Exploiting point defects in two-dimensional materials for neuromorphic computing

H. Ravichandran[1], T. Knobloch[2], S.S. Radhakrishnan[1], C. Wilhelmer[2], S.P. Stepanoff[3], C. Chen[3], J.M. Redwing[3], D.E. Wolfe[1,3], T. Grasser[2] and S. Das[1,3]

[1]*Engineering Science and Mechanics, Penn State University, PA 16802, USA*

[2]*Institute for Microelectronics (TU Wien), Gusshausstrasse, 1040 Vienna, Austria*

[3]*Materials Science and Engineering, Penn State University, PA 16802, USA*

Defects pose a significant challenge to the reliability of electronic devices, particularly when dealing with scaled dimensions in the microelectronic industry. Consequently, extensive efforts have been made to eliminate these defects from devices through the optimization of growth and fabrication processes. However, in the realm of emerging nanomaterials, such as two-dimensional semiconductors, a different scenario unfolds, where point defects are considerably more prevalent than in silicon devices. In this study, we employ a multifaceted approach, encompassing atomistic imaging, density functional theory calculations, device modeling, and low-temperature transport experiments, to unveil the implications of point defects on random telegraph signals (RTS). On a parallel track, it is worth noting that point defects have proven to be beneficial in numerous quantum and energy-harvesting applications. Surprisingly, their potential for neuromorphic computing remains largely untapped. In our study, we harness defects in aggressively scaled WSe_2 FETs to accelerate an inference engine based on a stochastic spiking neural network, offering remarkable noise resilience. In essence, we demonstrate that the defect dynamics of point defects in ultra-scaled WSe_2 FETs can be exploited for noise resilient information processing. In conclusion, our investigation underscores the critical importance of comprehending and leveraging intrinsic point defects in 2D materials, both as challenges to reliability and as opportunities for neuromorphic computing.