Properties of ScN and (Sc,Al)N alloys grown by plasma-assisted molecular beam epitaxy

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In this work, we review our recent studies on the plasma-assisted molecular beam epitaxy of ScN, a group-IIIb transition-metal nitride, as well as its alloys with conventional group-IIIa wurtzite nitrides, focusing on the formation of wurtzite (Sc,Al)N.

Although ScN was first synthesized over five decades ago, its electrical and optical properties remain not fully understood. Regardless the growth method, ScN has usually been found to be heavily doped, making it a highly degenerate semiconductor. The uncontrolled doping and its consequences hinder the understanding of the intrinsic electrical and optical properties of ScN, and also impede many of its potential applications. We have recently shown that lattice-matched ScN layers on wurtzite GaN can be nondegenerate with comparatively low electron densities and high electron mobilities. Temperature-dependent Hall-effect measurements provide insights into the dominant scattering mechanisms [1].

Wurtzite (Sc,Al)N alloys are of great interest due to their strong piezoelectric response. Despite numerous studies, their lattice constants remain controversial. By optimizing the growth conditions of (Sc,Al)N on GaN, we were able to produce thick layers that allowed us to accurately measure their lattice constants. We found that $Sc_{0.1}Al_{0.9}N$ layers are lattice-matched to GaN. This knowledge has supported the development of (Sc,Al)N on polycrystalline diamond substrates for surface-acoustic-wave devices [2].

[1] D. V. Dinh, O. Brandt, Phys. Rev. Appl. 22, 014067 (2024).
[2] M. Yuan, D. V. Dinh, S. Mandal, O. A. Williams, Z. Chen, O. Brandt, P. V. Santos, J. Phys. D: Appl. Phys. 57, 495103 (2024).