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Effect of Temperature of Electrolyte Solution On Cu/Ni Layer On Low-Temperature Voltage Range Measurement Performance

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ABSTRACT

The electroplating method is considered an economical way in coating manufacture. However, this method is more widely used to treat chemical waste management and material properties engineering. The purpose of this research is to make a low-temperature sensor Cu/Ni film using an electroplating method assisted by an external magnetic field. The materials used are nickel (Ni) and copper (Cu), placed as anode and cathode. The electrolyte solution used is made from a mixture of H_3BO_3 (40 g/L), $NiSO_4$ (260 g/L), and $NiCl_2$ (60 g/L). The deposition process is carried out using an external magnetic field of 200 G and installed perpendicular to the deposition current, 120 s deposition time, and 3 Volt voltage. Preparation of Cu/Ni layer sensor samples is done by changing the electrolyte solution's temperature by varying the temperature between 30 ºC to 70 ºC with intervals of 10 ºC. The results of the research show that in testing the performance of the low-temperature sensor, each Cu/Ni layer sample has been able to offer its character as a low-temperature sensor. The character is indicated by changes in the output voltage's value following changes in the thermocouple value. Each sample at variations in the temperature of the electrolyte solution shows that the measured voltage range varies with the most extensive voltage range the sample has with deposition at 60 ºC.

Keywords: Electrolyte Solution Temperature, Voltage Range, Cu/Ni layer, Low-Temperature Sensor, Electroplating.

INTRODUCTION

The temperature sensor is a detector that can detect temperature changes. Low-temperature sensors, the number of temperature changes that can be achieved is below 0 C. In general, most of the temperature sensors used are thermocouples because they can detect temperature changes in the range of -200 C to 1200 C. (Rosman, 2018; Kus et al., 2015). Another type of low-temperature sensor used is the RTD-Film model (Lebioda & Rymaszewski, 2015) in this method, the sensor takes advantage of changes in resistance of the material used (Han et al., 2014).

Electroplating is a method of making layers that have economic value (Dezfuli & Sabzi, 2019). However, so far in its utilization, electroplating methods are more widely used as waste management or as engineering properties of materials for decoration and jewelry (Deviana & Sakti, 2014; Prasetyaningrum et al., 2018). However, in its development, the electroplating method has been used as a method for sensor manufacturing applications. It shows that the Cu/Ni layer using the electroplating method can be used, and the resulting sensor can show its response as a low-temperature sensor (Toifur et al., 2020; Khusnani et al., 2020).

The magnetic field's addition during the deposition process affects the output current (Yu et al., 2015; Monzon & Coey, 2014), where this effect can accelerate the mass transport of the depositor (Yu et al., 2015). It can happen because when the deposition process takes place, the magnetic field and transport velocity are perpendicular to each other (Yu et al., 2015) so that it can generate Lorentz forces (Yu et al., 2016). Another effect that can affect the Ni deposit layer results is the temperature of the electrolyte solution. It is because the solution's temperature will facilitate the Ni ions on the way to the cathode. The higher the temperature, the easier the Ni ion reaches the cathode, the crystal size will increase, the effect of hydrogen gas is reduced, and the solution's viscosity is reduced (Kumar et al., 2015; Wu et al., 2015; Al-Duaij et al., 2017).

Therefore, in this study, samples of the Cu/Ni layer were prepared by electroplating method assisted by parallel magnetic fields and varying the electrolyte solution's temperature in the Ni deposition process. The sample was then tested for its characteristics as a temperature sensor for the Cu/Nilayer by testing it on liquid nitrogen (LN2). Then, by analyzing the data, it will get the sensor voltage range value.

RESEARCH METHOD

The materials used are nickel (Ni) and copper (Cu) plates of size (10 x 1.3) cm^2, which are placed as anodes and cathodes. The electrolyte solution used in the deposition process consists of a mixture of H_3BO_3 (40 g/L), $NiSO_4$ (260 g/L), and $NiCl_2$ (60 g/L). The deposition process is carried out using an external magnetic field of 200 G, time deposition 120 s, and voltage 3 Volt, which is mounted perpendicular to the deposition current. Sampling was done by changing the electrolyte temperature between 30 ºC to 70 ºC with 10 ºC intervals.

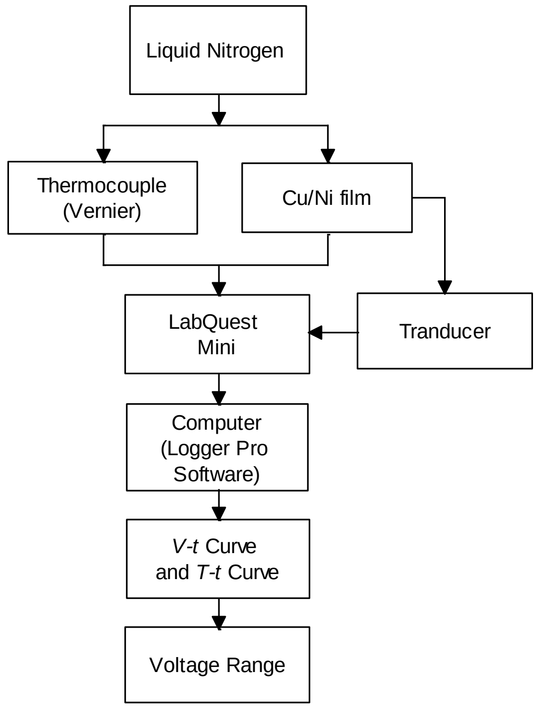

Figure 1. Flow-chart on the performance of Cu/Ni Film low-temperature sensor

The next step is to test the performance of the low-temperature sensor according to Figure 1. The temperature range is to test the low-temperature sensor's performance using a temperature range between 0 ºC to -180 ºC. As data collection material, vernier's TCA-BTA series thermocouple sensor is used. In the process of data collection, the Cu/Ni layer and thermocouple sensors are inserted into the nitrogen tube at a speed of 0.2 cm/s. The data output is in the form of *V-t* and *T-t* curves whose values vary depending on the medium's temperature using Logger Pro software. The voltage range analysis technique uses the highest and lowest voltage output values from each sample (Toifur et al., 2020).

RESULT AND DISCUSSION

Figure 2 shows two curves: the output voltage data on the Cu/Ni layer sensor and the thermocouple. The figure explains that the two curves decrease with the measured temperature and vice versa. These results indicate that the Cu/Ni layer has shown its character as a sensor as in thermocouples.

The results of data analysis for the voltage range are shown in Figure 3. Based on Figure 3, the highest voltage range or range value is owned by a sample with a deposition state at a temperature of 60 ºC with a range of 0.771 V to 0.872 V or 0.101 V. deposition at a temperature of 30 C with a range of 0.797 V to 0.877 V or 0.080 V. The value of the voltage range indicates the sensor's ability to detect changes in temperature within the range of the sensor, if it is outside this value, an inaccurate value will appear (Wilson, 2017). Jain (2012) also stated that the voltage range value shows the efficiency in its performance as a sensor.

Overall, the voltage range's value has a value with a small range, ranging from 0.080 V to 0.101 V. Toifur (2020) explains that the voltage range value on a sensor influences the performance of the sensor can be due to the external magnetic field on it. The deposition process is results in an increase in the growth rate of Ni towards the cathode.

Changes in solution temperature also result in cyclic changes in the solution. These changes cause the convection of heat propagation so that the evolution of hydrogen in solution appears (Al-Duaij et al., 2017), which in turn affects the chemical reactions in the electrolyte solution (Wu et al., 2015).

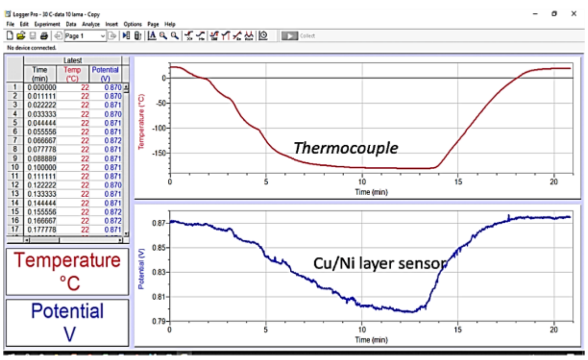

Figure 2. The results of the pro logger data output for Cu/Ni and thermocouple sensors

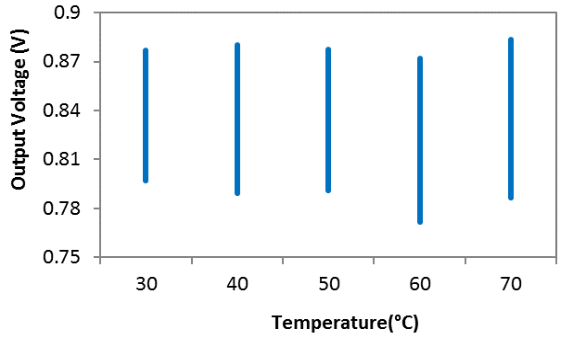

Figure 3. Voltage range values for each Cu/Ni layer sensor sample

CONCLUSION

This study concludes that each sample of the Cu/Ni layer sensor has shown its properties as a low-temperature sensor. This is indicated by changes in the value of the output voltage following changes in the temperature of the thermocouple. The characterization of the sensor for the value of the voltage range shows that the measured voltage range is different and has a difference with a small voltage range, whereas, for the widest voltage range, the sample is obtained by precipitation at a temperature of 60 °C.

The limitation of research with Cu/Ni samples is that there is no accurate parameter as a comparison other than the thermocouple. The next step is measuring the sensitivity level of the Cu/Ni sensor in response to low-temperature changes.

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