

## In-situ biasing and temperature influence on the electric fields across GaAs based p-n junction via 4D STEM

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The ability to determine electric fields at the nanoscale is critical for understanding semiconductor device properties. Until now, fundamental aspects of the electron interaction with the electric potential field have been investigated by employing transmission electron microscopes, especially with electron holography and differential phase contrast imaging (DPC) 1,2. Apart from detecting in-built electric fields, in situ biasing experiments on GaAs and Si p-n junctions have also been performed with electron holography 3,4. However, this approach requires a specialized setup where the primary beam is split into two, wherein the reference wave later interacts with the second wave passing via the specimen.

Nevertheless, in recent times the acquisition of four-dimensional datasets (diffraction patterns at each scan point) has become available using direct electron detectors. Here we combine in-situ biasing with a four-dimensional scanning transmission electron microscopy (4DSTEM) technique to study the influence on the depletion region in the GaAs-based p-n junction. Furthermore, the temperature influence on the electric fields is also undertaken at liquid nitrogen temperature (~ -183 °C) to above room temperature (~50 °C). The biasing and temperature-dependent studies are conducted by adopting an in situ biasing and a cryo holder, respectively.

In this study, the momentum transfer induced by internal electric fields is measured by the diffraction pattern's center-of-mass (COM) shift 5. Identical imaging conditions are employed, which are used for obtaining high-resolution STEM images. Moreover, our sample preparation approach is based on the focused ion beam (FIB) method, which is nontrivial from the perspective of placing the lamella on the biasing MEMS chip. This enables us to determine the electrical properties observed from both biased and unbiased junctions followed by temperature application for a known sample thickness. Here we will show the critical characteristic of the biasing and temperature dependence on the depletion region width 5.

### References

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