Performance Enhancement of Thermoelectric Devices: Synthesis of Novel Materials and Thermal Evaluations (Abstract)

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Thermoelectric materials hold tremendous promise for advances in fundamental science and practical applications; particularly for robust electricity generation in extreme and remote environments. However, for most materials, the energy conversion efficiency is limited by the proportionality between the electrical and thermal conductivities and small values of the Seebeck coefficient for metals. Despite these limitations, promising thermoelectric properties have been reported for some Yb-based heavy-fermion compounds and some binary and ternary compounds with Kagome lattice. In this dissertation, I explore the hypothesis that the thermoelectric properties of those family compounds, due to their novel structure with exotic electronic and magnetic properties, can be further enhanced through chemical substitution. Additionally, I elaborate on the manufacturability of thermoelectric devices using these compounds and their possible application for cooling probes.

The dissertation is structured as follows: Chapter 1 presents a general background about thermoelectricity, including historical insights and the parameters and equations involved in the performance of a thermoelectric device. It also includes an introduction to the family of compounds involved in this thesis. Chapter 2 is dedicated to detailing the experimental methods employed in this dissertation. It includes a comprehensive introduction to the various characterization techniques that were implemented, along with a thorough description of the systems and devices utilized throughout the research. Chapter 3 focuses on the enhancement of the thermoelectric properties of $YbIr_2Zn_{20}$ through chemical substitution in the Yb site. Chapter 4 concentrates on $YbCo_2Zn_{20}$, where the thermoelectric enhancement is also being explored through chemical substitution, both in the Yb and Co sites. Chapter 5 presents numerical models of thermoelectric devices for low-temperature applications based on the materials being studied in this dissertation. Finally, Chapter 6 concludes the dissertation with a summary and future directions for the research.