# Substrate condition and metrology considerations in Poly Gate doping implants

David Kirkwood
Axcelis Technologies Inc.
Beverly, USA
david.kirkwood@axcelis.com

Ivy Wu
Axcelis Technologies Inc.
Beverly, USA
ivy.wu@axcelis.com

Dwight Roh
Axcelis Technologies Inc.
Beverly, USA
dwight.roh@axcelis.com

***Abstract*** **The evolution from planar to 3D structures in advanced memory devices has resulted in semiconductor equipment manufacturers facing unprecedented challenges in delivering products that can demonstrate simultaneous compliance to the productivity, reliability and process requirements of their customers. In the field of ion implantation, these challenges are driven by: (i) the increasing prevalence of hard mask and removal of PR stripping process and (ii) the transition from the use of implants in dopant application to that of materials modification. These have resulted in large reductions in both the particle size and number density that can be tolerated from implant steps.**

**One area where these issues have proven challenging is that of contact engineering. Low energy phosphorus implants are used to improve the contact resistivity of poly Si contact. This is critical for the read/write time of the storage node capacitor in DRAM operation. As devices shrink further, the thickness of the poly gate in the peripheral transistors become as low as a few hundred Å. This results in a phosphorus implant requirement of ~1keV. Depletion in the poly Si gate requires a few keV implant energy for poly doping for both NMOS and PMOS. In order to maintain proper gate operation, gate doping requires around E15 doses. This places a large amount of implanted phosphorus at or near the surface of the wafer.**

**In this paper, a phenomenon is described where the magnitude of surf**

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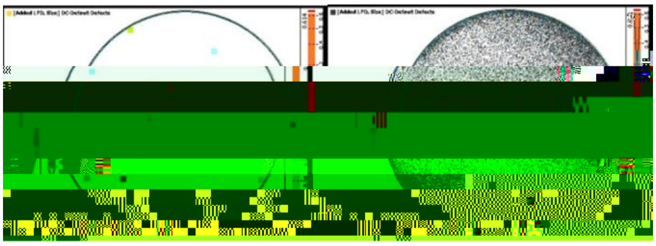

Fig. 1. Effect of Delay on measured particle map

For DRAM devices, low energy high dose implantation historically has been applied across the transistor structure with different goals. For shallow junction formation these include precise dose control, across wafer uniformity (afforded by beam angle control), optimization of co-implant and damage engineering. For materials modification implants such as contact implant to Si and/or poly-Si, cross contamination, energy contamination and optimization of dose rate control have been required to meet device node requirements. Defect control including understanding particle generation, monitori

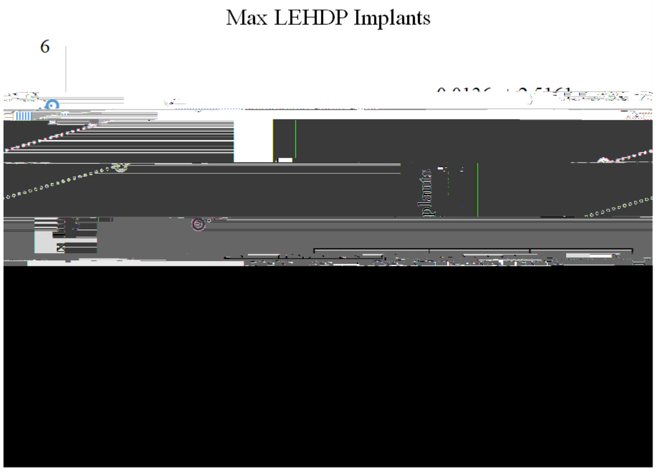


Fig. 2. Max implants as a function of energy and dose

The proposed mechanism for this observed issue is the large amount of surface Phosphorus resulting from the implant. T

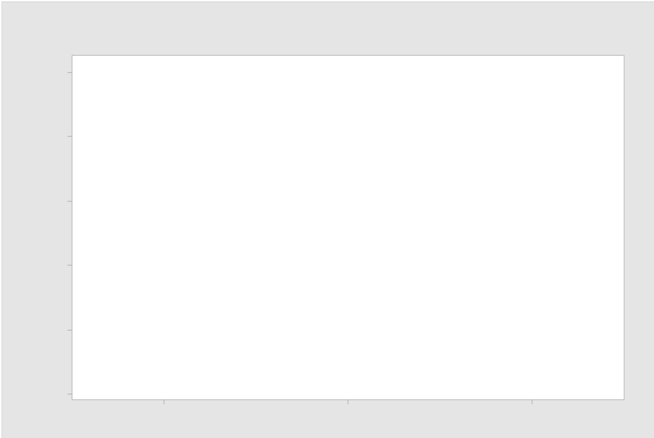

Fig 5. Size distribution of LEHDP particle types

Subjectively, these have been classified into 5 types. The smallest particles are spherical in morphology those with a

stains. Fig. 5 shows the size distribution observed when sampling 100 particles on 10 wafers implanted with 1x LEHDP implants. The EDX data are shown in Fig. 6 the
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right plot is a plot of a ring/stain particle. Phosphorus only appears as a small signal for the spherical particles but is absent from the stains, indicating that the dopant has reacted