High temperature alternating current poling for $0.24Pb(In_{1/2}Nb_{1/2})O_3$-$0.46Pb(Mg_{1/3}Nb_{2/3})O_3$-$0.30PbTiO_3$ single crystals

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Recently, an increasing number of researchers have focused on $Pb(In_{1/2}Nb_{1/2})O_3$-$Pb(Mg_{1/3}Nb_{2/3})$-$PbTiO_3$ (PIN-PMN-PT) ternary system single crystal (SC) possessing higher phase change temperature (Tpc) > 90 ºC, which can be used in wider temperature range comparing with traditional PMN-xPT binary system SC. In this work, we have investigated high temperature alternate current poling (ACP) on [001] oriented 0.24PIN-0.46PMN-0.30PT (PIMN-0.30PT) SC manufactured by continuous-feeding Bridgman (CF BM) method which can partly eliminate the compositional segregation compared with the traditional one charge Bridgman method. High dielectric permittivity ($\varepsilon^T_{33}/\varepsilon_0$) of 6730 and piezoelectric constant d_{33} of 2240 pC/N, which were both 24% larger than those of direct current poling (DCP) using same poling voltage, was obtained by the ACP condition of 4 kVrms/cm, 10 Hz, and 12 cycles at 90 ºC. Temperature dependence of these $\varepsilon^T_{33}/\varepsilon_0$ (Fig. 1) and phase analysis by X-ray diffraction (XRD) (Fig. 2) of these ACP and DCP SCs showed clear different properties. We concluded that the best ACP poling temperature for CF BM PIMN-0.30PT SC is 90 ºC which is almost as same as its Tpc.

Table I. Electrical properties of ACP with different temperatures and DCP for PIMN-0.30PT SCs.

#	Condition	$\varepsilon^T_{33}/\varepsilon_0$	$\varepsilon^S_{33}/\varepsilon_0$	Loss (%)	kt (%)	Nt (Hz m)	k_{33} (%)	d_{33} (pC/N)
1	ACP-70 ºC	6660	670	0.30	57.3	1900	94.9	2130
2	ACP-90 ºC	6730	680	0.27	58.0	1898	94.8	2240
3	ACP-110 ºC	5810	770	0.32	56.4	1898	93.2	1800
4	ACP-130 ºC	5190	840	0.42	53.7	1896	91.6	1790
5	DCP-50 ºC	5440	650	0.51	57.8	1890	93.8	1810

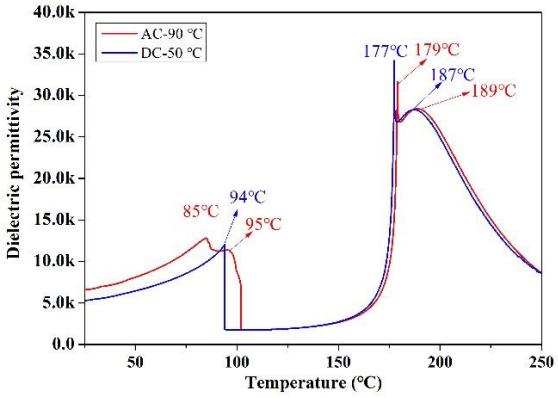

Fig. 1. Temp. dependence of $\varepsilon^T_{33}/\varepsilon_0$ of ACP (90ºC) and DCP.

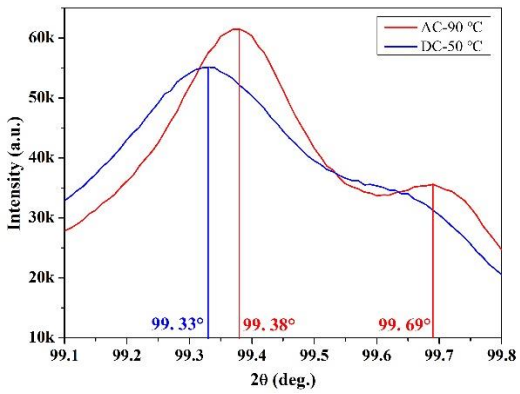

Fig. 2. XRD of ACP (90ºC) and DCP.