(130) A New Silicon Sensor for Hot Metal Measurements

K.Ichihara*, D.Janke** and H.-J.Engell**

* Sumitomo Metal Industries Ltd. Wakayama Steel Works

** Max-Planck-Institut fur Eisenforschung GmbH

I. INTRODUCTION

An electrochemical sensor has been designed for the direct measurement of silicon content in hot metal. A reproducible EMF vs wt.%[Si] relationship was obtained for measurements in carbon-saturated Fe-C-Si melts at 1,400°C and Si contents from 0.05 to 1.80 wt.%. (1)

II. EXPERIMENTAL

The sensor investigated is based on the cell

$$Ni\text{-}Si(l)//CaO\text{-}Al_2O_3\text{-}SiO_2//Fe\text{-}C\text{-}Si(l)$$

where the molten Ni-Si alloy represents the silicon reference and the molten Fe-C-Si alloy the hot metal of variable Si content, respectively.

The design of the sensor is schematically shown in Figure 1. All measurements were carried out at 1,400°C in a Tammann furnace using carbon crucibles.

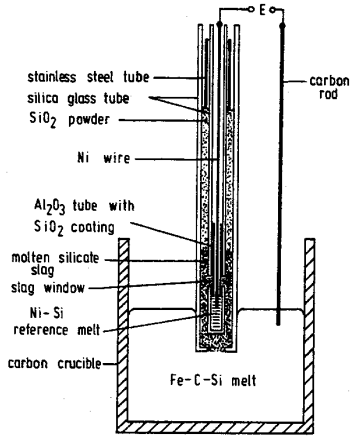

Fig.1. Schematic sketch of the silicon sensor

III. RESULTS AND DISCUSSION

MEASURED EMF DATA : Stable EMF readings were obtained after 30 to 60 seconds as shown in Figure 2. Photo 1 shows a longitudinal section of a used sensor. Since the thermoelectric voltage, E_{th}, between nickel and graphite is involved in the measured EMF, a correlation had to be made according to

$$E(\text{galvanic}) = E(\text{measured}) - E_{th} \quad [\text{volt}]$$

From the measurements,

$$E_{th} = 0.03 \quad [\text{volt}]$$

is obtained at 1,400°C.

The experimental data of E(galvanic) vs log wt.%[Si] are given in Figure 3 and may be expressed as

$$E(\text{galvanic}) = -0.096 \cdot \log \text{wt.\%[Si]} - 0.123 \quad [\text{volt}]$$

The pre-logarithmic factor 0.096 is equivalent to a charge transfer number of n=3.5 .

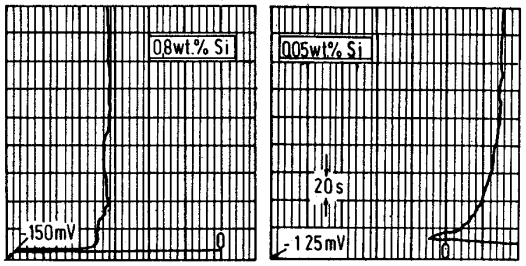

Fig.2. EMF readings from sensors at various Si contents

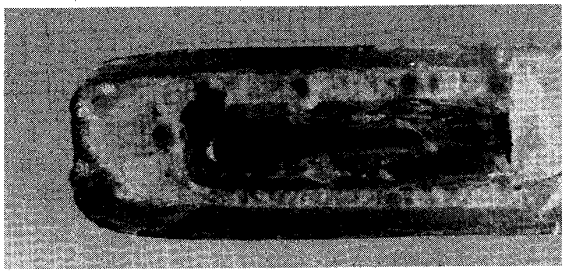

Photo 1. Longitudinal section of a used Si sensor

CALCULATED EMF DATA : Assuming n=4.0 and t_{ion}=1, the EMF of the silicon concentration cell should follow the relationship

$$E = -\frac{RT}{4F} \ln \frac{a_{Si}(Fe)}{a_{Si}(Ni)}$$

$a_{Si}(Fe)$ and $a_{Si}(Ni)$ are calculated from the existing thermodynamic data (2)-(5). There is only a small deviation of the experimental data from the calculated line represented by a slightly different slope which results in an equivalent charge transfer number of n=3.5 instead of n=4.0.

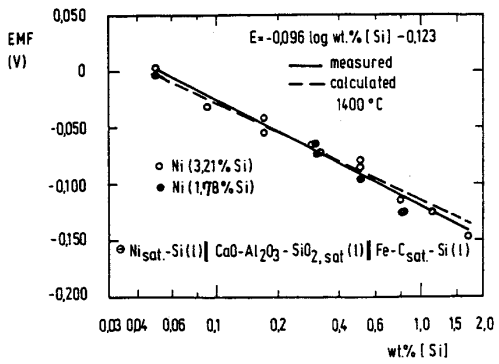

Fig.3. Corrected EMF vs wt.%[Si] in carbon-saturated Fe-C-Si melts at 1,400°C

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