Advanced Soldier Thermoelectric Power System for Power Generation from Battlefield Heat Sources

SERDP Project #SI-1652

Dr. Terry J. Hendricks, Program Manager
Pacific Northwest National Laboratory, Corvallis, OR

Dr. Tim P. Hogan, Associate Professor
Dr. Eldon D. Case, Professor
Dr. Harold Schock, Professor
Michigan State University, East Lansing, MI

Charles J. Cauchy, President
Jim Barnard, Materials Scientist; Mike Spry, Project Engineer
Tellurex Corporation, Traverse City, MI

DOE 2009 Thermoelectrics Applications Workshop
San Diego, CA
30 September 2009
Our Project Team Would Like to Express our Sincerest Thanks to Dr. John Hall, Sustainable Infrastructure Program Manager, Strategic Environmental Research & Development Program Office and Ms. Carrie Wood, Technical Monitor, HGL, Inc. for their Support and Funding of this Project.
Project Technical Objective

- Develop a Light-Weight, Small-Form-Factor, Soldier-Portable Advanced Thermoelectric Power (TEP) System
  - Develop Bench-Scale Prototype to Recover & Convert Waste Heat
  - Variety of Deployed U.S. Army and Marine Equipment
    - Diesel Generators/Engines, Incinerators, Vehicles, & Potentially Mobile Kitchens
- Achieve Power Conversion Efficiencies of ~10% (Double Current TE System Efficiencies) With Operating Power System Output of ~1.6 kW
- Research & Solve Never-Before-Addressed System Integration Challenges
  - Segmenting LAST (Lead-Antimony-Silver-Telluride) Compounds & Bi$_2$Te$_3$ TE Materials in Operating TEP System
  - Thermal Expansion, Thermal Diffusion, Electrical Interconnection, Thermal & Electrical Interfaces in Thin “TE power panels” With Segmented LAST/ Bi$_2$Te$_3$
Project Summary

- Advanced TE Materials and Micro-Technology Designs Combined into Operating 1.6 kW TEP System (3-Phase Program)
- Bench-Scale Prototype Testing (Phase 2)
- Application-Scale Testing @ U.S. Army Aberdeen Testing Center
  - Adapted to Tactical Quite Generator (TQG) in Phase 3 Application-Scale Testing
  - Potentially Applied to Several Battlefield Heat Sources, But TQG Being Used as the Test Bed Demonstrator
  - Reduce Base Fuel Consumption or Provide More Power Output
Properties of Tellurex P-type Samples

- P-type LASTT TE Materials Quite Reproducible & Showing Power Factor Improvements
- Starting to Approach the Performance Levels of Cast LASTT Materials
Properties of Tellurex N-type Samples

Higher Pb content has a doping effect and moves the peak of the power factor to higher temperatures.

- N-type LAST TE Materials Showing Power Factor Improvements
- Starting to Approach the Performance Levels of Cast LASTT Materials
- Peak ZT Increasing
- Shallower ZT Slope
TE Material Thermal Stability Studies

Material Processing to Support Testing

Ingot

Material Processing
- Powder
- Cold Pressing
- Hot Pressing
- Sintering

Biaxial Flexure Fracture Samples

Raw Wafers

Thermal Fatigue Samples
Thermal fatigue testing

Evolution of Thermal Fatigue Damage Monitored Through Elastic Moduli

- LAST, LASTT and undoped PbTe specimens placed in a chamber - Argon gas
- Specimens undergo up to 200 thermal fatigue cycles (50 C – 400 C)
- Specimen temperature monitored during thermal fatigue process

- Young’s modulus and the Poisson’s ratio measured using the Resonant Ultrasound Spectroscopy (RUS)
- Fracture strength in biaxial flexure -- accommodates disc-shaped specimens
Young’s modulus, E, versus N results

LASTT results
- Latest specimens survived the 200 thermal cycles without appreciable decrease in E
- One specimen broke into two pieces following the 170th cycle.
- One specimen, E dropped from 46.4 GPa (N = 170) to 26.1 GPa (N =180 --> substantial increase in crack damage between 170 and 180 thermal cycles.

LAST results
- E for the two LAST specimens decreased by less than 0.7 % for N = 200.

Undoped PbTe results
- E for two of the PbTe specimens decreased by only about 2 percent for N = 200
- Other two specimens, E decreased by eight percent and 20 percent, respectively.
## Mean biaxial fracture strength of specimens tested to date in this study

<table>
<thead>
<tr>
<th>Material</th>
<th>Specimen</th>
<th>Condition</th>
<th>Test</th>
<th>N\textsubscript{valid}/N\textsubscript{total}</th>
<th>Strength (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LASTT</td>
<td>P14</td>
<td>As-received</td>
<td>BOR</td>
<td>6/10</td>
<td>46 ± 4</td>
</tr>
<tr>
<td></td>
<td>P15</td>
<td>Polished</td>
<td>BOR</td>
<td>6/10</td>
<td>58 ± 8</td>
</tr>
<tr>
<td></td>
<td>P15</td>
<td>As-received</td>
<td>ROR</td>
<td>9/10</td>
<td>32 ± 5</td>
</tr>
<tr>
<td></td>
<td>P15</td>
<td>30 thermal cycles</td>
<td>ROR</td>
<td>9/10</td>
<td>30 ± 5</td>
</tr>
<tr>
<td>PbTe</td>
<td>PbTe1</td>
<td>As-received</td>
<td>ROR</td>
<td>10/10</td>
<td>19 ± 6</td>
</tr>
<tr>
<td></td>
<td>PbTe1</td>
<td>30 thermal cycles</td>
<td>ROR</td>
<td>16/20</td>
<td>20 ± 3</td>
</tr>
<tr>
<td></td>
<td>PbTe2</td>
<td>30 thermal cycles</td>
<td>ROR</td>
<td>10/10</td>
<td>15 ± 4</td>
</tr>
<tr>
<td></td>
<td>PbTe2</td>
<td>Annealed 400°C 2hr</td>
<td>ROR</td>
<td>7/10</td>
<td>22 ± 3</td>
</tr>
<tr>
<td></td>
<td>PbTe2</td>
<td>Annealed 500°C 2hr</td>
<td>ROR</td>
<td>10/10</td>
<td>15 ± 6</td>
</tr>
<tr>
<td>LAST</td>
<td>N37</td>
<td>As-received</td>
<td>ROR</td>
<td>7/8</td>
<td>26 ± 4.4</td>
</tr>
</tbody>
</table>

### Ring-on-Ring Biaxial Flexure Test (ASTM Standard C1499-05)

![Ring-on-Ring Biaxial Flexure Test Diagram](image)
TE Module Fabrication with LAST/Bi$_2$Te$_3$

- Tellurex Working On 2 Segmented Module Designs
  - 49 Couples
  - 24 Couples
- Intended to Fit on 7.6 cm X 2.0 cm Heat Exchanger Footprint
- Module Efficiency ~9% (Including Contact Resistance Effects; 670 – 312 K)
  - Current Status with Current LAST/LASTT Material Performance
  - Seeking Further Material Progress to Allow us to Improve this Result to 10%
Efficiency for Segmented Legs with Tellurex Samples

- $\eta = 9.8\%$ (Ideal, No Contact Losses); 9.0% With Contact Losses
- Heat flux to TE material hot side $q_h = \sim 12$ W/cm$^2$
- Module Efficiency Quite Good Given the Number of Material “Process Parameters” We Are Trying to Control

宗宗=0.72
An=0.87
An=1.01
An=1.16
An=1.30
An=1.44
An=1.59
An=1.73
An=1.88
An=2.02
An=2.17

For $\delta = 0.1$
Current output at peak power = 0.73 (A)
Load resistance per unicouple at peak power = 115 (m$\Omega$)

Modeling software developed under ONR support.
**Thermal - Structural Analysis Results**

**Configuration 1**
- p1: Tellurex LAST
- p2: p_Bi2Te3
- n1: Tellurex LAST
- n2: n_Bi2Te3

**Quarter Models**
- Alumina (25 mil)
- Copper (10 mil)

**Module Dimensions:**
- Length: 72.91 mm
- Width: 18.46 mm

**Configuration 2**

**Module Dimensions:**
- Length: 36.61 mm
- Width: 18.46 mm

- Alumina (25 mil)
- Copper (10 mil)
Stress - Z

- Using Structural Analysis to Define Critical Interface Materials & Element Design
- Structural Stresses Controlling Element Design as Much as TE Properties
- X- and Y-Stresses OK
- Z-Tensile Stresses Creating Small Challenges Due to Expanding Cu

Stress – X (Y-Stresses Also)
Microchannel Heat Exchanger Design Results

- Hot-Side & Cold-Side Heat Exchanger Designs Exhibit High Heat Flux Capability
  - 12 W/cm² on Hot-Side
  - While Providing:
    - 670 K TEG Hot-Side Temperature
    - 312 K TEG Cold-Side Temperature
  - Allows for Compact System Design
  - 11 W/cm² on Cold-Side

- Materials
  - Hot-Side Design: Stainless Steel 304 or 316
  - Cold-Side Design: Copper or Aluminum

- Each Heat Exchanger: 7.6 cm x 2.0 cm Heat Transfer Footprint
Various Hot-Side Heat Exchanger Design Concepts Have Been Studied

Anticipated Hot Side Heat Flux Determined

Pressure Differential Dependency Established

TQG Exhaust Flow Conditions

Given Exhaust – Device Hot Side Temperature Differential

Hot-Side Heat Flux-Pressure Differential Tradeoff Is Clear
Microchannel Heat Exchanger Designs

- Exploratory Heat Exchanger Test Specimens Fabricated
- Hot-Side Heat Exchanger Design Developed & Being Refined
- Hot-Side Heat Exchanger Testing in Next Project Phase
- Performance Goals:
  - High Thermal Transfer Flux (~12 W/cm²) in Hot-Side Heat Exchanger
  - Low Pressure Drop (< 1 psi)
  - Heat Flux vs. Pressure Drop Characteristics Quantified for Different Design Approaches
- Integrate TE/HX Interface Design & Material

COMSOL CFD Analysis

Hydrodynamic Conditioning & Mixing
Air Supply Heaters
Water-Cooled Heat Sink
Dual Section Design Approach & Analysis

- Dual Section Design Allows Higher Power @ Highest Efficiency
- 30-kW Exhaust Conditions & Results Shown Above (754 K, 0.097 kg/sec)
- Important Design Tradeoffs Between the Two Sections
- 30-kW Exhaust Conditions Create Designs That Fall Short of Project Goals
  - 1.4 kW, ~8.1% Efficiency
  - Still Significant Opportunity in TQG’s

\[ \text{TEG} \]

\[ 1^{\text{st}} \text{ Section} \rightarrow 675.5 \text{ K K} \rightarrow 2^{\text{nd}} \text{ Section} \rightarrow 591.3 \text{ K K} \]

\[ \begin{align*}
    \text{P1} & \rightarrow 670 \text{ K} \\
    \text{L}_n & \rightarrow \text{Bi}_x\text{Te}_{3-x}\text{Se}_x \\
    \text{L}_{p1} & \rightarrow \text{Bi}_x\text{Sb}_{2-x}\text{Te}_3 \\
    \text{T}_{jn} & \rightarrow \text{L}_{\text{total}} \\
    \text{T}_{ip} & \rightarrow \text{L}_{\text{total}} \\
\end{align*} \]
Dual - Section TEG Design Analysis

- LAST/LASTT/Bismuth Telluride Segmented in First Section; Bismuth Telluride In Second Section
- 30 kW Tactical Quiet Generator (TQG) Flow Conditions
  - 0.1 kg/sec
  - 754 K
  - ~1.4 kW @ 8.8% Possible With ~11% TE Module
  - ~1.4 kW @ 8.1% with 10% Module

![Power vs Efficiency Graph]

- ~1.4 kW Possible Overall Efficiency Too Low
- Less 2nd Section Power
- More 2nd Section Power

800 Watts/Section
**Dual Section Design Approach & Analysis**

- Dual Section Design Allows Higher Power @ Highest Efficiency
- 60-kW Exhaust Conditions & Results Shown Above (780 K, 0.158 kg/sec)
- Important Design Tradeoffs Between the Two Sections
- 60-kW Exhaust Conditions Allow One to Achieve Very Close to Project Goals
  - Single-Section Design Can Almost Achieve Goals (~1.6 kW with a 10% Efficient TE Modules)
  - Dual-Section Design Creates More Power at Slightly Reduced Overall Conversion Efficiency
    - 2.6 kW @ 8.2% System Efficiency
TEG System Analysis

- Detailed TE System Analysis Has Shown That:
  - 30 kW TQG Enthalpy Flow is Too Low to Achieve Project Objectives
  - Dual-Section Design Could Get 1.4 kW But Only at 8.1% Efficiency
    - Flow Temperature and Mass Flow Rate Simply Too Low
      - 0.1 kg/sec @ 754 K
    - TE Material Properties Simply Not High Enough
  - 60 kW TQG Could Provide the Necessary Flow Conditions To Reach Close to Project Goals
    - 0.158 kg/sec @ 780 K
  - Single-Section TEP Design
- Current System Design Is Being Performed Around 60 kW TQG Flow Conditions
- Design Options/Approaches Now Exist for Multiple TQG’s
LAST/LASTT Materials Making Significant Improvements for Implementation into TE Devices
  - TE Material Properties Improving
  - Structural Properties & Thermal Fatigue Characteristics Being Quantified
Micro-Technology Heat Exchanger Designs Identified and Test Articles Fabricated
Flexible & Modular System Design Identified – Key Tradeoffs Quantified
System Analysis Shows That Project Needs a 60 kW TQG Rather Than a 30 kW TQG
  - Enthalpy Flow is Too Low in 30 kW TQG Exhaust to Meet Original Project Goals
  - However, 30 kW TQG’s Still Present a Significant Energy Recovery Opportunity
  - As do 100 kW TQG’s
This Project Provides Pathway for Flexible, Modular System Design to Address All TQG Opportunities and Other Battlefield Heat Sources
BACKUP MATERIAL

These charts are required, but will only be briefed if questions arise.
## Material Properties (Mechanical & Thermal) used in FEA

<table>
<thead>
<tr>
<th></th>
<th>Alumina</th>
<th>Copper</th>
<th>LASTT (p1)</th>
<th>LAST (n1)</th>
<th>p_{Bi_2TE_3} (p2)</th>
<th>n_{Bi_2TE_3} (n2)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Young's Mod (GPa)</em></td>
<td>300</td>
<td>129</td>
<td>46.55</td>
<td>54.5</td>
<td>43.6</td>
<td>43.6</td>
</tr>
<tr>
<td><strong>Yield / Fracture Strength (MPa)</strong></td>
<td>2100 (compressive)</td>
<td>~198</td>
<td>30-32(ROR)</td>
<td>26(ROR)</td>
<td>8-166</td>
<td>8-166</td>
</tr>
<tr>
<td>CTE (x10^{-6} / °C)</td>
<td>8.2</td>
<td>Temp Dependent</td>
<td>18</td>
<td>21.3</td>
<td>18</td>
<td>21.3</td>
</tr>
<tr>
<td>Thermal Conductivity (W/m°C)</td>
<td>25</td>
<td>Temp Dependent</td>
<td>1.5035</td>
<td>1.25</td>
<td>2.27</td>
<td>1.103</td>
</tr>
</tbody>
</table>

* Properties are approximate averages over T_h to T_c range

** For information only. Not used in FEA.
<table>
<thead>
<tr>
<th>Material Case # / TE Materials</th>
<th>$\eta_1$-Segmented (%)</th>
<th>$Q_{h1}$ [W]</th>
<th>$P_{1}$-Segmented [W]</th>
<th>$\eta_{total}$ [%]</th>
<th>Material Case # / TE Materials</th>
<th>$\eta_2$ (%)</th>
<th>$Q_{h2}$ [W]</th>
<th>$P_{2}$ [W]</th>
<th>$P_{total}$ [W]</th>
<th>$Q_{htotal}$ [W]</th>
<th>$\eta_{total}$ (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Cast LAST &amp; Bi2Te3 Materials – Best</td>
<td>12.1</td>
<td>.9*17585</td>
<td>1910.3</td>
<td>10.9</td>
<td>Bi2Te3 (only)</td>
<td>7.37</td>
<td>.9*14398</td>
<td>955.0</td>
<td>2865.3</td>
<td>31983</td>
<td>9.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>28. Best Tellurex LAST/LASTT &amp; Bi2Te3 (Segmented)</td>
<td>8.34</td>
<td>.9*14398</td>
<td>1080.7</td>
<td>2991.0</td>
<td>31983</td>
<td>9.4</td>
</tr>
<tr>
<td>10. Cast LAST Materials – Average</td>
<td>10.5</td>
<td>.9*17585</td>
<td>1664.9</td>
<td>9.5</td>
<td>Bi2Te3 (only)</td>
<td>7.37</td>
<td>.9*14398</td>
<td>955.0</td>
<td>2619.9</td>
<td>31983</td>
<td>8.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>28. Best Tellurex LAST/LASTT &amp; Bi2Te3 (Segmented)</td>
<td>8.34</td>
<td>1080.7</td>
<td>2745.6</td>
<td>31983</td>
<td>8.6</td>
<td></td>
</tr>
<tr>
<td>14. SERDP Project – Average LAST/LASTT Materials</td>
<td>9.5</td>
<td>.9*17585</td>
<td>1503.5</td>
<td>8.6</td>
<td>Bi2Te3 (only)</td>
<td>7.37</td>
<td>.9*14398</td>
<td>955.0</td>
<td>2458.5</td>
<td>31983</td>
<td>7.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>28. Best Tellurex LAST/LASTT &amp; Bi2Te3 (Segmented)</td>
<td>8.34</td>
<td>1080.7</td>
<td>2584.2</td>
<td>31983</td>
<td>8.1</td>
<td></td>
</tr>
<tr>
<td>12. SERDP Project – Best LAST/LASTT &amp; Bi2Te3 Materials</td>
<td>10.1</td>
<td>.9*17585</td>
<td>1598.5</td>
<td>9.1</td>
<td>Bi2Te3 (only)</td>
<td>7.37</td>
<td>.9*14398</td>
<td>955.0</td>
<td>2553.5</td>
<td>31983</td>
<td>8.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>28. Best Tellurex LAST/LASTT &amp; Bi2Te3 (Segmented)</td>
<td>8.34</td>
<td>1080.7</td>
<td>2679.2</td>
<td>31983</td>
<td>8.4</td>
<td></td>
</tr>
<tr>
<td>8. SERDP Project – LAST/LASTT With Zhou-based Process on n-type, Best Tellurex LASTT &amp; Bi2Te3 Materials</td>
<td>10.9</td>
<td>.9*17585</td>
<td>1725.1</td>
<td>9.8</td>
<td>Bi2Te3 (only)</td>
<td>7.37</td>
<td>.9*14398</td>
<td>955.0</td>
<td>2553.5</td>
<td>31983</td>
<td>8.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>28. Best Tellurex LAST/LASTT &amp; Bi2Te3 (Segmented)</td>
<td>8.34</td>
<td>1080.7</td>
<td>2679.2</td>
<td>31983</td>
<td>8.4</td>
<td></td>
</tr>
<tr>
<td>7. TAGS-85/PbTe &amp; Bi2Te3 Materials</td>
<td>11.4</td>
<td>.9*17585</td>
<td>2001.2</td>
<td>10.2</td>
<td>Bi2Te3 (only)</td>
<td>7.37</td>
<td>.9*14398</td>
<td>955.0</td>
<td>2553.5</td>
<td>31983</td>
<td>9.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>21. TAGS-85/PbTe &amp; Bi2Te3 Materials</td>
<td>9.2</td>
<td>1192.2</td>
<td>3193.4</td>
<td>31983</td>
<td>10.0</td>
<td></td>
</tr>
<tr>
<td>4. n-type Ba$_2$Yb$_3$Co$<em>4$Sb$</em>{12}$ Skutterudites &amp; TAGS-85 &amp; Bi2Te3 Materials</td>
<td>11.7</td>
<td>.9*17585</td>
<td>2055.7</td>
<td>10.5</td>
<td>Bi2Te3 (only)</td>
<td>7.37</td>
<td>.9*14398</td>
<td>955.0</td>
<td>2553.5</td>
<td>31983</td>
<td>9.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>28. Best Tellurex LAST/LASTT &amp; Bi2Te3 (Segmented)</td>
<td>8.34</td>
<td>1080.7</td>
<td>3136.4</td>
<td>31983</td>
<td>9.8</td>
<td></td>
</tr>
<tr>
<td>15. n-type Ba$_2$Yb$_3$Co$<em>4$Sb$</em>{12}$ Skutterudites, Best Tellurex LASTT &amp; Bi2Te3 Materials</td>
<td>10.7</td>
<td>.9*17585</td>
<td>1693.4</td>
<td>9.6</td>
<td>Bi2Te3 (only)</td>
<td>7.37</td>
<td>.9*14398</td>
<td>955.0</td>
<td>2553.5</td>
<td>31983</td>
<td>8.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>30. n-type Ba$_2$Yb$_3$Co$<em>4$Sb$</em>{12}$ Best Tellurex LASTT &amp; Bi2Te3 (Segmented)</td>
<td>8.8</td>
<td>1140.3</td>
<td>2833.7</td>
<td>31983</td>
<td>8.9</td>
<td></td>
</tr>
</tbody>
</table>
Room temperature mechanical properties for selected wide and narrow band gap semiconductors

<table>
<thead>
<tr>
<th>Mat’l</th>
<th>E (GPa)</th>
<th>υ</th>
<th>K_c (MPa-m^{0.5})</th>
<th>σ_f / (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Si</td>
<td>163 p</td>
<td>0.22 p</td>
<td>0.7 a</td>
<td>247 s</td>
</tr>
<tr>
<td>Ge</td>
<td>128 l</td>
<td>0.21 l</td>
<td>0.60 j</td>
<td>231-392 q</td>
</tr>
<tr>
<td>GaAs</td>
<td>117 j</td>
<td>0.24 j</td>
<td>0.46 d</td>
<td>66 m</td>
</tr>
<tr>
<td>PbTe</td>
<td>58</td>
<td>0.26</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LAST/-T (MSU)</td>
<td>24.6 – 71.2</td>
<td>0.24 – 0.28</td>
<td>--</td>
<td>15.3 – 51.6</td>
</tr>
<tr>
<td>PbTe (Tellurex)</td>
<td>51.7 – 52.5</td>
<td>0.26 – 0.28</td>
<td>--</td>
<td>15 – 20 (ROR)</td>
</tr>
<tr>
<td>LAST (Tellurex)</td>
<td>54 – 55</td>
<td>0.27 – 0.28</td>
<td>--</td>
<td>~ 21-30 (ROR)</td>
</tr>
<tr>
<td>LASTT (Tellurex)</td>
<td>46.3 - 46.8</td>
<td>0.26 – 0.27</td>
<td>--</td>
<td>30 – 32 (ROR)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>46 – 58 (BOR)</td>
</tr>
<tr>
<td>ZnSe</td>
<td>76.1 n</td>
<td>0.29 n</td>
<td>0.9 f</td>
<td>~60 r</td>
</tr>
<tr>
<td>Zn₄Sb₃</td>
<td>57.9 – 76.3</td>
<td></td>
<td>0.64 – 1.49</td>
<td>56.5 – 83.4</td>
</tr>
<tr>
<td>Bi₂Te₃</td>
<td>40.4 – 46.8</td>
<td>0.21 – 0.37</td>
<td></td>
<td>8 – 166</td>
</tr>
<tr>
<td>Skutterudites</td>
<td>136 (n)</td>
<td>0.14-0.25 (n)</td>
<td>1.7 (n)</td>
<td>86 (n)</td>
</tr>
<tr>
<td>(n and p)</td>
<td>133 (p)</td>
<td>0.22-0.29 (p)</td>
<td>1.1 - 2.8 (p)</td>
<td>37 (p)</td>
</tr>
</tbody>
</table>