

Riley Hanus, PhD

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Education **Northwestern University**

Ph.D., Materials Science and Engineering, 2014 – 2019
Fields: Solid-state physics/chemistry, heat transport, thermoelectrics
GPA: 3.83/4.0

Thesis “Heat conduction in defective solids: phonon scattering and beyond”

This thesis utilized a combined experimental and theoretical approach to establish materials design principles in defective crystals. Particular focus was given to the influence of interfaces, dislocations, and point defects on thermal transport. Additionally, the influence of chemical bonding and electronic doping on the electronic band structure of skutterudite thermoelectrics was established.

Iowa State University

B.S., Materials Engineering, 2013
Minor, Music Technology, 2013
GPA: 3.63/4.0

Experience **Georgia Institute of Technology: Mechanical Engineering**

Postdoc, Nov. 2019 – present

Developing and characterizing wide and ultrawide bandgap electronic devices funded by and in collaboration with U.S. Department of Defense, Air Force Research Lab.

Characterization and modeling of electronically conducting polymers.

CalcHub

Co-Founder, Nov. 2018 – present

CalcHub is an easy-to-use online math workspace with goals of improving STEM education (www.calchub.co).

Oak Ridge National Lab

Visiting Researcher, June 2019 – November 2019

Appointment funded through the Science Graduate Research Award (DOE). Conducting experimental work on neutron beam lines in support of my thesis work at Northwestern University.

Northwestern University: Materials Science

PhD Student, August 2014 – present

Studying heat conduction in defective crystals in Prof. G. Jeff Snyder’s research group.

Bemis North America

Product Development Engineer, Jan. 2014 – Aug. 2014

Primary technical contact for Bemis forming film products. Built Bemis' innovation pipeline with new technological developments. Conducted independent research projects to differentiate Bemis technology from competitors.

Ames Laboratory: US Department of Energy

Undergraduate Research Assistant, 2012 – 2013

Worked in Dr. Schmidt-Rohr's research group for Dr. Evgenii Levin developing experimental methods for improving the performance of GeTe- and Mg₂Si-based thermoelectric materials [22, 25, 26].

Iowa State University: Materials Engineering

Undergraduate Research Assistant, 2010 – 2012

Worked in Dr. Michael Kessler's polymer composite research group, including two Science Undergraduate Laboratory Internships (SULI). Developed a method for toughening a high performance thermosetting resin [27]. Analyzed the environmental degradation of bio-renewable polymers [24].

Teaching **Mat. Sci. E./Mech. E., Georgia Institute of Technology**

Special topic lecture series (2019)

Developed and delivered a lecture series on 'nanoscale heat transfer'.

Materials Science and Engineering, Northwestern University

Teaching Assistant, Introductory Physics of Materials (MSE 351-1, 2015)

Taught one recitation class a week and guest lectured. Developed curriculum for and taught a computational lab section (2015, 2016, 2018). Graded homework, lab reports, and exams. Developed material for the implementation of an online course.

Materials Engineering, Iowa State Engineering

Grader/Course Assistant, Introduction to Polymers (Mat E 351, 2012)

Guest lectured on the topic of thermosetting resins. Held review sessions for quizzes and exams. Graded homework and lab reports.

Awards & Fellowships

Graduate Student Award, ITS (2019)

International award recognizing excellence in graduate research in thermoelectrics (International Thermoelectric Society).

Science Graduate Research Award, DOE (2018)

National award enabling outstanding U.S. graduate students to pursue graduate research at a DOE laboratory (Oak Ridge National Lab).

Weertman Fellowship (2018)

Achievement-based award to recognize one Ph.D. candidate in Northwestern Materials Science and Engineering for outstanding scholarly achievements and promise.

McCormick Global Initiatives: Student Ambassador Award (2016)

Award funding travel expenses to Arusha Tanzania for the 2016 JUAMI Outreach program (details in 'Outreach').

National Defense Science & Engineering Graduate Fellowship (2015)
Honorable Mention

National Science Foundation Graduate Research Fellowship (2015)
Alternate Selectee

Dean's List: ISU College of Engineering
Fall 2009, Fall 2010, Fall 2011, Fall 2012, and Spring 2013

Iowa State Academic Recognition Award (2009-2013)
Scholarship recognizing academic achievement.

Delta Tau Delta National Fraternity awards:
Excellence in Recruitment Programming (Feb. 2012)
Exceeding Recruitment Goals (Feb. 2012)
Hugh Shields Award for Chapter Excellence (Feb. 2012)

ISU Materials Science Undergraduate Poster Competition:
1st place (2012), 3rd place (2013)

Leadership **Materials Science and Engineering, Northwestern University**
Vice President for Materials Science Student Association (2015 – 2016)
Organized and executed prospective student visit weekends. Conducted Materials Science social and professional networking events. Organized outreach programs.

Delta Tau Delta Fraternity, ISU chapter (Gamma Pi)
Vice President of Recruitment (2012)
Operated on an award winning Executive Committee for a 90+ member chapter and managed a three-member recruitment team (see Awards). Exceeded our recruitment goal by 36% and maintained a 97% retention rate while staying under budget.

Outreach **Joint Undertaking for an African Materials Institute (JUAMI)**
Outreach workshop hosted by the Nelson Mandela African Institution of Science and Technology in Arusha, Tanzania (www.juami.org). Teaching assistant for the thermoelectrics sub-section. Designed, built, and lead an hands on lab activity for native African scientists and other JUAMI participants. Read about the experience at juamiafrica.blogspot.com.

Languages **Coding and Software**
Python (advanced; data analytics, user interface development), Mathematica (advanced), General Structure Analysis System (GSAS-II, advanced; GSASscriptable.py), MATLAB (intermediate), HTML/CSS/JS (intermediate), almaBTE (intermediate), Quantum Espresso, L^AT_EX

Skills **Lab Expertise**

Transistor characterization; Thermoreflectance Imaging; Laser Flash Analysis (experience running, servicing, and repairing Netzsch LFA 457); Ultrasound characterization (Pulse-Echo and Resonant Ultrasound Spectroscopy); X-Ray diffraction (phase analysis, structure refinement, Laue, microstructural analysis, synchrotron experience, 11-BM APS); Synthesis: quartz ampule chemistry, single crystal growth and characterization; Scanning electron microscopy (SEM); Electrical Conductivity (Van der Pauw, 4-point probe); Seebeck Coefficient; Differential scanning calorimetry (DSC); Dynamic mechanical analysis (DMA); Fourier transform infrared spectroscopy (FT-IR); Polymer synthesis; Mechanical testing (Instron); Rheology testing; Thermogravimetric analysis (TGA); Thermomechanical analysis (TMA)

Peer Review APL Materials (2), Advanced Science (1), Advanced Functional Materials (1)

Publications

1. Gregory, S. A., **Hanus***, R., Atassi, A., Rinehart, J. M., Wooding, J. P., Menon, A. K., Losego, M. D., Snyder, G. J., Yee*, S. K., Quantifying Charge Carrier Localization in Chemically Doped Semiconducting Polymers. *In-review (available on request)*. ***corresponding** (2020).
2. Gurunathan, R., **Hanus, R.**, Dylla, M., Katre, A., Snyder, G. J., Analytical Models of Phonon-Point-Defect Scattering. *Physical Review Applied* **13**, 1 (2020).
3. Gurunathan, R., **Hanus, R.**, Snyder, G. J., Alloy scattering of phonons. *Materials Horizons* **7**, 1452–1456 (2020).
4. **Hanus, R.**, George, J., Wood, M., Cheng, Y., Abernathy, D., Manley, M., Hautier, G., Snyder, G. J., Hermann, R., Transition from Crystal-like to Amorphous-like Heat Conduction in Structurally-Complex Crystals. *Chemrxiv*, 0–11 (2020).
5. Li, H., **Hanus, R.**, Polanco, C. A., Zeidler, A., Koblmüller, G., Koh, Y. K., Lindsay, L., GaN thermal transport limited by the interplay of dislocations and size effects. *Physical Review B* **102**, 1–10 (2020).
6. **Hanus, R.**, Agne, M. T., Rettie, A. J. E., Chen, Z., Tan, G., Chung, D. Y., Kanatzidis, M. G., Pei, Y., Voorhees, P. W., Snyder, G. J., Lattice Softening Significantly Reduces Thermal Conductivity and Leads to High Thermoelectric Efficiency. *Advanced Materials*, 1900108 (Apr. 2019).
7. Rangnekar, S., **Hanus, R.**, Julia and Hans Weertman: A legacy of scholarship, mentorship, and lives well-lived. *MRS Bulletin* **44**, 221–222 (Mar. 2019).
8. Agne, M. T., **Hanus, R.**, Snyder, G. J., Minimum thermal conductivity in the context of diffuson-mediated thermal transport. *Energy and Environmental Science* **11**, 609–616 (2018).
9. **Hanus, R.**, Garg, A., Snyder, G. J., Phonon diffraction and dimensionality crossover in phonon-interface scattering. *NPG: Communications Physics* **1**, 78 (Dec. 2018).

10. Pan, Y., Aydemir, U., Grovogui, J. A., Witting, I. T., **Hanus, R.**, Xu, Y., Wu, J., Wu, C.-F., Sun, F.-H., Zhuang, H.-L., Dong, J.-F., Li, J.-F., Dravid, V. P., Snyder, G. J., Melt-Centrifuged (Bi,Sb)₂Te₃: Engineering Microstructure toward High Thermoelectric Efficiency. *Advanced Materials* **30**, 1802016 (Aug. 2018).
11. Tan, G., Hao, S., **Hanus, R. C.**, Zhang, X., Anand, S., Bailey, T. P., Rettie, A. J. E., Su, X., Uher, C., Dravid, V. P., Snyder, G. J., Wolverton, C., Kanatzidis, M. G., High Thermoelectric Performance in SnTe–AgSbTe₂ Alloys from Lattice Softening, Giant Phonon–Vacancy Scattering, and Valence Band Convergence. *ACS Energy Letters* **3**, 705–712 (Mar. 2018).
12. Xu, D., **Hanus, R.**, Xiao, Y., Wang, S., Snyder, G., Hao, Q., Thermal boundary resistance correlated with strain energy in individual Si film-wafer twist boundaries. *Materials Today Physics* **6**, 53–59 (Aug. 2018).
13. Chen, Z., Ge, B., Li, W., Lin, S., Shen, J., Chang, Y., **Hanus, R.**, Snyder, G. J., Pei, Y., Vacancy-induced dislocations within grains for high-performance PbSe thermoelectrics. *Nature Communications* **8**, 13828 (Jan. 2017).
14. Chen, Z., Jian, Z., Li, W., Chang, Y., Ge, B., **Hanus, R.**, Yang, J., Chen, Y., Huang, M., Snyder, G. J., Pei, Y., Lattice Dislocations Enhancing Thermoelectric PbTe in Addition to Band Convergence. *Advanced Materials* **29**, 1606768 (Jan. 2017).
15. **Hanus, R.**, Guo, X., Tang, Y., Li, G., Snyder, G. J., Zeier, W. G., A Chemical Understanding of the Band Convergence in Thermoelectric CoSb₃ Skutterudites: Influence of Electron Population, Local Thermal Expansion, and Bonding Interactions. *Chemistry of Materials* **29**, 1156–1164 (Feb. 2017).
16. Kang, S. D., Pöhls, J.-H., Aydemir, U., Qiu, P., Stoumpos, C. C., **Hanus, R.**, White, M. A., Shi, X., Chen, L., Kanatzidis, M. G., Snyder, G. J., Enhanced stability and thermoelectric figure-of-merit in copper selenide by lithium doping. *Materials Today Physics* **1**, 7–13 (2017).
17. Nunna, R., Qiu, P., Yin, M., Chen, H., **Hanus, R.**, Song, Q., Zhang, T., Chou, M. Y., Agne, M. T., He, J., Snyder, G. J., Shi, X., Chen, L., Ultrahigh thermoelectric performance in Cu₂Se-based hybrid materials with highly dispersed molecular CNTs. *Energy and Environmental Science* **10**, 1928–1935 (2017).
18. Zhao, K., Blichfeld, A. B., Chen, H., Song, Q., Zhang, T., Zhu, C., Ren, D., **Hanus, R.**, Qiu, P., Iversen, B. B., Xu, F., Snyder, G. J., Shi, X., Chen, L., Enhanced Thermoelectric Performance through Tuning Bonding Energy in Cu₂Se_{1-x}S_x Liquid-like Materials. *Chemistry of Materials* **29**, 6367–6377 (Aug. 2017).
19. Zong*, P.-a., **Hanus***, **R.**, Dylla, M., Tang, Y., Liao, J., Zhang, Q., Snyder, G. J., Chen, L., Skutterudite with graphene-modified grain-boundary complexation enhances zT enabling high-efficiency thermoelectric device. *Energy Environ. Sci.* **10**. ***contributed equally**, 183–191 (2017).
20. Kim, H.-S., Kang, S. D., Tang, Y., **Hanus, R.**, Jeffrey Snyder, G., Dislocation strain as the mechanism of phonon scattering at grain boundaries. *Mater. Horiz.* **3**, 234–240 (2016).
21. Li, G., An, Q., Goddard, W. A., **Hanus, R.**, Zhai, P., Zhang, Q., Snyder, G. J., Atomistic explanation of brittle failure of thermoelectric skutterudite CoSb₃. *Acta Materialia* **103**, 775–780 (Jan. 2016).

22. Levin, E. M., **Hanus, R.**, Cui, J., Xing, Q., Riedemann, T., Lograsso, T. A., Schmidt-Rohr, K., Phase analysis and determination of local charge carrier concentration in eutectic Mg₂Si-Si alloys. *Materials Chemistry and Physics* **158**, 1–9 (2015).
23. Tang, Y., **Hanus, R.**, Chen, S.-w., Snyder, G. J., Solubility design leading to high figure of merit in low-cost Ce-CoSb₃ skutterudites. *Nature Communications* **6**, 7584 (July 2015).
24. Cui, H., **Hanus, R.**, Kessler, M. R., Degradation of ROMP-based bio-renewable polymers by UV radiation. *Polymer Degradation and Stability* **98**, 2357–2365 (2013).
25. Levin, E. M., Besser, M. F., **Hanus, R.**, Electronic and thermal transport in GeTe: A versatile base for thermoelectric materials. *Journal of Applied Physics* **114**, 083713 (Aug. 2013).
26. Levin, E. M., **Hanus, R.**, Hanson, M., Straszheim, W. E., Schmidt-Rohr, K., Thermoelectric properties of Ag₂Sb₂Ge_{46-x}Dy_xTe₅O alloys with high power factor. *physica status solidi (a)* **210**, 2628–2637 (Dec. 2013).
27. Sheng, X., **Hanus, R.**, Bauer, A., Kessler, M. R., Effect of PEGDE addition on rheological and mechanical properties of bisphenol E cyanate ester. *Journal of Applied Polymer Science* **130**, 463–469 (Oct. 2013).

Presentations

Invited:

- R. Hanus. “Heat conduction in defective and complex crystals: phonon scattering and beyond”. Department of Physics and Astronomy Seminar. Stony Brook, NY, USA. October 2019. Host: Prof. Philip B. Allen
- R. Hanus, G. J. Snyder. “Engineering thermal conductivity through microstructure”. SPIE-MRSEC student seminar. Evanston, IL, USA. October 2018.

Conferences presentations:

- American Physical Society, Phoenix, Arizona, USA. March 2019. (30 min. invited talk for G. J. Snyder. 2 posters. Nominee for Best Poster Award)
- Materials Research Society (talk, poster). Boston, MA, USA. November 2018.
- International Conference of Thermoelectrics (talk). Caen, France. July 2018.
- American Physical Society (talk). Los Angeles, CA, USA. March 2018.
- Centre Européen de Calcul Atomique et Moléculaire (CECAM, talk). Paris, France. January 2018.
- Materials Research Society (2 talks). Boston, MA, USA. November 2017
- International Conference of Thermoelectrics (talk). Pasadena, CA, USA. July 2017.
- Electronic Materials Conference (talk). West Bend, IN, USA. June 2017.