DONOR ACTIVATION IN BORON AND PHOSPHORUS IMPLANTED SELF-ALIGNED BOTTOM-GATE IGZO TFTS

Eli Powell, Microsystems Engineering, Rochester Institute of Technology
epp7151@rit.edu
Muhammad Salahuddin Kabir, Microsystems Engineering, Rochester Institute of Technology
Rahnuma Rifat Chowdhury Microelectronic Engineering, Rochester Institute of Technology
Karl D. Hirschman, Electrical & Microelectronic Engineering, Rochester Institute of Technology
Robert G. Manley, Science & Technology Research, Corning Incorporated
Bin Zhu, Science & Technology Research, Corning Incorporated

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Self-aligned channel regions in thin-film transistors (TFTs) have advantages in reduced parasitic capacitance and stage delay, and a reduction in overhead real estate. A common method used to fabricate self-aligned a-Si:H TFTs is to utilize a through-glass exposure of photoresist which is blocked by the opaque metal bottom-gate electrode [1,2]. This process does not require an additional photomask or lithographic alignment, and thus supports low production cost. Sputtered IGZO has been introduced into flat panel display product manufacturing, exhibiting a channel mobility of approximately an order of magnitude higher than a-Si:H. The working source/drain electrodes in IGZO TFTs can be direct metal contact regions to the IGZO, without the need for additional processes such as doping to render the IGZO conductive. Proper metallurgy and annealing processes can provide ohmic behavior with minimal series resistance, however this usually requires several microns of gate-to-source/drain overlap to ensure such behavior.

This work provides an interpretation of donor activation in self-aligned bottom-gate IGZO TFTs with ion-implantation of boron ($^{11}B^{+}$) and phosphorus ($^{31}P^{+}$) species as the source/drain treatment. In previous investigations of boron implantation, utilizing an anneal-implant sequence resulted in self-aligned devices with transfer characteristics comparable to non-self-aligned TFTs. A left shift in transfer characteristics was observed following thermal stress at 175 °C which is not consistent with recent work from alternate sources which have shown boron implanted devices temperature stable at 200 °C [3,4]. It is hypothesized that this is the result of implant species contamination due to the presence of hydrogen in the implant gas distribution system. In contrast, following an implant-anneal sequence at 400 °C did not support an electrically active species. The implant-anneal strategy seems to result in a different bonding arrangement which does not support donor-like behavior related to boron. Self-aligned phosphorus implants present promising behavior using the implant-anneal strategy, potentially serving as a lightly doped drain (LDD) structure for sub-micron scaled devices.

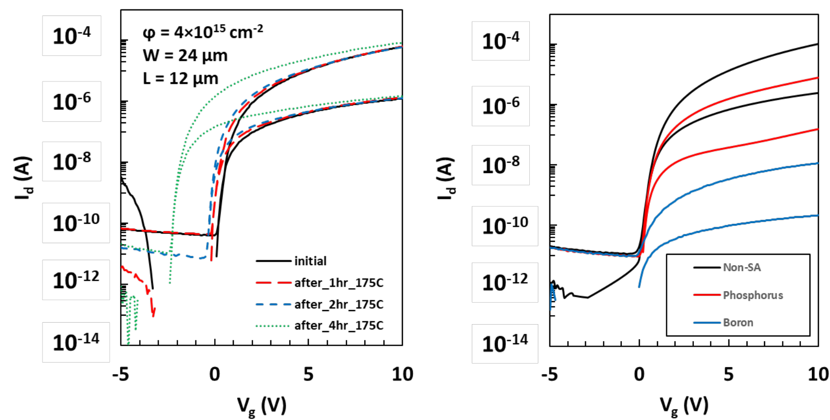

Figure 1. Temperature instability of boron implanted IGZO TFTs following 1, 2, and 4 hours at 175°C. Comparison of phosphorus and boron implants following an anneal-last strategy. Devices were annealed for 3 hours at 400°C in an oxygen ambient.

[1] Kawai, S. SID. 1984. [2] Kuo, Y. J. ECS. 1991. [3] Kang, S. ACS AEM. 2022. [4] Ui, T. ECS Trans. 2022.