

Optical Measurements of Electric Fields for Electron Microscopy Applications

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Charging results in numerous and unpredictable artefacts during scanning electron microscopy (SEM) [1]. While strategies are being developed to mitigate its effect, there is no reliable way to measure the magnitude of charging in-situ. The ability to measure charging during SEM operation would better inform charge mitigation and beam scanning strategies for more reliable image interpretation. We have utilized electric-field-induced second harmonic generation (EFISH) to detect and quantify electric fields that arise from the presence of charge in thin film capacitors. Future work will apply this technique to measure electric fields caused by electron-beam irradiation. Most amorphous thin film dielectrics used in semiconductor manufacturing have an average centrosymmetric structure and because of this, do not generate second harmonic light (SHG) in their normal state. However, electric fields will break inversion symmetry, now allowing SHG, with the SHG intensity proportional to the applied electric field strength squared ($I_{2\omega} \propto |E_{DC}^2|$) [2].

To calibrate EFISH as a function of electric field strength, voltages were applied to known thicknesses of thin film capacitors. We demonstrate the ability of EFISH to quantify both magnitude and direction of electric field across thin film Si_3N_4 and SiO_2 capacitors, with the sensitivity to detect field strengths as small as 0.1 kV/mm in some cases. In addition, by scanning the laser beam across in-plane capacitors with and without applied bias, 2D EFISH maps were produced to determine the location of electric fields.

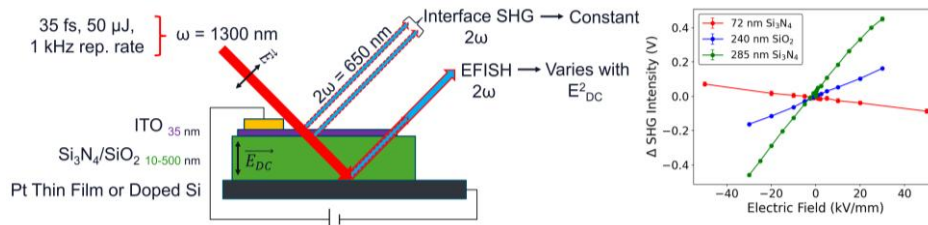


Figure 1. (Left) Cross-section illustration of capacitors used to calibrate EFISH intensity vs electric field strength (Right) EFISH vs electric field strength for dielectrics of varying thicknesses (only 3 samples shown for clarity)

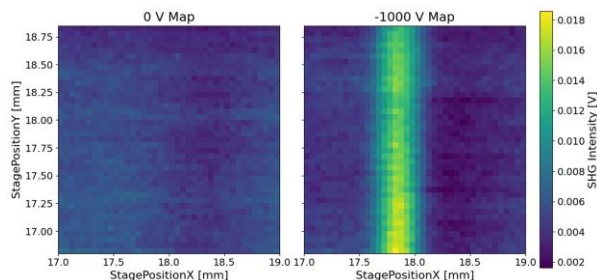


Figure 2. Plan-view SHG images of ITO electrodes embedded within Si_3N_4 with a 0.4 mm gap without an applied bias (left) and with an applied electric field of 2.5 kV/mm (right).

Acknowledgements

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References

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