# A Study on the PTCR Characteristics of $BaTiO_3$ Semiconductor Ceramics (I) (Preparation of Y-doped $BaTiO_3$ Powder by Hydrothermal Method)

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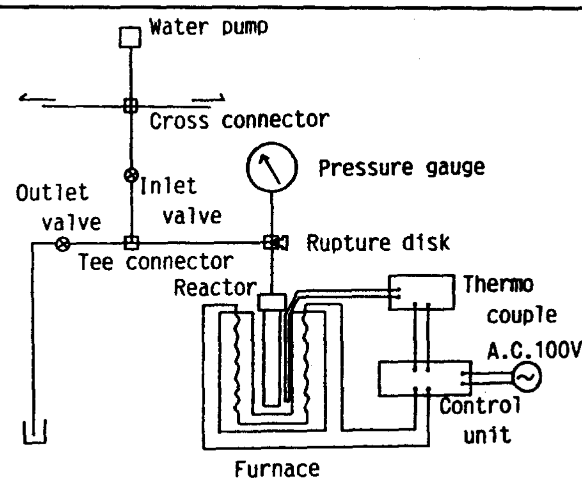
PTCR(Positive Temperature Coefficient Resistivity) characteristics of $BaTiO_3$ ceramics is known as grain boundary effect in which potential barrier is formed by physical and chemical properties of grain boundary itself. And it has been known that the procedure to make a PTCR devices is delicate because a lot of factors can affect the PTCR characteristics. Among the process factors, powder preparation method and its characteristics are known as crucial factors to obtain the final device characteristics because it affects the sintering temperature, impurities, porosity and grain size of sintered body.

Preparation of oxide powder by hydrothermal process has severall strong points which are the easiness to control composition and morphology of particles, and more it needs no calcination and milling procedure after powder preparation because oxide powder can be obtained directly during hydrothermal process. The morphology control during hydrothermal synthesis can be performed by control of the solubility of the constituant materials which depends on the concentration and the kind of solvent material and reaction temperature. There is a drawback in the sol-gel method that barium carbonate forms easily because of the use of the compounds that include carbon as raw materials.

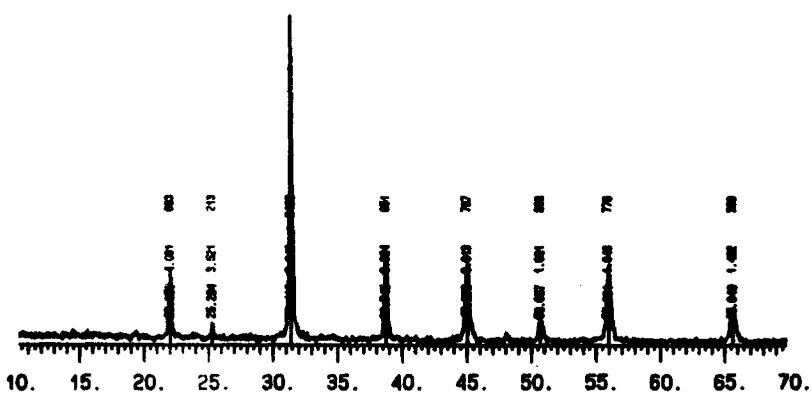
In this study, we prepared semiconducting yttrium doped barium titanate powder by hydrothermal method for PTCR ceramics. Yttrium was chosen as a dopant for semiconducting property because $BaTiO_3$ has no drastic change of resistivity at room temperature by the change of yttrium concentration in the range of 0.2 - 0.4 mole % of $Y_2O_3$. The conditions for synthesis of Y-doped $BaTiO_3$ and their morphology were investigated.

Titanium dioxide, $TiO_2$ (Wako Pure Chem. Ind., Ltd., research grade, purity > 99.9%) and barium hydroxide, $Ba(OH)_2 \cdot 8H_2O$ (Wako Pure Chem. Ind., Ltd., research grade, purity > 98%) were used as starting materials. 8M-NaOH solution and pure water were used as solvent material. After addition of barium hydroxide and titanium dioxide to the sovent at various Ba/Ti atomic ratios in the range from 1 to 15, the solvent was stirred in a conventional autoclave at various temperature in the range from 200 to 270°C for 24hrs, and barium titanate was precipitated. After precipitation was performed, the autoclave was quenched to room temperature in order to avoid hydration of barium titanate. The precipitates were then filtered, washed and dried in a oven overnight at temperature of 110°C. And the crystal structure of the particles was investigated at room temperature using a powder X-ray diffractometer, and morphology and size of particle were also investigated by using scanning electron microscope.



Schematic diagram of the apparatus for hydrothermal synthesis

Cubic Y-doped $BaTiO_3$ powder were succefully synthesied at various temperature in the range from 200 to 270°C with pure water and NaOH solution as solvent materials. Barium carbonate were formed during filtering and washing procedure in the Ba exess samples and its amount was proportional to the Ba concentration in solvent, but not in Ba/Ti atomic ratio of 1. This means that all the $TiO_2$ particles were fully reacted with $Ba^{2+}$ ions in the solution and formed cubic phase. And the $BaCO_3$ can be washed out by the acetic acid treatment and washing in the Ba exess samples. The synthesis of semiconducting $BaTiO_3$ powder without using of alkali materials shows a possibility that this power can be used commercially for the PTCR devices.



XRD pattern of Y-doped $BaTiO_3$ powder Ba/Ti atomic ratio of 1 dried at 110°C