Thermoelectric effect and its some aspects in Solids

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Abstract- *Thermoelectric effect is basically Seebeck effect observed in various materials. Thermoelectric effect has been employed in various devices for specific application. Thermodynamics of thermoelectric effect predicts direct and cross coupled thermal and Electrical quantities with their feasibility. Also sincere efforts are being made to improve the figure of Merit of Solids for Thermoelectric devices.*

Keywords- Thermodynamics, Figure of Merit, Thermoelectric.

I. INTRODUCTION

Energy has always been a mystery to human civilisation. It was initially considered to be a creation of nature but now it has been discovered by the intelligence of Humans and with the passage of time humans have to some extent managed it and used it for improving the quality of life of ordinary people in various sectors of living. Thermoelectricity is also one the energy conversion methods available to us. Thermoelectric effect was being discovered in 1821 by Thomas Johann Seebeck and later on there was revival of thermoelectric effect in 1990 due to the requirement of Green tech with solid state devices. Thermoelectricity with it green tech energy solution for our current energy and environmental crisis [1]. Moreover now prototypes of thermoelectricity being used with photovoltaic to improve the Solar power generation. Thermoelectricity is a phenomenal of conversion of thermal gradient into electrical energy. Thermoelectricity is defined by following effects given below i.e. Seebeck Effect [2], Pelteir Effect [3] and Thomson Effect [4]. Currently for the development of thermoelectric people are working on these three aspects and for obtaining best thermoelectric effect (i) Material tailoring , (ii) Development of novel TE materials and (iii) Synthesis of Composites-TE nanostructures materials. In this paper we have discussed some aspects of thermoelectric effect (TE) and its basic concepts.

II. PHENOMENON OF THERMOELECTRICITY

In Seebeck effect a thermopower of millivolt is generated due to temperature difference between hot and cold junction when two dissimilar metals are joined. Meanwhile in the Peltier effect on passing current through the metals one junction becomes hot and other junction cold. Also in Thomson effect when two different metals were joined and current is passed then there is absorption of heat at one junction and evolution of heat at other junction. Thus the Thomson effect is a result of combined Seebeck and Peltier effect. The phenomenology of thermoelectric was been explained by Onsager. He related the direct & cross-coupled effect of electrical and thermal quantities with their feasibility shown in table1.

	Electrical	**Thermal**	*Type*
Quantity	Charge	Heat	Reversible
Potential	Potential	Temperature	Reversible
Current Type	Electrical Current	Heat Current	Irreversible
Driving Force	Temperature Difference	Potential Difference	Irreversible

Table 1. Relation between Electrical and Thermal quantities with feasibility.

Based on the above relation between electrical and thermal quantities were used to define thermoelectric transport coefficients which is shown in table 2.

Thermoelectric Properties	*Defined*	*Applicable Conditions*	*Type*	Comments
Electrical Conductivity	$J=\sigma E$	$\nabla T=0$	Direct	Ohm Law
Thermal Conductivity	$Q=-k \nabla T$	i=0	Direct	Fourier Law
Seebeck Coefficient	$E=\alpha \nabla T$	i=0	Cross	Thermoelectric
Peltier Coefficient	$Q=\pi i$	$\nabla T=0$	Cross	Thermoelectric

Table 2. Here α, π Seebeck and Peltier Coefficents respectively defining the Thermo-electric phenomenon.

Latter Lord Kelvin also known as Thompson related the Seebeck and Peltier Coefficients as

$$\pi = T\alpha \qquad \text{…….. (1)}$$

Here T is the Thompson effect.

III. FIGURE OF MERIT IN SOLIDS

Thermoelectricity is basically Seebeck effect, Figure of Merit is the parameter that makes good thermoelectric. The Figure of Merit is being denoted as ZT and for solids it is defined as

$ZT= (\alpha^2\sigma/k)*T$, here α = Seebeck coefficient, k= Thermal Conductivity & σ =Conductivity of Solids.

For the Dimensionality of Solids the comparison of Figure of merit (ZT)

$$\mathbf{ZT_{0D} > ZT_{1D} > ZT_{2D} > ZT_{3D}} \quad \ldots\ldots\ldots\ldots (2)$$

Where ZT_{0D}, ZT_{1D}, ZT_{2D}, ZT_{3D} are Figure of Merit in 0D, 1D, 2D & 3D respectively.

Thermoelectricity is used in thermoelectric generator (TEG) and the above thermodynamics may be used to calculate its Figure of Merit of TEG.

IV. CONCLUSIONS

The thermodynamics of thermoelectric material describe here about the feasibility of the various situation occurring in material. The Complex Material Science and Advanced synthesis technologies are used for obtaining better Thermoelectric materials like tailoring the Figure of Merit in Solids. Thermoelectricity devices are being used for various critical space and civilian applications.

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