
n-type	600	1124.73	-223.57	4.19	0.801	**1.009**
	850	1021.43	-248.14	4.42	1.186	(600-850K)
p-type	600	795.25	197.79	3.42	0.539	**0.693**
	850	706.27	218.82	3.42	0.821	(600-850K)

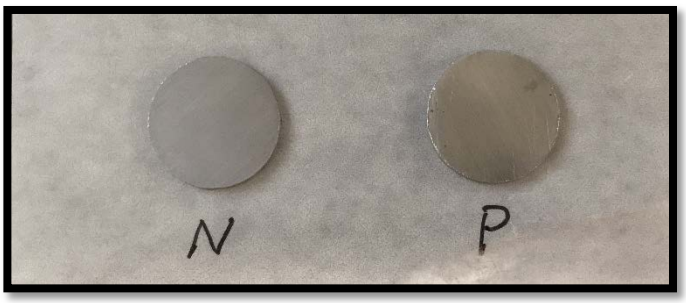


The wafers for device fabrication with ϕ 20 mm and 1.5 mm thickness. Contact Virginia Tech (Shashank Priya, spriya@vt.edu) for material samples.

NETS Thermoelectric Skutterudite Materials

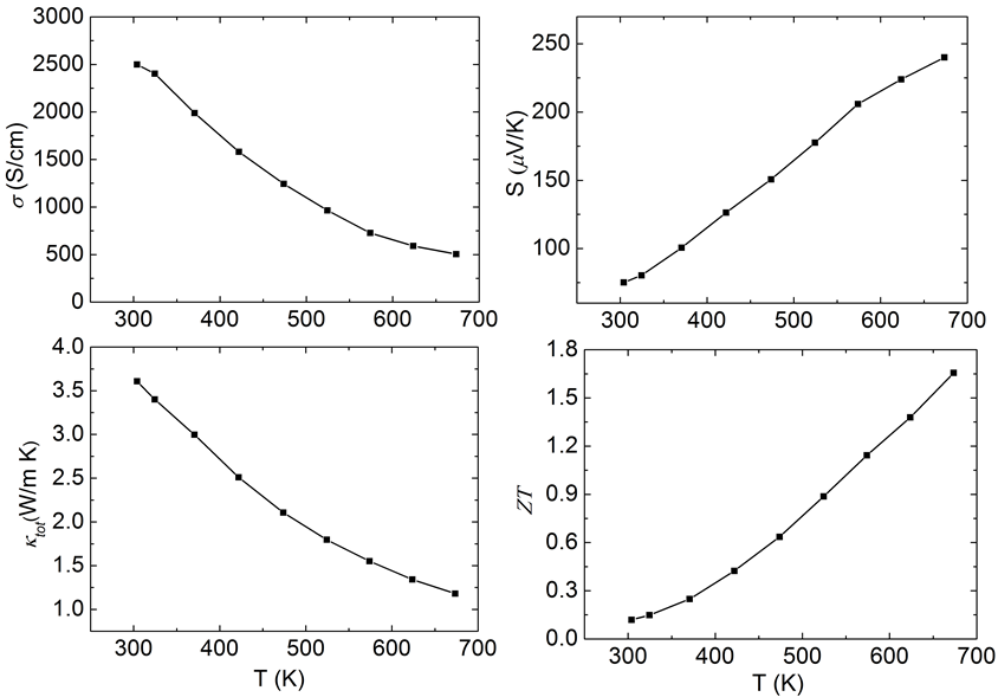


Materials	Temperature (K)	σ (S/cm)	S (μV/K)	κ (W/mK)	zT	zT_{avg}
N-type	400	740.74	-198.36	2.23	0.525	0.776 (400-600 K)
	600	649.35	-230.95	2.01	1.033	
P-type	400	878.73	146.41	1.93	0.390	0.598 (400-600 K)
	600	730.19	188.60	1.82	0.854	



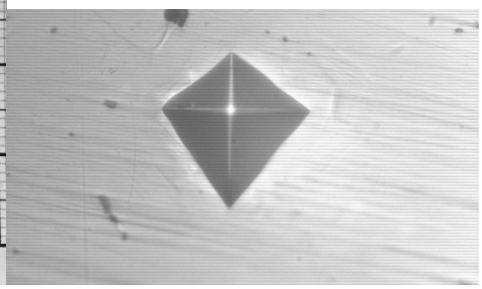
The wafers for device fabrication with ϕ 20 mm and 1.5 mm thickness (Contact Shashank Priya, spriya@vt.edu for samples).

NETS P- Type PbTe Material

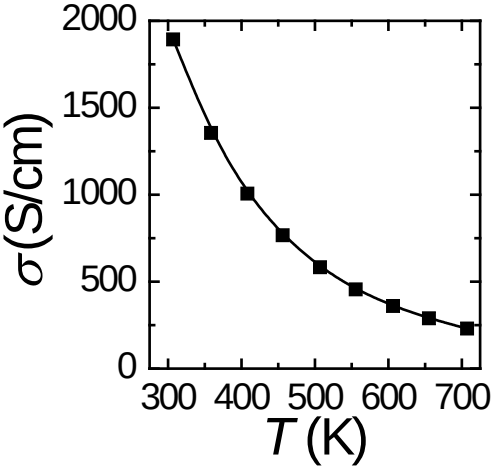


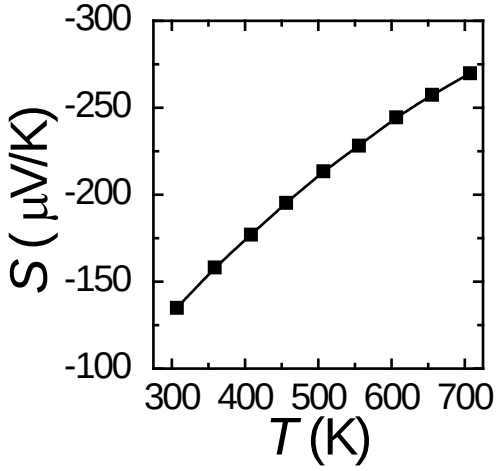
T (K)	σ (S/cm)	S (μV/K)	κ (W/mK)	ZT	ZTavg	Vicker's Const. (Kg/ mm2)
300	2500	75	3.6	0.11	1.02 (423-673 K)	84
673	504	240	1.2	1.66		

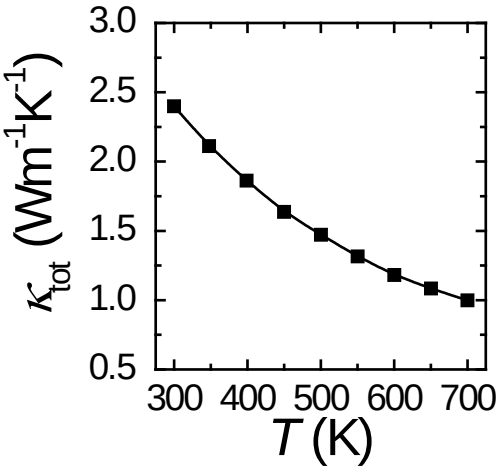
Indentation for Hardness Test

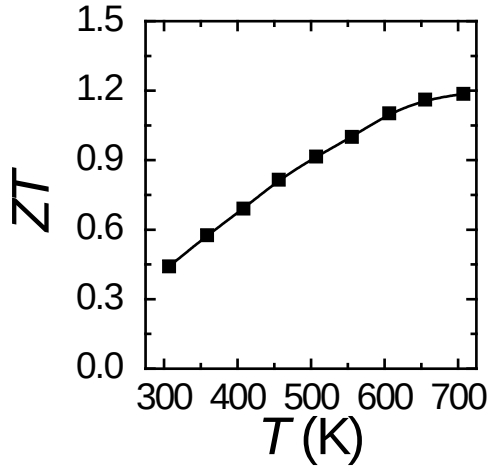


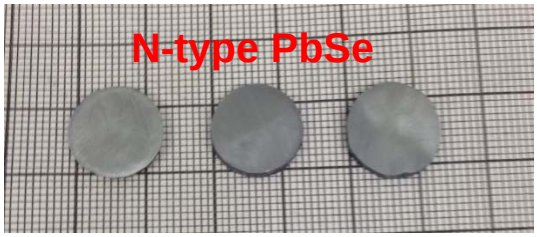
NETS N-type PbSe Material

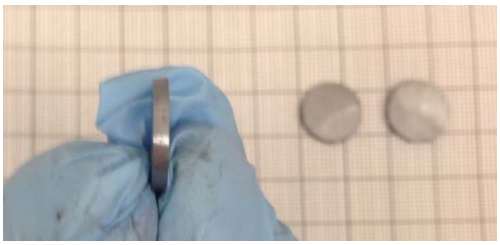












Physical parameters for n-type PbSe

σ (S/cm, 300 K)	S (μV/K, 300 K)	κ (W/mK, 300 K)	ZT (300 K)	Vickers hardness (Kg/mm^2, 300K)
1890	-135	2.4	0.44	57*
σ (S/cm, 700 K)	S (μV/K, 700 K)	κ (W/mK, 700 K)	ZT (700 K)	ZT_{ave} (300-700 K)
230	-270	1	1.19	0.92

* Journal of Materials Science 4 (1969): 313-319; Data acquired with a 15 g load