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The Synthesis And Thermoelectrical Characterization Of YBaCuO-Doped PZT

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ABSTRACT

In this paper, the synthetic process of YbaCuO-doped PZT is briefly talked. The thermoelectrical properties of YBaCuO-PZT was mainly focused and three different stoichiometric ratios of PZT and YBaCuO(70:30, 90:10, and 95:5) were included for the investigation of electrical conductivity with an abroad range of temperature which is from room temperature and enhanced up to 945^{0}C. The results shows the electric conductivity changes from $3.33\times10^{-5}(\Omega^{-1}cm^{-1})$to $1.04\times10^{-1}(\Omega^{-1}cm^{-1})$ as the temperature increased.

INTRODUCTION

The important piezoelectric ceramic material, Lead Zirconate Titanate(PZT) has been used in modern industrial technology area due to its prominent properties. The application of PZT has an extensive range which includes ultrasonic actuators, pyroelectric detector, photoelectric devices, and hydrophones and so on[1, 2].

The high Tc superconductor Yttrium Barium Copper oxide($YBa_2Cu_3O_{7-\delta}$) has been discovered in 1986, and it is the first material to become superconducting at 92.3K which is above the boiling point of nitrogen(77K)[3]. This characteristic of high temperature superconductor cut down the cost of refrigeration process compared to the use of low temperature materials, the higher stability give a increased reliability[4]. Thus the new field of application of high Tc superconductor has been opened, such as Motors, generators, transformers, current leads, fault current limiters, and so forth[3, 4]. In my research, PZT has been doped with $YBa_2Cu_3O_{7-\delta}$ by three different stoichiometric ratios(70:30, 90:10, and 95:5) to form the new-model functional ceramic material. The compounds showed good R-T characteristics, and especially within the high temperature rang 600-945^{0}C) the electric conductivity was largely increased as the temperature enhanced.

EXPERIMENTAL

Synthesis of PZT

There major raw materials $Pb(NO_3)_2$, TiO_2 and ZrO_2 (Zr/Ti=50/50) were prepared for the further synthesis processing via sol-gel method. Firstly,

TABLE 1: Electrical conductivity of three synthesised PZT-YBaCuO compounds at different temperature

PY_1 (70:30)			PY_2 (90:10)			PY_3 (95:5)		
Temperature		Electrical conductivity	Temperature		Electrical conductivity	Temperature		Electrical conductivity
°C	K	$\sigma(\Omega^{-1}cm^{-1})$	°C	K	$\sigma(\Omega^{-1}cm^{-1})$	°C	K	$\sigma(\Omega^{-1}cm^{-1})$
15	288	1.76×10^{-4}	17	290	3.33×10^{-5}	17	290	3.88×10^{-5}
100	373	2.79×10^{-4}	80	353	3.55×10^{-5}	100	373	4.46×10^{-5}
200	473	5.57×10^{-4}	200	473	4.61×10^{-5}	220	493	6.26×10^{-5}
320	593	1.86×10^{-3}	280	553	6.04×10^{-5}	290	563	8.74×10^{-5}
440	713	4.76×10^{-3}	330	603	7.01×10^{-5}	320	593	1.16×10^{-4}
480	753	5.94×10^{-3}	350	623	1.04×10^{-4}	380	653	2.32×10^{-4}
580	853	1.37×10^{-3}	470	743	4.29×10^{-4}	440	713	5.85×10^{-4}
600	873	2.85×10^{-4}	500	773	6.36×10^{-4}	490	763	9.94×10^{-4}
630	903	2.35×10^{-4}	530	803	9.88×10^{-4}	540	813	1.24×10^{-3}
680	953	5.67×10^{-4}	580	853	1.1×10^{-3}	560	833	8.76×10^{-4}
715	988	1.44×10^{-3}	600	873	7.52×10^{-4}	600	873	1.47×10^{-4}
740	1013	2.65×10^{-3}	640	913	2.62×10^{-4}	700	973	4.49×10^{-4}
795	1068	6.01×10^{-3}	690	963	4.33×10^{-4}	720	993	9.97×10^{-4}
800	1073	1.53×10^{-2}	720	993	8.05×10^{-4}	730	1003	1.9×10^{-3}
875	1148	2.09×10^{-2}	750	1023	1.59×10^{-3}	800	1073	8.92×10^{-3}
905	1178	6.16×10^{-2}	800	1073	5.16×10^{-3}	850	1123	1.73×10^{-2}
918	1191	9.42×10^{-2}	850	1123	8.58×10^{-3}	900	1173	2.9×10^{-2}
920	1193	1.15×10^{-1}	900	1173	1.78×10^{-2}	910	1183	3.71×10^{-2}
925	1198	1.15×10^{-1}	920	1193	2.26×10^{-2}	920	1193	4.78×10^{-2}
940	1213	1.15×10^{-1}	930	1203	2.5×10^{-2}	940	1213	4.84×10^{-2}
			945	1218	1.04×10^{-1}			

dissolved stoichiometric amount of $Pb(NO_3)_2$ into distilled water. After the complete dissolution of $Pb(NO_3)_2$, put stoichiometric of TiO_2 fine powder into the prepared solution to form the mixed PT solution. On the other hand, concentrated nitric acid has been used as the solvent of another raw material ZrO_2. Secondly, mixed the two solutions, and a certain amount of citric acid in. citric acid was helping the powder suspension to prevent the aggregation. Thirdly, sol-gel method was used to create the new compounds-dried gel, and dried gel was the dried at 135°C for 4 hours. Finally, the product was ground and calcined at 900°C for two hours. After cooling and further grinding process, the synthesis of PZT was completely formed.

Synthesis of YBaCuO superconducting powder

YBaCuO powder has been synthesised by sol-gel technique. After the complete auto-combustion of citrate acid which was during the thermal magnetic stirrer process. Then leave it into an oven at 200°C for 4 hours to yield the YBaCuO primary powder. The further calcination process is required to form the superconducting powder at 980°C for 6 hours.

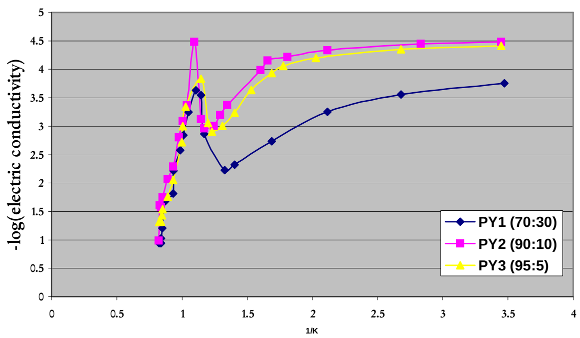
Formation of PZT-YBaCuO compounds

PZT powder and YBaCuO superconducting powder were synthesised by three different ratios: 70:30, 90:10, and 95:5 in agate mortar. The completely mixed powder was compressed to the wafer (size: $\Phi 13\times 2mm$) by using $10MPa/cm^2$ compressive stress on the powder compressing machine.

Calcined the wafers at 1170°C for two hours in high-temperature furnace and let them cool down as the temperature of the furnace decreased.

Measurement of electrical conductivity of PZT-YBaCuO powder

The calcined products were washed by using 90%



Graph1 : Electrical conductivity of three synthesised PZT-YBaCuO compounds at different temperature

ethanol to obtain the cleaned surface. Conducting glue was applied on the both surface of the wafer then dry up, and adding the electrode on the both sides. Put the whole kit into the furnace, and control the inside temperature to measure the electrical conductivity at the different range of temperature.

RESULTS AND DISCUSSION

Three products have been synthesised by three chemical ratios of PZT and YBaCuO, which are 70:30, 90:10, and 95:5. The electrical conductivities of the three synthesised products have been measured at an abroad range of temperature, and the results have shown the strong thermo-sensitive ability of the PZT-YBaCuO compounds. All measured electrical conductivity values have list in TABLE 1 as below. As can be seen, electrical conductivity of PZT-YBaCuO is increased along with the temperature enhancing. The electrical conductivities of PY_1 and PY_3 were increased up to 3 levels of magnitude as the temperature changed from room temperature up to 940^{0}C, and the electrical conductivity for PY_2 changed 4 levels of magnitude even higher than the synthesised compounds PY_1 and PY_3. Compare different compounds at same temperature, the different chemical ratio of each compound gave a slight different electrical conductivity value; as can be seen in table 1 and graph 1, such as, PY_1 has a stronger conductivity(1.76×10^{-4}) than PY_2(3.33×10^{-5}) and PY_3(3.88×10^{-5}) at room temperature.

However, at 940^{0}C, both PY_1 (1.15×10^{-1}) and PY_2(1.04×10^{-1}) gave the higher conductivity value than PY_3 (4.84×10^{-2}). In the mixed powder, the single structure of both PZT and YBaCuO has crossed together to form an abroad range of crosslink structure. The consistent characteristic of the synthesised compound lead to the creation of the new thermal-sensitive ability by two simplex and dissimilar powders (PZT and YBaCuO).

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