High Temperature Quantum Well Materials

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Thermoelectric Property Measurements by Various Organizations and Calculated Figures of Merit

	Measured Seebeck α $\mu V/°C$	Measured electrical resistivity - 4 probe technique (excludes contact resistance) ρ $m\Omega$-cm	Power Factor α^2/ρ $\mu W/cm°K^2$	Figure of Merit[1] ZT = $\alpha^2 x T/(\rho \times \kappa)$	Projected Efficiency[1] 50-250°C %
Former Si/SiGe QW sample	1100		1,210	>3	13
Cleaned Contacts	1200	0.04	36,000		28
Si/SiGe data observed by UCSD at Hi-Z (12/06)	1200		1,920	>4	16
Si/SiGe data observed by UCSD at Hi-Z (12/06)	1200	0.042	34,286	>10	28
Si/SiGe data at Hi-Z observed by NIST (3/07)	1302		4,709	>10	17
Si/SiGe data at Hi-Z observed by NIST (3/07)	1302	0.05	33,904	>10	28
Si/SiGe data measured by UCSD at UCSD (12/06)	1000		1,333	>3	14
Si/SiGe data measured by UCSD at UCSD (09/07)	800		1,939	>4	19
Si/SiGe data measured by UCSD at UCSD (09/07)	800 1500	0.2 0.12	3,200 18,750	>8 >10	25 27
Si/SiGe data measured by JPL at JPL (10/07-Interim Preliminary Report)	1420	0.35 in 2 probe measurement	5,761	Footnote # 4	Footnote # 4
Current Bi_2Te_3 bulk alloy	220	1.1	44	0.8	5

Summary of QW Film Data Obtained in BN Test Fixture

	Temperatures			Measurements			Lit. Data	Efficiency Based on ZT from Measured Data and Literature Bulk κ					Normalized Efficiency to Bi_2Te_3 & ΔT
Sample #	T_H (°C)	T_C (°C)	ΔT (°C)	α (μV/°C)	ρ (mΩ-cm)	P Pwr (μW)	κ (W/cm-°C)	ZT_{ave}	M	Carnot Efficiency (%)	Materials Efficiency(a) η_{mat} (%)	Total Efficiency (%)	$\frac{\eta_{mat,QW}}{\eta_{mat,Bi_2Te_3}}$
N type Bi_2Te_3	74.6	65.08	9.52	-176.7	1.02	7.35	0.012	~0.8	1.36	2.74	15.6	0.43	1.00
Si/SiGe	77.6	70.49	7.108	794.6	0.28	0.58	0.110	~7	2.87	2.03	48.6	0.98	3.11
Si/SiGe	92.94	85.49	7.45	758.8	0.25	1.8	0.110	~7	2.93	2.04	49.4	1.01	3.17
Si/SiGe	83.07	72.1	10.97	642.7	0.22	1.9	0.110	~6	2.63	3.08	45.2	1.39	2.90

	Efficiency based on measured power and heat balance					
Sample #	Seebeck Heat (μW)	Joule Heat (μW)	Fourier Heat (μW)	Total Heat (μW)	Efficiency at maximum power (%)	Normalized Efficiency to Bi_2Te_3 & ΔT
N type Bi_2Te_3	520.9	-3.67	1159	1676	0.44	1.00
Si/SiGe	65.5	-0.29	21	86	0.68	2.06
Si/SiGe	175.8	-0.90	45	220	0.82	2.39
Si/SiGe	121.1	-0.94	40	160	1.17	2.32
Maximum efficiency calculation for QW from efficiency-current theoretical plot (e.g. Fig. 7)					Value at maximum efficiency	
Si/SiGe	39.29	-0.10	21	60	0.97	2.96
Si/SiGe	123.1	-0.44	45	168	1.07	3.13
Si/SiGe	84.75	-0.46	40	125	1.51	2.98

Good correlation between both approaches

(a) $\eta_{mat} = \frac{M-1}{M+\frac{T_C}{T_H}}$