Investigation of Silicon Carbide (SiC) Power Electronic Converters for Wireless Microwave Power Transmission

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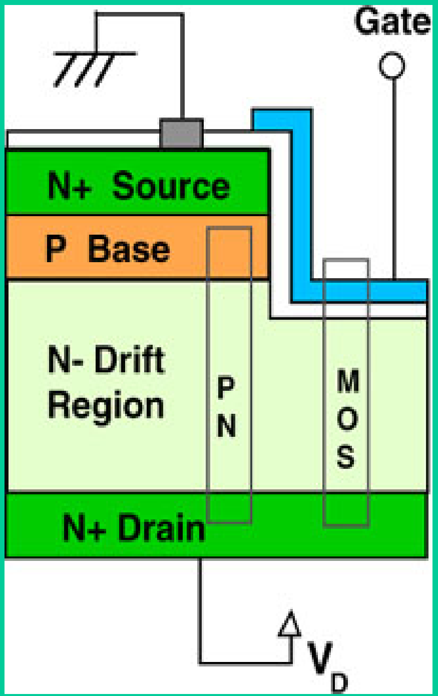
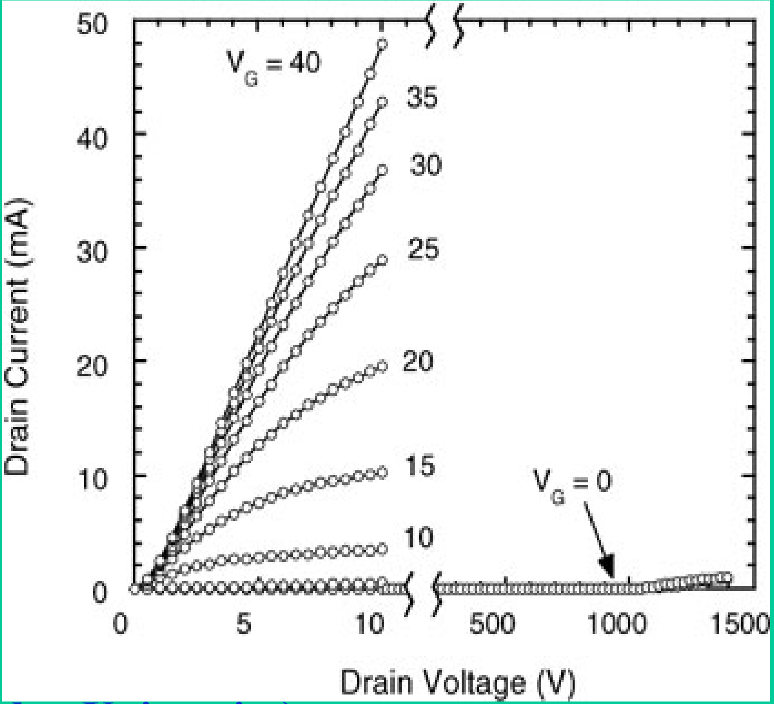
Project Objectives

- The primary objective of this proposal is to investigate a variety of new converter topologies (DC to DC; DC to AC Converters), which can be directly interfaced with a rectenna array.
- The project consists of two parts. The first part will focus on an experimental setup to demonstrate suitable DC to DC and DC to AC converter topologies for rectenna type DC power source (Fig. 1c).
- An experimental 100V, 200W, 500kHz, SiC DC to DC and DC to AC power conversion powered by a rectenna will be studied for its performance followed by an in-depth evaluation.
- The second part of this project will perform a trade study to investigate rectenna power converter architectures for higher power, higher voltage WPT systems. A rectenna array interfaced to a power converter will be considered as a building block and several series / parallel combinations of the building blocks will be studied for increased voltage and current capability (Fig. 2).

Silicon Carbide U MOSFET

- MOSFET, IGBT and MCT can be made using SiC
- Higher breakdown field of SiC allows to reduce the On resistance 100-200 lower than similar devices in Silicon





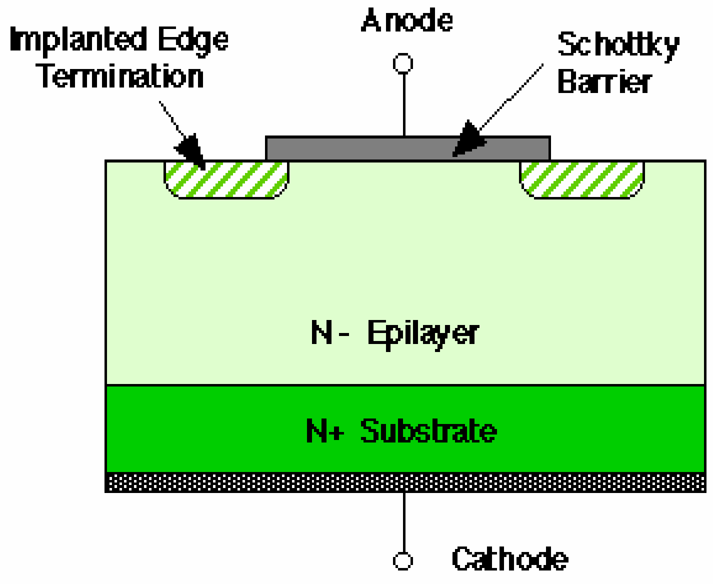
(Developed at Purdue University)

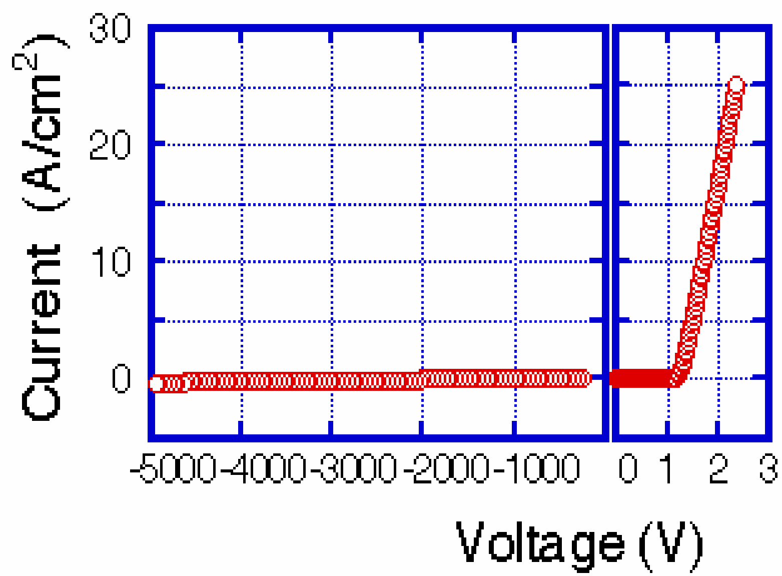
- Blocking Voltage: 1500V
- Specific ON Resistance: 1.6 μΩ •m2

$V^2/R_{ON}=10^8$ W/cm^2

Silicon Carbide Schottky Diode

- Boron atoms are used for doping
- Niquel and Titanium are used as Schottky metals
- High breakdown voltage (as high as 5 kV) is obtained while maintaning good ON behavior





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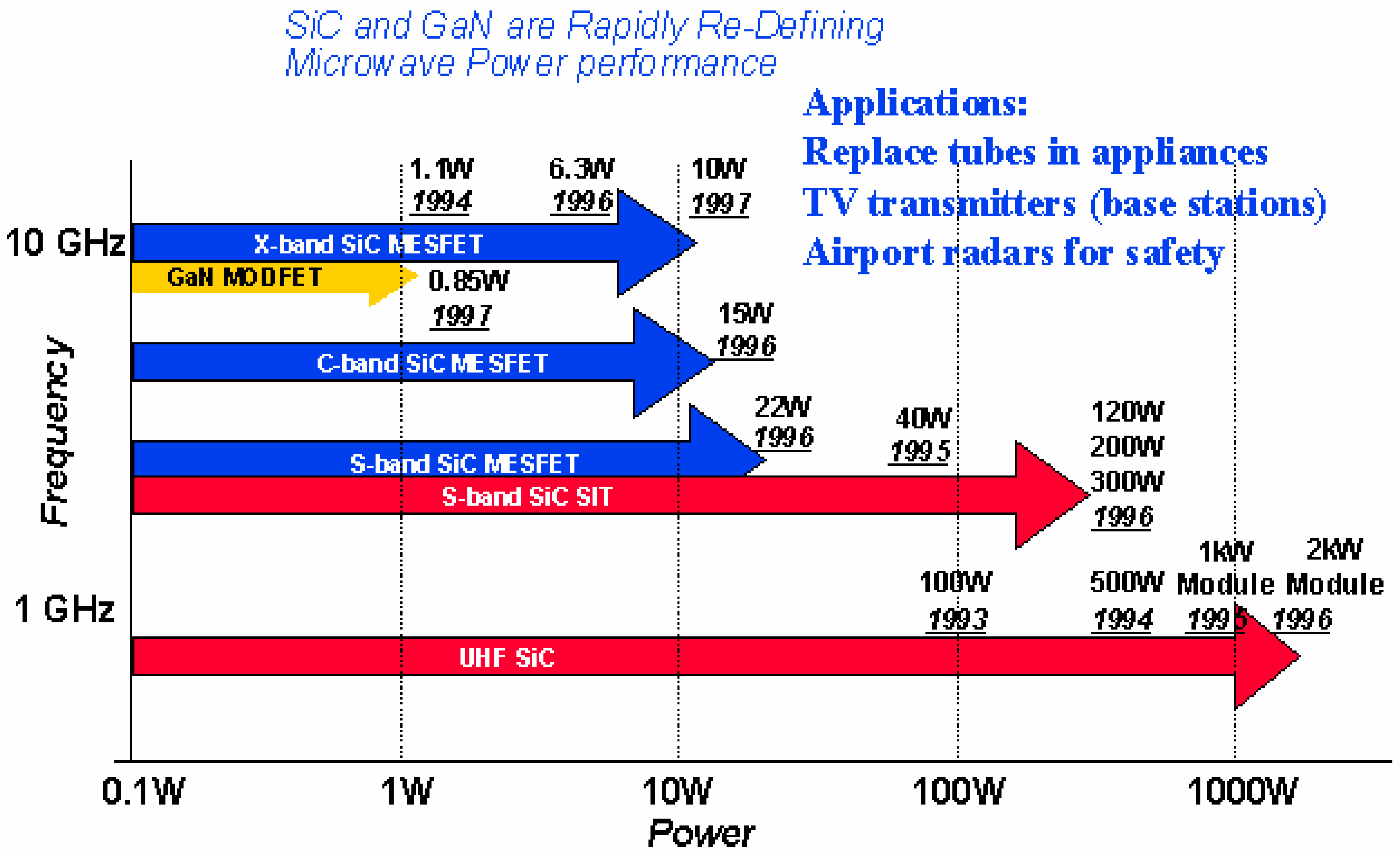
Applications



- Power advantages of 3X-7X over Si and GaAs are being measured in prototype devices
- UHF & S-band SITs in pilot production at Northrop Grumman

Advantages of SiC Devices

- Silicon Carbide (SiC) has the potential to change the design, topology and circuits used in power electronics especially where space weight, power density and thermal management issues dominate as in stationary & mobile platforms: on aircrafts, on vehicles, on spacecrafts and on electric utility systems [5]. The advantages of SiC based power electronics include:
- SiC technology will enable higher temperature operation and high frequency operation.
- Increase the switching frequency of DC-DC and DC-AC converters (say 100 to 500kHz). This will reduce the size of magnetic components. The losses in magnetics needs careful attention and optimization
- The use of SiC devices will enable DC-DC, DC-AC converters to operate at higher temperatures, thereby allowing for smaller cooling burden. Further, SiC devices offer fast switching with very low reverse recovery; this enables drastic reductions in EMI emissions.

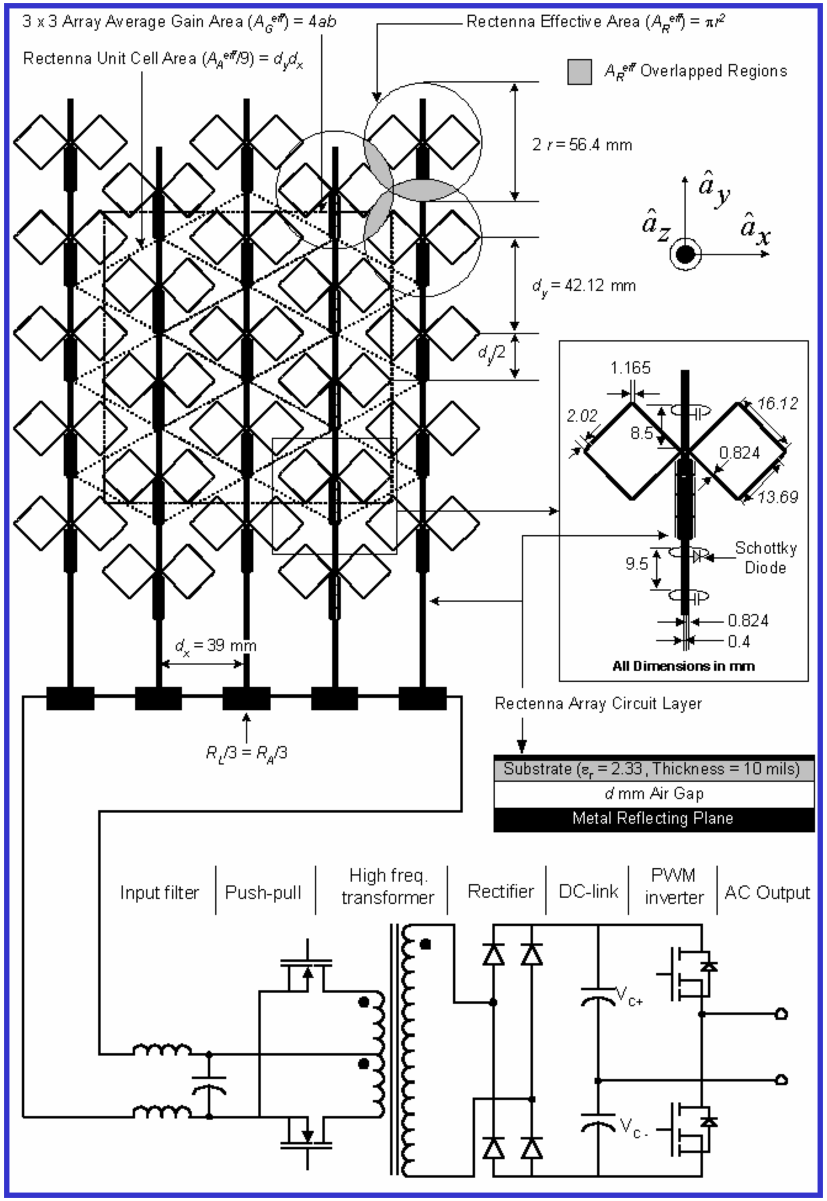
Suitable Power Converter Topologies for Converting DC Power Available From a Rectenna

- **The project will design & construct the power conversion hardware with the commercially available SiC devices. This will be conducted in the Power Electronics Laboratory of TAMU.**

- **After testing the developed hardware, the C-band rectenna and the power conversion hardware will be interfaced. We expect to run a number of controlled experiments (see list of Tasks).**

- **Since SiC diodes are readily available the first step would be to replace the Si diodes with SiC. TAMU will continue to procure SiC MOSFETs and/or IGBTs to construct a complete SiC based power conversion system.**

- **An input filter is added to reduce the ripple current drawn by the DC to DC converter from the rectenna. One of the tasks is to determine the rectenna's performance for various input ripple current magnitudes**



C-Band rectenna interfaced to a SiC, DC-DC and DC-AC Converter topology

Trade Study to Evaluate Suitable Power Converter Topologies for a Higher Power, Beamed Microwave Power Transmission