# Electric-optic properties of $Hf_{0.5}Zr_{0.5}O_2$ thin films on (La, Sr) $MnO_3/SrTiO_3(100)$

Nagoya Univ.[1], Kyoto Univ.[2], Tokyo Tech. MDX[3],
Afeefa Dastgir[1], Xueyou Yuan[1], Yufan Shen[2], Daisuke Kan[2], Yuichi Shimakawa[2],
Tomoaki Yamada[1,3]
E-mail: t-yamada@energy.nagoya-u.ac.jp

Ferroelectricity in $HfO_2$based thin films is attractive for applications in ferroelectric random-access memory and ferroelectric tunnelling junctions. We recently found that the Y-doped $HfO_2$ thin films exhibit the linear electro-optic (EO) property. Although the observed EO coefficient was below 1 pm/V, which is one or two order magnitudes smaller than that of conventional ferroelectric EO materials, it is interesting for the Si-integrated photonics as $HfO_2$ is highly compatible with CMOS process. Therefore, the enhancement of EO coefficient in $HfO_2$-based thin films can be expected.

In this study, we investigated the thickness -dependence of EO property in $Hf_{0.5}Zr_{0.5}O_2$ (HZO) thin films, revealing an enhanced EO response in 10 nm-thick films compared to thicker films. HZO films were deposited on (La, Sr) $MnO_3/SrTiO_3(100)$ [1] using pulsed laser deposition, with the thickness in the range of 3 to 30 nm. As can be seen in Fig. 1, there is a partial phase transition from ferroelectric orthorhombic to paraelectric monoclinic with increasing film thickness from 10 nm to 30 nm, meaning that both orthorhombic and monoclinic phases coexist in the 30 nm-thick film. The EO response of those films was characterized using in-house modulation ellipsometry [2]. It was found that both 10 nm and 30 nm films exhibited evident linear EO response, and the EO coefficient for the 10 nm-thick film was 1.0 pm/V, which was larger than that for 30 nm-thick film (0.8 pm/V). This implies that the larger volume fraction of ferroelectric orthorhombic phase in thinner films contributed to the larger EO response.

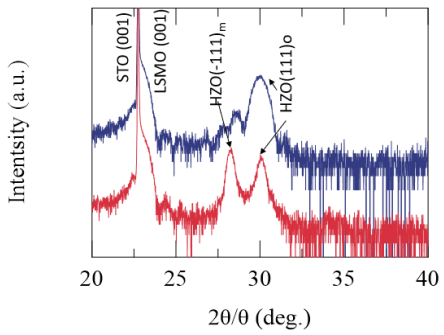


Fig. 1: XRD 2θ scan-spectra for 10nm(blue) and 30nm(red)-thick HZO films on LSMO/STO (001)

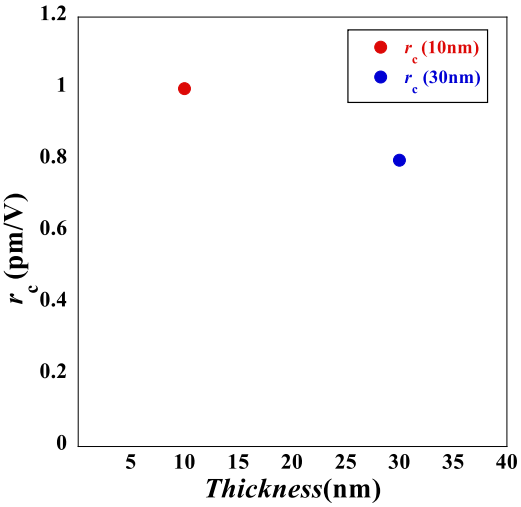


Fig. 2: EO coefficient $r_c$ , for 10nm and 30nm-thick HZO films on LSMO/STO (001)

References:

[1] Y. Shen, K. Ooe, X. Yuan, T. Yamada, S. Kobayashi, M. Haruta, D. Kan, and Y. Shimakawa, *Nat. Commun*. (in press).
[2] S. Kondo, T. Yamada, A. K. Tagantsev, P. Ma, J. Leuthold, P. Martelli, P. Boffi, M. Martinelli, M. Yoshino, and T. Nagasaki, *Appl. Phys. Lett.*, **115**, 092901 (2019).