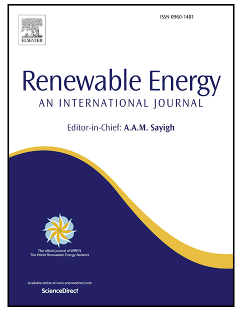
Accepted Manuscript



Thermal conductivity and Seebeck coefficient of Fe and Fe-Si alloys: Implications for variable Lorenz number

Richard A. Secco

PII: S0960-1481(17)30072-1

DOI: 10.1016/j.renene.2017.01.061

Reference: RENE 8500

To appear in: *Renewable Energy*

Received Date: 4 August 2016

Revised Date: 17 January 2017

Accepted Date: 29 January 2017

Please cite this article as: Secco RA, Thermal conductivity and Seebeck coefficient of Fe and Fe-Si alloys: Implications for variable Lorenz number, *Renewable Energy* (2017), doi: 10.1016/j.renene.2017.01.061.

Thermal Conductivity and Seebeck Coefficient of Fe and Fe-Si Alloys: Implications for Variable Lorenz Number

Richard A. Secco, Department of Earth Sciences, University of Western Ontario, London, Ontario, Canada N6A 5B7

Abstract

The Wiedemann-Franz Law is often used to calculate the thermal conductivity of Fe from experimental measurements of the electrical conductivity. It is shown by measurements of the Seebeck coefficient (S) of solid and liquid Fe at pressures up to 6GPa and temperatures up to 2100K that the Sommerfeld value (L_0 =2.445 × 10^{-8} W Ω K^{-2}) of the Lorenz number (L) represents more than 99% of the electronic component of the thermal conductivity of Fe. Using experimental values of electrical resistivity and thermal conductivity of Fe, L/L_0 is shown to vary by as much as 1.22 in the solid state and 1.32 in the liquid state, signifying a non-negligible phonon component. An expression for the pressure dependence of L at the melting boundary up to 5GPa is derived for electron-phonon scattering. For Fe-Si alloys, L/L_0 varies more than for pure Fe and generally increases with increasing Si and state of disorder. New values for the conductive heat flow in a pure Fe core of Mercury are presented.

Keywords: core heat flow; electrical resistivity; thermal conductivity; Wiedemann-Franz Law, iron-silicon

1. Introduction

The thermal conductivity of the Earth's liquid metallic outer core (OC) has direct bearing on the growth rate of the solid inner core (IC), and therefore its age, as well as the production of the geomagnetic field through dynamo action. The age of the IC has been estimated to be between 1.0-2.5Ga by energy conservation modelling (Labrosse et al 2001), 1.0-1.5Ga by an increase in both average geomagnetic field strength and variability (Biggin et al 2015), and as young as 0.5Ga from models employing high thermal conductivity values calculated from measurements