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1. Main Research Results

- 1) Effects of cuspidine grain size on radiative heat transfer across mould flux for continuous casting

Apparent reflectivities and transmissivities have been measured as functions of cuspidine grain diameter for mould fluxes having constant degrees of crystallinity. Samples used were two types of synthesised mould flux with the basicity of 1, one of which samples contained 1 mass % of Fe_2O_3 , and the grain diameter was varied in the range 1 – 3.5 μm . The optical measurements were carried out in the wavelength range 300 – 2600 nm at room temperature using a spectrophotometer with an integrating sphere. With increasing grain diameter, the apparent reflectivity tended to increase and the apparent transmissivity tended to decrease at higher wavelengths for iron oxide free mould fluxes: it seemed that the apparent reflectivity showed a maximum value and the apparent transmissivity showed a minimum value in the grain diameter range 2 – 3 μm . In contrast, there was less significant dependence on grain size for mould fluxes containing iron oxides. The total radiative heat flux which may reach the mould from the steel shell has been evaluated using apparent reflectivity and transmissivity data on the basis of an optical process model. It has been found that the total radiative heat flux would be smallest in iron oxide free mould fluxes having the highest apparent reflectivity and the lowest apparent transmissivity at higher wavelengths. Effects of grain size on the radiative heat flux are smaller for mould flux containing iron oxides. Comparison of the total radiative heat flux with the total heat flux including conductive contribution suggests that control of cuspidine grain diameter would lead to reduction of the total heat flux by 7 – 8 % for iron oxide free mould fluxes. In addition, the air gap layer would affect the total heat flux more efficiently where the volume fraction of air in the layer exceeds 85 %.

- 2) Thermal conductivities of Sb-Te alloys for PCM memory application

Sb-Te alloys have drawn much attention due to the application in phase change memory as well as the unique properties as chalcogenide. In this work, the thermal conductivities of Sb- x at%Te alloys ($x = 14, 25, 44, 60, 70$ and 90) have been measured by the hot strip method from room temperature up to temperature just below the respective melting points. For the intermetallic compound Sb_2Te_3 ($x = 60$),

the thermal conductivity decreases up to approximately 600 K and then increases. For other Sb- x at%Te alloys where $x > 60$, the thermal conductivities of the alloys decrease with increasing temperature. In contrast, for $x < 60$, the thermal conductivities of the alloys keep roughly constant up to approximately 600 K and then increase with increasing temperature. It is proposed that free electron dominates the heat transport below 600 K and ambipolar diffusion also contributes to the increase in the thermal conductivity at higher temperatures. The prediction equation from temperature and chemical composition has been proposed for thermal conductivities of Sb-Te alloys.

2. List of Publications

Refereed

- 1) R Endo, S Maeda, Y Jinnai, R Lan, M Kuwahara, Y Kobayashi and M Susa: Electric Resistivity Measurements of Sb₂Te₃ and Ge₂Sb₂Te₅ Melts Using Four-Terminal Method; JJAP, 49 (2010) 065802-1-7
- 2) R Lan, R Endo, M Kuwahara, Y Kobayashi, M Susa: Thermal Conductivity Measurements of Solid Sb₂Te₃ by Hot-Strip Method, JJAP, 49 (2010) 078003
- 3) R Endo, M Shima, M Susa: Thermal-Conductivity Measurements and Predictions for Ni-Cr Solid Solution Alloys; Int. J. Thermophys., 31 (2010) 1991-2003
- 4) Y Kobayashi, T Shimizu, S Miyashita, R Endo, M Susa: Determination of Refractive Indices and Linear Coefficients of Thermal Expansion of Silicate Glasses Containing Titanium Oxides; ISIJ International, 51 (2011) 186-192

3. Conferences

[International]

Invited

- 1) M Susa, A Kushimoto, R Endo, Y Kobayashi: Suggestion as to Continuous Casting Mould Flux for Mild Cooling From Reflectivity and Transmissivity Data; China-Japan Symposium on Science and Technology of Iron and Steel, 18-19 October (2010) 112-117

Oral

- 1) M Susa, A Kushimoto, M Hayashi, R Endo, Y Kobayashi: Magic Mould Flux for Continuous Casting to Further Reduce Radiative Heat Transfer; Seetharaman Seminar, 14-15 June (2010)
- 2) Y Kobayashi, H Sonezaki, R Endo M Susa: Possibility of Ironmaking from Lunar

Soils by Graphite Smelting Reduction; Proc. 6th Korea-Japan Workshop on Science and Technology in Ironmaking and Steelmaking, (2010) 42-46

- 3) R Endo, S Maeda, M Kuwahara, Y Kobayashi, M Susa; Electric Resistivity of Sb-Te and Sb_2Te_3 -GeTe Systems in Liquid State, Proceedings of the 2nd International Symposium on Thermal Design and Thermophysical Property for Electronics and Energy (e Therm 2010), pp.131-133, (2010)

Poster

- 1) R Endo, S Maeda, M Kuwahara, Y Kobayashi and M Susa: Electric resistivity of Sb_2Te_3 -GeTe pseudo binary system in liquid state; EPCOS2010, Milan, (2010)

[Domestic]

Oral

- 1) R Lan, R Endo, M Kuwahara, Y Kobayashi, M Susa: Thermal Conductivity Measurements of Sb-Te Binary Alloys by Hot Strip Method; CAMP-ISIJ, Vol. 23, No.4, pp. 978 (2010)
- 2) H Tanigawa, Y Kobayashi, R Endo, M Susa: Activity Coefficient of CaS in CaS-CaF₂ Flux at 1673K; CAMP-ISIJ, Vol. 23, No.4, pp. 789-792 (2010)
- 3) R Lan, R Endo, M Kuwahara, Y Kobayashi, M Susa: Thermal Conductivity Measurements of Ge-Sb-Te Alloys by Hot Strip Method, CAMP-ISIJ, (2011)
- 4) R Endo, S Maeda, M Kuwahara, Y Kobayashi, M Susa: Electric Resistivity for Molten Sb-Te and Sb_2Te_3 -GeTe Systems; Proceedings of the 22nd Symposium on Phase Change Optical Information Storage (PCOS 2010), pp.58-60, (2010)
- 5) R Lan, R Endo, M Kuwahara, Y Kobayashi, M Susa; Thermal Conductivities and Conduction Mechanisms of Sb-Te Alloys; Proceedings of the 22nd Symposium on Phase Change Optical Information Storage (PCOS 2010), pp. 61-64, (2010)

Poster

- 1) Min Wang, M Susa, Y Kobayashi, R Endo; Effects of Manganese Oxide on the Radiative Heat Transfer in Mould Fluxes; CAMP-ISIJ, (2010)

4. International Collaboration

- 1) Collaborative Work on Mould Fluxes with Corus, The Netherlands