Ga_2O_3 Power Devices and How They Stand up to GaN and SiC?

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[Adapted from Ref. 1] It's of little surprise that there has been a consistent drive toward the use of wider bandgap materials for power electronics. After all, the wider the bandgap, the greater the breakdown field, opening the door to making devices with a higher breakdown voltage for the same material thickness.

However, nature is not always that generous. Typically, a move to a wider bandgap is accompanied by more challenging doping, along with difficulty in making high-quality native substrates. Judged in these terms, gallium oxide appears to offer a sweet spot beyond SiC and GaN.

One of the most promising forms of gallium oxide is its β-phase, which has a bandgap of 4.5-4.7 eV. Luckily, it is easy to dope this oxide n-type in a controllable manner, to realize doping that spans 10^{15} cm^{-3} to 10^{20} cm^{-3}. Thanks to shallow donor levels throughout this range, doping efficiency is high at room temperature. Another encouraging aspect of Ga_2O_3 is that single-crystal substrates of this material can be readily produced with melt-growth techniques, mirroring the manufacture of those made from silicon. On the other hand, the thermal conductivity Ga_2O_3 of is rather low, and it is most likely impossible to dope Ga_2O_3 p-type. Given all these promises and obstacles, is it possible to harvest all the benefits arising from the large bandgap of Ga_2O_3 and demonstrate devices that are superior to those made from SiC and GaN?

I will reflect on our efforts in seeking answers to these questions in the past many years researching on power devices. The work on Ga_2O_3 has been in part supported by AFOSR FA9550-17-1-0048, NSF DMREF 1534303, and AFOSR FA9550-18-1-0529; performed in part at Cornell NanoScale Facility, an NNCI member supported by NSF Grant ECCS-1542081.

References:

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