CASE FOR DESIGNATION

The *Advancing Gallium Nitride (GaN) Technology in the Greater Burlington Metropolitan Area (GaN-VT*) consortium is a close-working team of existing collaborators in Vermont—leaders from industry, state, city, academic, and non-profit organizations aligned towards making our region a global leader in the next generation of material technology for wireless communication and semiconductor production. GaN-VT seeks to advance Key Technology Focus Area (KTFA) 10: Advanced materials science, including composites 2D materials, other next-generation materials, and related manufacturing technologies. The basic building blocks of this tech hub, including the relationships and programs needed to put GaN materials into production and create an economic development engine for Vermont, are already in place, and are detailed in the letters that accompany this application. This includes workforce development programs through the Vermont State Colleges System (VSCS)[1], high-end materials and manufacturing research at the University of Vermont (UVM) and Dartmouth College, regional and statewide labor training and industry support programming from the State of Vermont, and municipal partnership. These elements are coupled with a commitment from regional, corporate partner GlobalFoundries (GF)[2] and a range of related industry partners in the region, including Green Mountain Semiconductor[3] and Marvell Technologies.[4] With the investment of Phase 2 Tech Hub support from the US Economic Development Agency, this "turnkey" partnership will more rapidly and effectively launch the next generation of GaN manufacturing, catalyze early-stage, university-industry R&D partnerships, and support an emerging advanced materials and manufacturing startup economy, and in the process will transform our region into a global leader in this critical new technology. Kirk Dombrowski, Vice President for Research and Economic Development at UVM, will lead and coordinate partners as interim Regional Innovation Officer. As part of the building of the Tech Hub, a search will be conducted for a permanent RIO who will guide the work of the consortium.

GaN-VT Consortium

Institutions of Higher Education
- University of Vermont (lead)
- Vermont State Colleges System

Industry Groups or Firms
- GlobalFoundries
- Green Mountain Semiconductor

State and Local Govt
- State of VT Agency of Commerce & Community Development
- City of Essex Junction

Economic Development
- VT Economic Development Authority

Workforce Development
- VT Workforce Development Board

The Burlington-South Burlington Metropolitan Statistical Area (MSA), our geographic focus, is a dynamic and thriving region in Vermont, an EPSCoR (Established Program to Stimulate Competitive Research) state. Vermont is actively engaged in cutting-edge research and innovation, and has a climate of innovation and entrepreneurship, creating a thriving start-up economy. In 2022, Vermont received .4% of all venture capital funding in the US—on par with much larger states like Connecticut—despite having only .1% of the US population. The Burlington MSA is home to 227,521 people and offers a high quality of life; breathtaking landscapes, good schools, a strong sense of community, and a rich cultural heritage that make it an appealing destination for new companies, climate migrants, and next-generation workers. The MSA serves as a hub of economic activity for the region but remains heavily reliant on tourism, despite a strong, emerging technology and manufacturing sector. Technology and manufacturing is, by value, roughly 6 times the economic value of agriculture in Vermont. Indeed, the Burlington-South Burlington MSA has a competitive location quotient of 7.94 for semiconductor and other electronic component

manufacturing, indicating a uniquely high concentration of this industry in the region.[5] UVM is the region's largest employer, followed by GlobalFoundries Fab 9 facility in Essex Junction.

Technology-based potential of the region for global competitiveness

Vermont meets several of the geographic criteria cited by EDA that warrant investment in the region. Vermont is an EPSCoR jurisdiction, a low-population state, and 64.9% of the population lives in rural communities.[6] The proposed GaN-VT Tech Hub will drive development of KTFA 10 Advanced materials science, including composites 2D materials, other next-generation materials, and related manufacturing technologies, while supporting KTFA 2, high-performance computing, semiconductors, and advanced computer hardware and software. Over the last two years, GlobalFoundries (GF) has been investing, in partnership with the US Government, to develop on-shore 200mm GaN-on-Si foundry technology supporting both RF and High-Voltage power applications—with a particular focus on the Fab 9 facility in Essex Junction, VT. The result of this investment to-date is a 200mm GaN-on-Si fabrication corridor that has delivered prototypes, which validate the fundamental advantage of GaN over conventional semiconductor solutions and provide insight into next-generation fabrication modules that dramatically improve performance for dual-use commercial applications and defense and security needs. This investment, combined with other regional assets, positions the Burlington-South Burlington MSA to become globally competitive in this space. Given the breadth of 5G/6G and electronic warfare dual-use applications, further investment in RF high electron mobility transistor (HEMT) GaN-on-Si technology will further mature the domestic technology capabilities, and open high-volume market opportunities that will grow the wide-bandgap (WBG) ecosystem.

The readiness of this technology is clear. In addition to the existing collaborations listed below, GF is actively investing in next-generation GaN power and RF HEMT fabrication module capability and subsequent integration of these new capabilities into the existing 200mm GaN-on-Si corridor at Fab 9 and the surrounding region. Specifically, this tech hub proposal foresees an enhanced HEMT GaN-on-Si fabrication corridor centered in the Burlington area, augmented with key capabilities including: the tooling and metrology for an InAlN based epitaxial layer for improved 2DEG concentration; an advanced ALD (atomic layer deposition) Al_2O_3+HfO_2 gate dielectric module to reduce gate leakage and sustain large voltages; a regrown InGaN heavily-doped, ultra-low resistance ohmic contact module; a reduction of the minimum effective gate width from 150nm to less than 50nm for dramatically improved performance; a complete Copper back-end-of-line (Cu BEOL) for electrical interconnect; and high-value poly resistor integration and high-quality passive device integration.

Role of the Private Sector

A Tech Hub centered around GaN technology in the Burlington MSA represents a strategic direction for the region, which includes key industry players such as GlobalFoundries, Marvell Technologies, ASIC North[7], and Green Mountain Semiconductor, all of whom are actively engaged in this transformation of semiconductor materials and have committed to becoming integral members of the GaN-VT consortium. Active venture funds in the region, including FreshTracks Capital,[8] The Dudley Fund,[9] The Fund at Hula,[10] and several Vermont-focused funds managed by the Vermont Center for Emerging Technologies (VCET)[11] will provide vital financial resources, expertise, and guidance to startups, and facilitate commercialization efforts. In addition, the region has close connections to nearby innovation hubs like Boston, Manchester NH, and Montreal. As part of the GaN-VT consortium, our partners will actively contribute to the long-term economic growth and success of the region by building on key elements of the existing

business ecosystem, such as inclusive hiring practices, promoting equitable labor strategies, fostering community ties, and sharing industry knowledge. By integrating these contributions into our GaN-VT Tech Hub strategy, we will create a sustainable and inclusive environment that benefits not only large companies but also startups, small- and medium-sized enterprises, and employee-owned businesses in the wider GaN technology supply chain.

Regional coordination & partnerships

Our partners envision dynamic and sustained growth in the regional economy through collaborative workforce initiatives, focused research, enhancements to the regional supply chain and complementary industries, and tech spin offs —all driven by the launch of a series of GaN-based products (technology readiness levels 6 through 9) at GlobalFoundries Fab 9 in the next 3 years. An infusion of EDA support will provide the resources to amplify many years of mutual support and bring into strategic focus the existing education, training, research, and business development programs that currently support semiconductor manufacturing in Vermont.

If awarded Phase 2 funding, the coalition will formalize the tech hub effort in a non-profit economic development corporation in close coordination with the Vermont Agency for Commerce and Community development, will recruit strong leadership, and will coordinate the use of funds to advance GaN product development and commercialization, manufacturing transition/integration, and advance industry labor practices to ensure rapid and coordinated uptake of this new technology. The building blocks for this work are in place. UVM's College of Engineering and Mathematical Sciences' (CEMS)[12] undergraduate and graduate certificate programs in semiconductor engineering and design were developed in collaboration with GF and complement additional semiconductor workforce development programming offered by the Vermont State Colleges System (VSCS). The VSCS provides career pathways to the semiconductor and tech sectors through certifications, apprenticeships, associate and bachelor's degree programs, including some delivered on-site at GF. In addition to career pathways, UVM's CEMS and nearby, Dartmouth's Thayer School of Engineering, are actively engaged in various areas of GaN and semiconductor research. Both Dartmouth and UVM are home to strong technology commercialization programs.[13] GF is committed to a strong future for advanced manufacturing in the region and regards the Tech Hub as an opportunity to grow and sustain its workforce, while supporting complementary businesses throughout the region. The Greater Burlington Industrial Development Corporation[14] represents regional employers and will serve as a connector and advocate for businesses and partners involved in the Tech Hub. The VSCS will work in collaboration with UVM, the Vermont Department of Labor,[15] the Career and Technical Education[16] system, local labor unions including Vermont's electrical union, IBEW 300,[17] and other educational providers to increase and sustain the semiconductor and related workforces. The State of Vermont Agency of Commerce and Community Development[18] will coordinate with relevant state agencies, including the Department of Labor, to support the Tech Hub.

Equity and Diversity

Equity and diversity are key elements of Vermont's economic future. The Burlington MSA and entire State feature existing programs to benefit disadvantaged and low-to-moderate income, new Vermonters (refugees, asylees, foreign-born individuals), underemployed/low skilled, ethnic and racial minorities, high school graduates not attending post-secondary education, persons with disabilities, older workers, and those in rural communities. The GaN-VT Hub will: develop a position(s) to actively engage underserved communities in the emerging GaN industry; develop a participation agreement with partners committing to advancing this work; engage the State

Refugee Office[19] and their partners to encourage new Vermonters to engage in employment in this industry; and work with organizations actively involved in this area such as Vermont Associates for Training and Development,[20] the Vermont Office of Racial Equality,[21] the Governor's Workforce Equity and Diversity Council,[22] the Office of Economic Opportunity,[23] Good News Garage,[24] Working Bridges/United Way,[25] HireAbility,[26] labor unions active in the region, the Vermont Professionals of Color Network,[27] Vermont minority/women owned businesses, and the Vermont Manufacturing Extension Center.[28] The GaN-VT consortium will develop a database to help connect women-, minority-, BIPOC-, and new Vermonters-owned businesses, suppliers, and service providers with industry and product needs, and will accompany this effort with an outreach strategy to these businesses. GaN-VT will partner with the Vermont Small Business Development Center's Community Navigator Program,[29] which works to reduce barriers for small businesses, including rural, veteran, and women-owned businesses and helps small businesses access critical support. These programs will complement existing workforce development collaborations between UVM and VSCS, including our EPSCOR-funded Center for Workforce Development and Diversity.[30]

Composition and capacity of the regional workforce

Vermont is a small state, both geographically and in terms of total population (647,067). According to July 2022 US census data estimates, Vermont's population is 93.8% white, and 21.6% of the population is over sixty-five. As such, the need to attract a younger and more diverse workforce is clear. There are strong foundations to build on: 93.9% of our population age 25 or older are high school graduates, and 40.9% possess a bachelor's degree or higher. Labor force estimates show a civilian labor force of ~346,000, with ~338,000 employed at the current time. Vermont has recently enjoyed in-migration due to security and climate change risks, and more recently during the paradigm shift in remote and flexible work related to COVID.

Vermont has robust workforce development programs through state and federal resources, higher education, regional partners, and non-profit partners. Workforce efforts are focused on jobs in line with the USDOL "Good Jobs Principles" of livable wages,[31] benefits enabling economic security, and advancing diversity. The Vermont Workforce Development Board has developed strategies for workforce expansion, upskilling and welcoming new Vermonters, retaining student graduates, encouraging disengaged workers to return to the workforce, and adding five thousand net new Vermont workers per year[32]. The plan has been endorsed by the Governor and implementation began in 2022. The Vermont Department of Labor is the recipient of federal Workforce Innovation and Opportunities Act (WIOA) funding to assist dislocated workers with training, career counseling and job search skills, and the Vermont Training Program[33] uses state funds to partner with employers for training to prepare Vermont's workforce for the jobs of tomorrow.

Innovative "lab to market" approaches

UVM commercialization efforts are robust. Recent successes include the acquisition of Packetized Energy by EnergyHub[34] in 2022, spinoffs Benchmark Space Systems[35] and CoreMap Medical[36] completing Series B financing in 2022-3—efforts supported by incubator partners Hula Lakeside[10] and VCET.[11] As an NSF I-Corps Hub partner, and via state-funded programs such as UVM Ventures,[37] and internally funded programs like SPARK-VT,[37] ARC[38] and I-TREP,[39] UVM mentors would-be entrepreneurs and funds proof-of-concept toward commercialization. UVM and Dartmouth College provide a strong pipeline of emerging, fundamental science on GaN to feed innovation in this area. This includes experts in circuit design and GaN deposition, as well as the development of AI-based tools for GaN circuit design. Current projects demonstrate the talent

available at the University, including research in exploring GaN for 5G and 6G communication and for designing novel multifunctional power and communication System in a Package (SiP); developing on-chip, in-package and wafer-level methods of making chips more resilient to mechanical shock and vibration; designing GaN chips with the appropriate voltage and frequency range for integration directly into ultrasound and piezoelectric package systems; designing, fabricating, and testing custom on-chip, co-packaged and stand-alone custom GaN devices for RF analog signal control and reception; and exploring machine learning (ML) techniques for design automation of GaN analog and RF circuit design, testing, and yield analysis.

The domain expertise in AI/ML resident in the academic institutions will also be used to strengthen the GaN manufacturing base. AI/ML/NLP (natural language processing) approaches will be utilized for predictive control and analysis of the unique semiconductor fabrication flows necessary for WBG materials. The performance of the new semiconductor manufacturing tooling required for GaN materials will be optimized utilizing AI/ML/NLP algorithms performed on data provided directly from the manufacturing floor. Leveraging this academic expertise will improve yield and reduce the cost of manufacturing and help enable world-class manufacturing capability.

Impact on economic and national security of the entire United States

Long-term investments from the US Government into WBG semiconductor technologies are bearing fruit in prototypes of high-power, highly energy-efficient systems. Dual-use applications such as electric vehicles, electronic warfare, and 5G/6G cellular base stations require new and improved semiconductor materials and novel semiconductor device constructions that support fast switching at very high power levels with ultra-low DC and RF losses. GaN-based technologies have experienced a rather fast learning curve in moving from fundamental material studies into prototype lab demonstrations, with relatively few products being shipped in moderate volume. As with the silicon semiconductor ecosystem, it is expected that improvements in WBG semiconductor device and process performance will increase the rate and pace of adoption as well as enable new market segments that improve the economic viability of WBG solutions. We expect that additional investment will accelerate the GaN-on-Si platform development, as well as provide additional capabilities that address unique dual-use applications. This investment will enable significant technology innovation and prototype demonstrations – as a wide range of entities obtain access to this platform via a Cloud-based electronic design automation (EDA) service.

From a national security perspective, HEMT GaN-on-Si technology capability enhancements will address single transistor, high-gain, high-voltage stages for electronic warfare, power amplifier modules and monolithic microwave integrated circuits (MMICs) for scanned array radar, modules for airborne radar spectrum denial, multi-band tactical radio, SATCOM, and air and missile defense – as well as the very demanding requirements of next-generation FR3-band RF switches, power amplifiers (PAs), and antenna tuners, which are foundational to the 5G/6G front end module in both mobile devices and base stations. In frequency regimes <13GHz, we expect this investment to result in over an order-of-magnitude improvement in key device figures-of-merit, an increase of up to 5dB in total system RF output power, and several dB reduction in total RF system power dissipation. In addition to the electronic warfare applications, GaN-on-Si is a key component in the electrification of all military fleet vehicles.

The estimated global demand for GaN-based semiconductor solutions is growing at a CAGR of +23% with consensus dual-use demand expected to be in excess of $4.2B in 2026. Investment in the unique capabilities and ecosystem outlined herein will position this region to address this substantial global demand for next generation semiconductor solutions and manufacturing.[40]

APPENDIX

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