Electrical Characteristics CuFe$_2$O$_4$ Ceramics With and Without Al$_2$O$_3$ for Negative Thermal Coefficient (NTC) Thermistor

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**INTRODUCTION**

Thermistor → Thermally Sensitive Resistor.

**NTC CHARACTERISTIC**

**PRODUCT EXAMPLES**

- Specialized Thermistor
- Current Limiter Thermistor
- Incubator

**APPLICATIONS**

- Biomedical, aerospace, instrumentation, communications, automotive
- HVACR (Heating, Ventilation, Air conditioning and Refrigeration)
- Temperature sensor, electric current limiter, flowrate meter and pressure sensor.
- Most, thermistors are produced from spinel ceramics based on transition metal oxides forming general formula $AB_2O_4$.
- Predicted that the $Al_2O_3$ addition can improve the characteristics of the CuFe$_2$O$_4$ ceramic for NTC thermistors.

**EXPERIMENT**

![ çocuk](image)

**RESULT (XRD)**

- XRD profiles of CuFe$_2$O$_4$ based-ceramics

**RESULT (ELECTRICAL CHARACTERISTIC)**

<table>
<thead>
<tr>
<th>Additive of $Al_2O_3$ (mol %)</th>
<th>$\alpha$ (K$^{-1}$)</th>
<th>$\varphi$ (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>2862</td>
<td>3.22</td>
</tr>
<tr>
<td>1</td>
<td>3208</td>
<td>3.61</td>
</tr>
<tr>
<td>5</td>
<td>3958</td>
<td>4.46</td>
</tr>
</tbody>
</table>

The relation between Electrical Resistivity and $1/T$.

**CONCLUSION**

- All CuFe$_2$O$_4$ base-ceramic crystallized in tetragonal structure.
- Thermistor constant (B) and sensitivity (a) of the CuFe$_2$O$_4$ base-ceramics increase with the increase of $Al_2O_3$ concentration.
- This means that the addition of $Al_2O_3$ can be used as a controlling parameter.
- However, the addition of $Al_2O_3$ decreases the electrical stability of the CuFe$_2$O$_4$ base-ceramics. Only sample without $Al_2O_3$ and that added with 1 mole % $Al_2O_3$ fit the electrical stability condition.
- Heating at 150°C for 200 hours can be used to make CuFe$_2$O$_4$ base-ceramic stably electrically.

**ACKNOWLEDGMENT**

The authors wish to acknowledge their deep gratitude to DIKTI, Department of National Education of Indonesian Government for financial support under Hibah PEKERTI program with contract No.034/SP.017/P.2026. April 24, 2006.
**INTRODUCTION**

**NTC CHARACTERISTIC**
- Thermally Sensitive Resistor.

**PRODUCT EXAMPLES**

**APPLICATIONS**
- Computer
- HVACR (Heating, Ventilation, Air conditioning and Refrigeration)
- Pressure sensor
- Flowrate meter

**IMPORTANT ELECTRONIC COMPONENT**

**ELECTRICAL CHARACTERISTIC**

**REFERENCE**

**CONCLUSION**

**RESULT (ELECTRICAL CHARACTERISTIC)**

**RESULT (XRD)**

**ACKNOWLEDGMENT**

**REFERENCES**

**SAMPLE COMPOSITION IN MOLE % TABLE**

**HEAT TREATMENT**
- 800°C 2h
- 1100°C 2h

**CHARACTERIZATION**
- Optical Microscope
- XRD

**HEATING**
- 100°C

**EXPERIMENT**
- Specialize Thermistor
- Current limiter thermistor

**APPLICATION**

**PRODUCT EXAMPLES**

**APPLICATIONS**

**RESULT (ELECTRICAL CHARACTERISTIC)**

**RESULT (XRD)**

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**SAMPLE COMPOSITION IN MOLE % TABLE**
**INTRODUCTION**

Biomedical, aerospace, instrumentation, communications, automotive: 

**THERMISTOR**→ Thermally Sensitive Resistor.

**NTC CHARACTERISTIC**

**PRODUCT EXAMPLES**

Current limiter thermistor

Specialize Thermistor

**APPLICATIONS**

**IMPORTANT ELECTRONIC COMPONENT**

- Sectors: Biomedical, aerospace, instrumentation, communications, automotive and HVACR (Heating, Ventilation, Air conditioning and Refrigeration).
- Application: Temperature sensor, electric current limiter, flowrate meter and pressure sensor.
- Most, thermistors are produced from spinel ceramics based on transition metal oxides forming general formula $A_B^{2+}O_4$.
- Predicted that the $A_{2}O_{3}$ addition can improve the characteristics of the $CuFe_2O_4$ ceramic for NTC thermistors.

**EXPERIMENT**

CuO

$Fe_2O_3$

SiO$_2$

MIXING

$800^\circ C / 2 h$

CALCINATION

CRUSHING

$3, 9$ ton/Cm$^2$

PRESSING

$1100^\circ C / 2 h$

SINTERING

**HEAT TREATMENT**

$T(\text{OC})$

$500^\circ C$

25' 30'

$(\text{minute})$

**SAMPLE COMPOSITION IN MOLE % TABLE**

<table>
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<tr>
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<th>CuO</th>
<th>$Fe_2O_3$</th>
<th>$Al_2O_3$</th>
</tr>
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<tbody>
<tr>
<td>1.</td>
<td>40</td>
<td>60</td>
<td>0</td>
</tr>
<tr>
<td>2.</td>
<td>40</td>
<td>59</td>
<td>1</td>
</tr>
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<td>3.</td>
<td>40</td>
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**ELECTRICAL CHARACTERISTIC**

$\bullet R = R_o \exp(B/T)$

$\bullet Ea = B.k$

$\bullet \alpha = -B/T^2$

$R = $ Thermistor resistance

$R_o = $ Resistance at the infinite temperature

$B = $ Thermistor constant

$T = $ Temperature of thermistor

$E_a = $ Activation energy

$k = $ The Boltzmann constant

$\alpha = $ Sensitivity of thermistor

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**REFERENCES**

- E.S. Na, S.C. Park, I.C. Choi, "The effect of a sintered microstructure on the electrical properties of a Mn-Co-Ni-O based-ceramics", Ceramics with and without $Fe_2O_3$ base-ceramic. Only sample without $Al_2O_3$ and that added with 1 mole $%Al_2O_3$ fit the electrical stability condition.
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