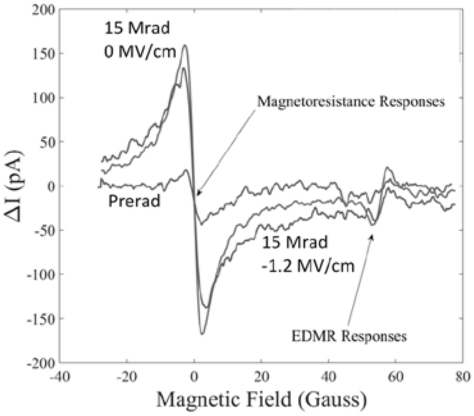
Magnetoresistance and Electrically Detected Magnetic Resonance Study of Leakage Currents in Low-*k* Dielectrics

R. Waskiewicz,[a] **M. Mutch,**[a] **P. Lenahan,**[a] **S. King**[b]
[a] *Pennsylvania State University, University Park, PA, USA*
[b] *Logic Technology Development, Intel Corporation, Hillsboro, OR, USA*

Leakage currents in low dielectric constant thin films utilized in present day integrated circuitry are important reliability concerns. We have initiated a study of the defects involved in electron transport through low-*k* films utilizing both electrically detected magnetic resonance (EDMR) and low field magnetoresistance (MR) measurements. The EDMR and MR response involves spin dependent trap assisted tunneling [1]. The investigated sample structures were p-Si/a-SiOC:H/Ti. In the MR measurement, we observe a response very similar to the EDMR response at resonance, but the MR response occurs around zero magnetic field applied and is due to a mixing of singlet and triplet defect electron states. We investigate the gamma radiation response of leakage currents in dense and porous a-SiOC:H thin films, which are utilized in industry. (The changes generated are likely also relevant to high electric field behavior in these films.) Representative EDMR and MR spectra for the porous films as a function of bias during irradiation are illustrated in Fig. 1. Before gamma irradiation, we observe a weak MR response and nearly no EDMR response. Along with changes in leakage currents after 15 Mrad irradiation, we observe a large increase in both MR and EDMR response although the MR response remains larger than then EDMR response. A qualitatively similar response is observed in the dense films (not shown). The response of these films as a function of applied bias has also been studied with both EDMR and MR measurements. The amplitude of both the EDMR and MR responses increase linearly with applied Ti gate bias. At a negative bias, both responses are below detection limits. This bias response allows us to draw some conclusions about defect energy levels, which will be provided during the conference. This bias response also suggests that the defects responsible for the EDMR and MR are the same defect. As a continuation of this study, we will further study the response of these films with stressing and attempt to identify the defect(s) responsible for transport, now tentatively identified as Si dangling bonds before irradiation and C dangling bonds after irradiation [2]. This project is sponsored in part by the Department of Defense, Defense Threat Reduction Agency under grant number HDTRA1-16-0008. The content of the information does not necessarily reflect the position or the policy of the federal government, and no official endorsement should be inferred.



+ Author for correspondence: rjw5352@psu.edu

[1] M. J. Mutch, P. M. Lenahan, and S. W. King, *J. Appl. Phys.* **119**, 094102 (2016).

[2] R. J. Waskiewicz, M. J. Mutch, P. M. Lenahan, and S. W. King, *IEEE Int. Integr. Reliab. Work. Final Rep.* 2016.