ABSTRACT:

Self-Sensing & Back-Contact Free Electrical Atomic Force Microscopy

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Electrical scanning probe microscopy is now a cornerstone of materials characterization with impact on the broader community of materials scientists, engineers and nanotechnologists. Sophisticated instruments for AFM morphology, such as those deployed in modern semiconductor cleanrooms, are capable of remarkable scanning stability, a large field of view, automation, high-speed data acquisition, and can potentially perform the majority of electrical AFM modes. However, a critical design constraint prevents their adoption in in-line wafer and panel metrology: the requirement for an electrical back-contact. This reliance on back-contact constitutes a significant roadblock, preventing the automated deployment of electrical AFM in complex manufacturing environments. To address the limitations imposed by physical back-contacts, we present a novel solution that replaces the mechanical connection with a low-energy electron beam focused on the sample surface near the AFM probe. We refer to this configuration as electron-beam excited AFM (EB-AFM). This approach yields results comparable to conventional techniques while unlocking applications previously inaccessible due to geometry or material constraints. In this work, we first detail the experimental setup and the key parameters governing e-beam stimulation. We then demonstrate the efficacy of this strategy by performing contact-free electrical characterization on various 2D materials and III-V compounds, showcasing application in the space of defect-mapping and reliability studies using EB-AFM.