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Past, present, and future prospective of alternating current poling for piezoelectric single crystals and applications

Abstract: Smart Alternating Current Poling (ACP) of bulk piezoelectric relaxor-$PbTiO_3$ (PT) single crystals (SCs) has been actively studied since 2018. In 2022, 25 peer-reviewed journal papers were published, and the number of total papers on ACP has reached 70 as of May 2023. Scaling effects in the ACP of thin PIN-PMN-PT SCs were studied at NCSU, revealing ACP is not effective for thin single crystals with thicknesses of less than 0.06 mm. In addition, over-poling effects of ACP on rhombohedral PMN-PT SCs were investigated at NCSU to study domain size dependences of piezoelectricity associated with ACP. The results show fine, 0.5 to 2.0 μm 109° stripe-like domains are more responsible for the optimum properties of ACP SCs. Summarized results and discussions are presented in the following two review papers. Toyama Prefectural University (TPU) reported 5 papers in 2022, including recent progresses on AC poling of relaxor-$PbTiO_3$ ferroelectric SCs (Review) and ACP effects of large sized (4-7 cm^2) cardiac and abdomen medical probes for binary and ternary SCs grown by the continuous feeding Bridgman process. Shonan Institute technology, Japan revealed SEM macro and microstructures of ACP and DCP relaxor-PT SCs. In this review presentation, we summarize the latest results on ACP for relaxor-PT SCs over the last several years during in the Covid-19 era (2020-2023).

Professor Yohachi (John) Yamashita was born in Kagoshima, Japan, in 1951. He received the Ph.D. degree in material science from Waseda University, Tokyo, Japan, in 1998. From April 1969 to February 2013, he worked for Toshiba Corporation, Tokyo. He is an Inventor of alternating current poling technology for piezoelectric single crystals. He is currently an Adjunct Professor with North Carolina State University, Raleigh, NC, USA, and Toyama Prefectural University, Toyama, Japan. He has published more than 200 journal papers and his H-index is 29. He has applied for 230 Japanese patents and 43 international patents. He is the editor-in-chief of Japan Journal of Applied Physics, member of Japan Society of Applied Physics, IEEE Senior Member. He is currently working in the field of piezoelectric materials, medical transducers, and alternating current poling technology.

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