Epilogue

As discussed in the preceding chapters, the material properties of GaN and related III-nitride semiconductors offer significant promise not only for established areas of light generation and detection (for lighting, sensing, and high-density data storage applications) and RF power amplification for wireless communications but also into emerging areas of ultra-high frequency applications as well. Scaling conventional device architectures, as well as unconventional device designs that leverage the unique properties of the nitrides, make this an especially vibrant area of exploration and research; the ongoing maturation of the material promises soon to allow many of these concepts to transfer from the domain of academic and industrial research labs into real-world applications.

In the microwave spectrum, GaN HEMTs today deliver the highest-in-class power for frequencies in the 1–100 GHz window owing to the high breakdown voltages of the devices, compared to InP-, SiGe-, and Si-based technologies. In the lowest frequency applications where cost is a more significant metric than performance and efficiency, several nonlinear circuit techniques exploiting silicon CMOS at small gate length nodes are competitive. For the middle frequency regime of the 1–100 GHz window, solving the challenges of linearity and efficient heat management is expected to significantly increase the acceptance and deployment of high-performance nitride HEMTs as replacements of electronics based on narrower band gap semiconductors.

For applications above 100 GHz and approaching the THz, nitride electronics can make inroads by (a) improving the speed of HEMTs with further scaling and materials advances and (b) exploiting several of the new techniques discussed in the chapters of this book. Some of the nonlinear techniques can be combined with and take advantage of GaN HEMTs to achieve direct on-chip frequency conversion to generate significant power in the THz window. The existing ecosystem of nitride semiconductor-based photonics and power electronics will significantly aid and inform the search and development for devices that will achieve the goal of significant power generation in the THz window.

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Index

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