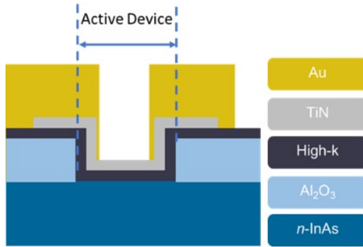

Supplementary Information:

Interface reactions during the ferroelectric switching of HfZrO thin films on InAs

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Fig. 1: Sketch of the processed ferroelectric MOS device structure. The active device consists of an InAs/HZO/TiN stack.

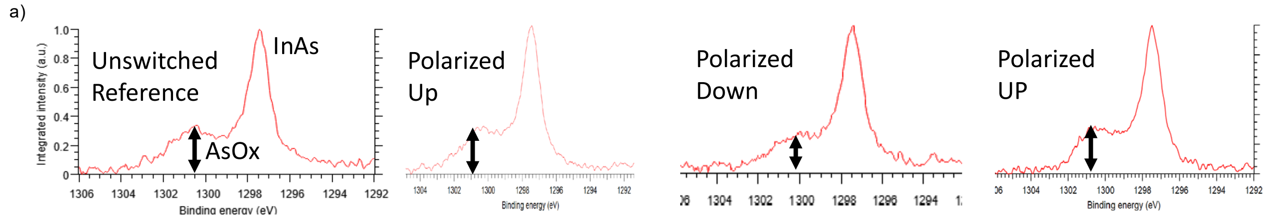

Fig. 2: As 2p HAXPES results obtained upon subsequent PUND switching of the ferroelectric device. The amount of As-oxide (at about 1300.5 eV) changes periodically, while the intensity of the As-In bulk peak (at about 1297.5 eV) remains constant.

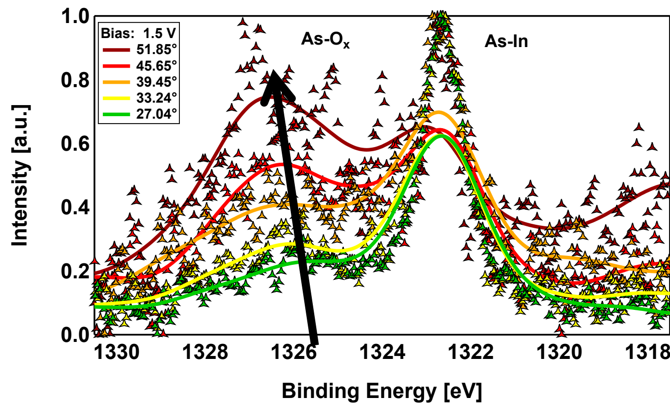

Fig. 3: Depth-dependent HAXPES As 2p spectra of the InAs/HZO interface obtained under applied bias of 1.5 V. Larger angle corresponds to smaller probing depth. The binding energy position of the As-oxide peak (at around 1326 – 1327 eV) shifts to higher binding energy with decreasing probing depth, since a positive bias is applied to the TiN top layer of the device. The bulk As-In peak remains at constant energy, since the InAs substrate is grounded. Accordingly, the applied bias drops across the As-oxide layer.

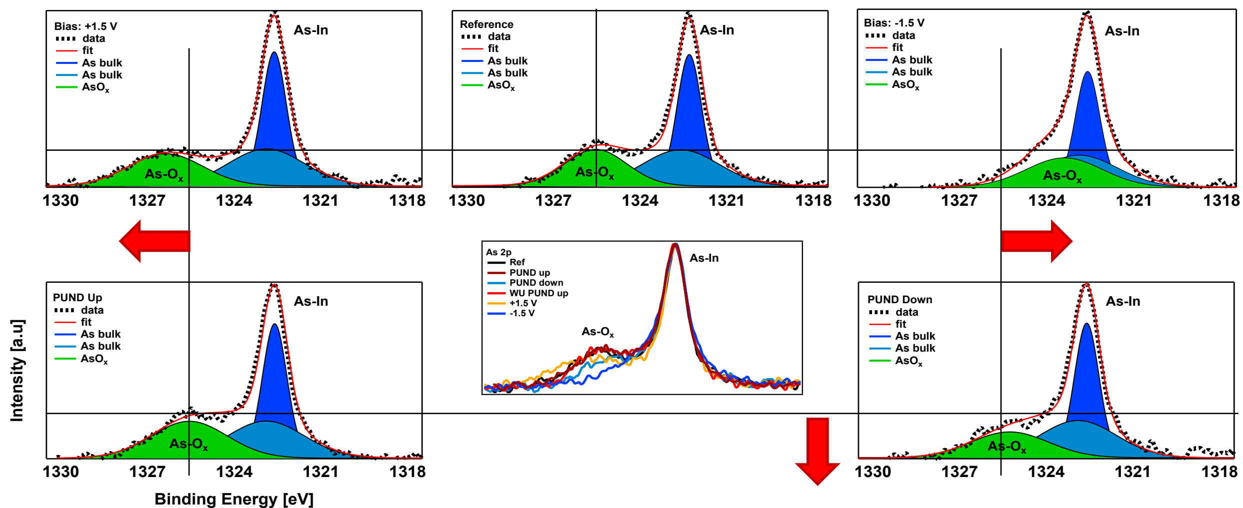

Fig. 4: Fitted As 2p spectra, summarizing results from Fig. 2 and Fig. 3. Top row: Spectra obtained under applied positive DC bias (left), no bias (center), and negative DC bias (right). The binding energy of the As bulk peak remains constant, while that of the As-oxide peak shifts to higher values upon positive bias and to lower values upon negative bias, showing that the applied bias drops over the As-oxide layer. Bottom row: Spectra obtained without applied bias, but after PUND up (left) and PUND down (right), with remanent polarization. No significant shift of the binding energy is observed, but a change in intensity of the oxide component. Center: Raw data for all cases discussed.