Solid State Terahertz Sources

Steven A. Retzloff, Jeffrey L. Hesler, Thomas W. Crowe*

Virginia Diodes, Inc. (VDI), Charlottesville, VA, USA
*Contact: crowe@vadiodes.com

Abstract**—** Solid-state sources using diode based frequency multipliers are critical for radio astronomy and atmospheric studies, as well as many other important scientific applications. VDI shipped its first multiplier based source operating above 1 THz in 2005, generating about 5 uW in the band from 1.3 to 1.35 THz. Since then, VDI and many other groups have worked to improve this technology with great success. However, the needs of the scientific community continue to increase and there is continuous demand for improved power, tuning bandwidth, noise and system reliability. An important example is the requirement for greatly increased power to allow the development of imaging array for radio astronomy; the more receiver pixels that can be pumped, the more rapidly scientific data can be collected. This talk will describe many of the technological innovations that are now used to achieve these goals and two specific recent examples that demonstrate the current capability of this technology.

VDI's THz sources rely on two types of multiplier circuits. Varactor multipliers are used at lower frequency because of their very high efficiency and power handling. For the varactor multipliers, the primary goal is to achieve the power needed to effectively pump the terahertz varistors with the greatest possible efficiency and reliability. This has required significant development of the thermal design of the complete circuit, including the use of diamond heat spreaders, optimal geometric layout of the assembly and more thermally robust materials. In-phase power combining is also used to achieve a roughly 3dB power handling improvement. However, we have found that for very high efficiency multipliers excessive AM noise can be generated due to complex interactions between the combined multiplier circuits if necessary counter measures are not employed.

Above about 500 GHz, varistor multipliers are generally used due to their inherently broad bandwidth and relative simplicity. Also, the efficiency benefit of varactor multipliers is not as significant at these higher frequencies. For these circuits, the primary improvements have been increased operating bandwidth and appropriate scaling to higher frequency. Also, it has been necessary to optimize the designs to achieve good performance at input power levels equal to those available from the lower frequency varactor multipliers. In fact, matching the input power requirement of each multiplier with the power available from the preceding multiplier is critical for the success of the system as a whole.

To demonstrate the success of this effort, two recent results will be briefly reviewed. The first is a 215 GHz varactor source that generates greater than 300 mW. The second is a 2.5 THz source that generates about 5uW in the band from 2.48 to 2.7 THz. This power level can be increased by several dB through the cooling of the final varistor multiplier stages. Prospects for further improvements and technical challenges and opportunities will be discussed.