To Whom It May Concern

This is to certify that the following research papers were published under collaborative research programme between Vidyasagar Metropolitan College and Department of Physics, Adams University during the academic sessions 2018-19 to 2022-23.

Title of the Article	Authors Name	Department	Name of Journal	Year	ISSN/ISBN
A simple Thermopower measurement model and related uncertainties	A. Jana. S. Mahakal, S. Sau, **Diptasikha Das, K. Malik**	Physics	Journal of Physics: Conference Series	2022	1742-6596
Effects of partial substitution of Co by Ni on structural and transport properties of TiCoSb-based half-Heusler compound	S. Mahakal, **Diptasikha Das**, P. Singha, N. Rana, S. Mukherjee, A. Banerjee, **K. Malik**	Physics	Journal of Physics: Conference Series	2022	1742-6596
Modulation of thermal conductivity and thermoelectric figure of merit by anharmonic lattice vibration in Sb2Te3 thermoelectrics	**D. Das, K. Malik**, S. Das, P. Singha, A. K. Deb, V.A. Kulbachinskii, R. Basu, S. Dhara, A. Dasgupta, S. Bandyopadhyay, A. Banerjee	Physics	AIP Advances	2018	2158-3226
Simple, efficient and economically viable techniques for temperature dependent thermopower data acquisition of thermoelectric materials	S. Mahakal, **D. Das**, A. Jana, A. Banerjee, **K. Malik**	Physics	Journal of Physics: Conference Series	2020	1742-6588

Moumita Dey

HoD
Department of Physics
Adams University

HOD
Department of Physics
Adamas University

Arghya Sarkar

Principal
Vidyasagar Metropolitan College

Principal
Vidyasagar Metropolitan College
Kolkata- 700 006

eSign
Signed by: ARGHYA SARKAR
Reason: Authentication
Location: Kolkata, India
Date: 27-Aug-2024 (08:12 PM)

Simple, Efficient and Economically Viable Techniques for temperature dependant Thermopower data acquisition of Thermoelectric materials

S Mahakal[1], Diptasikha Das[2], A Jana[1], Aritra Banerjee[3] and K Malik[*1]
[1]Vidyasagar Evening College, 39, Sankar Ghosh Lane, Kolkata 700006, India
[2]Adamas University, Barasat - Barrackpore Rd, Kolkata 700126, India
[3]University of Calcutta, 92 A P C Road, Kolkata 700009, India

[*]E-mail: kartick.phy09@gmail.com

Abstract. A simple, economically viable and precise thermopower measurement techniques have been presented in this paper. Continuous data acquisition and simultaneous control of the instruments are achieved by using LabVIEW software. Set-up is built to measure thermopower of the low temperature thermoelectric material down to 10K. A LabVIEW program is developed to collect thermopower data of few μV/K to few hundred μV/K. Thermal stabilization and simple calculations are incorporated to avoid the spurious thermopower. Thermopower measurements, carried out in this set-up are published in reputed journals.

1. Introduction

Limitation of conventional energy sources, increasing energy demands and environmental concern enforce the society and the researcher to concentrate on the sustainable energy. Waste heat energy conversion and management by thermoelectric (TE) materials is drawing attention of the scientist. However, worldwide there is resurgence to enhance the efficiency of thermoelectric materials. TE materials are those, which convert heat energy to electrical energy and vice-versa [1]. Efficiency of TE is evaluated by the Figure of merit: $ZT = \left(\frac{S^2\sigma}{\kappa}\right)T$, where S, σ, κ are thermopower, electrical conductivity and thermal conductivity respectively. These are interrelated material's property [1, 2]. Optimization of these inherent physical properties may only enhance the efficiency of the TE properties. However, measurements of these properties require dedicated technique.

Thermopower (S) is directly related with the electronics energy states of the materials. The nature of energy states and Fermi surface of the materials at a certain temperature are correlated with S by the following equation [3, 4]:

$$S = -\left(\pi^2 k_B^2 T \big/ 3|e|\right)\left[\frac{d(\ln A(E))}{dE} + \frac{d(\ln l(E))}{dE}\right]_{E=E_F} \quad (1)$$

where, k_B, e, A(E), l(E) are Boltzmann constant, electronic charge, area of the Fermi surface and mean free path of electrons respectively. Hence, S is a complementary tool to estimate the charge carrier, σ, κ etc. It is noteworthy to mention that sign of measured S usually represent the nature of the charge

Effects of partial substitution of Co by Ni on structural and transport properties of TiCoSb-based half-Heusler compound

S Mahakal[1], **Diptasikha Das**[2], **P Singha**[3], **N Rana**[3], **S Mukherjee**[3], **Aritra Banerjee**[3] and **K Malik**[1*]

[1]Department of Physics, Vidyasagar Metropolitan College, Kolkata, India.
[2]Department of Physics, ADAMAS University, Kolkata, India.
[3]Department of Physics, University of Calcutta, Kolkata, India.

[*]Corresponding author: kartickmalik@vec.ac.in

Abstract. Correlation amid structural and transport properties of $\mathrm{TiCo_{(1-x)}Ni_xSb}$, (x=0.00, 0.02, 0.04, 0.06) alloy have been investigated. Samples have been synthesized by solid state reaction method, followed by arc-melting. Minute amount of CoTi embedded phase has been revealed by in-depth structural characterization using Rietveld refinement. Unit cell volume decreases with increasing Ni in $\mathrm{TiCo_{(1-x)}Ni_xSb}$, indicate sucessful substitution. Lattice strain, crystalline size and dislocation density have been estimated from x-ray diffraction data. Temperature dependent resistivity ($\rho(T)$) measurements have been carried out down to 10 K. Transition from metallic to semiconducting behavior is observed in $\rho(T)$ data for x=0.00, 0.02. $\rho(T)$ for x=0.04 and 0.06 show metallic nature. Plausible explanation have been provided on the basis of position of Fermi surface and embedded phases.

Keywords: *Half-Heusler alloy, Thermoelectric material, embedded phase, Resistivity.*

1. Introduction

Thermoelectric (TE) materials convert thermal energy into electrical energy and vice versa. Efficiency of TE material is directly related with Figure of merit, $ZT = (S^2\sigma/\kappa)$; where S, σ and κ are thermopower, electrical conductivity and thermal conductivity respectively [1, 2]. TiCoSb, HH alloy with 18 valence electron count (VEC) are well known mid-temperature thermoelectric (TE) material [3]. High S and moderate σ have been made them attractive as TE material. However, efficiency is limited by high κ [4]. HH alloy, TiCoSb with VEC=18 exhibits semiconducting properties. TE properties as well as transport properties are strongly influenced by dopped material. Power factor increases at low temperature owing to moderate doping of Nb, Ta, Ni or Pt [5]. Noteworthy, transport properties of $\mathrm{TiCo_{(1-x)}Ni_xSb}$ solid solution show activated to metallic-like behavior [6]. TiCoSb, one of the end members of alloy is narrow-gap semiconductors[7]. However, another end member TiNiSb, displays metallic behaviour due to the position of Fermi level, E_F into the conduction band [7]. $\mathrm{TiCo_{(1-x)}Ni_xSb}$ show activated or metallic behaviour according to the position of E_F [8, 9, 10, 11].