Surprising Surfactant Properties of Zn in MOVPE Grown III-V Materials

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Metal organic vapor phase epitaxy (MOVPE) is a well-established technique with a broad range of applications. Nonetheless, there persists many unresolved issues effectively impeding the further development of III-V devices. A major unresolved issue is the long range "leakage" of the Zn (p-dopant of choice in MOVPE) into the intrinsic layers during (and post) growth, including the device processing steps [1-3]. Here, we report on a surprising finding on Zn diffusion, despite around 40 years of research on the topic.

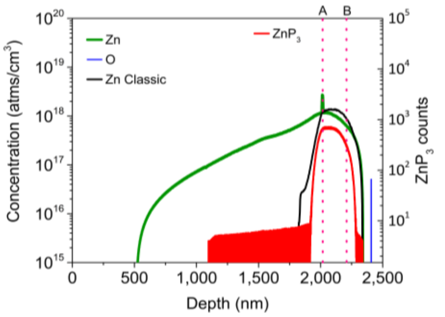

Fig. 1. Measured SIMS profile of Zn concentration of InP/Zn:InP/InP epitaxial layers. Comparison of the total Zn profile to active Zn and the conventional Zn(Cs) methodology used by industrial SIMS providers. Zero nm on the x axis of the depth profile is the sample surface. The oxygen peak marks the substrate-epitaxy interface. The dotted lines indicates the nominal boundaries between the Zn doped and not intentionally doped layers.

To analyze the Zn dopant behavior, we epitaxially grow a structure by sandwiching a 200 nm Zn doped InP layer between two undoped InP layers. Tailored secondary ion mass spectroscopy (SIMS) measurements detect Zn in the not intentionally doped layers for 1500 nm, a shockingly long thickness that cannot be described by diffusion alone (Fig 1). We also distinguished activation and passivation of Zn dopants in the reference structures by scanning the layers with a different SIMS methodology [4]. Our systematic evidence of the observed Zn dopant profile combined with a semi-quantitative theoretical model suggests that Zn (or precursor Zn) is (are) accumulating on the sample surface during the epitaxial growth and continues to incorporate into the epi-layers even after the Zn source has been shut off. We also found that a growth interruption with a "competing" surfactant species, in that case Sb or its precursor, can effectively suppress the Zn tailing in the forward grown layers, providing a solution to the potential problem.

The results of this work can enable growth designs for novel inverted laser structures and multicomponent devices, and broadly eliminate existing constraints while opening for new technological solutions.

References

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