preparation was an RCA clean and a dehydration bake. The FET's were fabricated in a concentric ring structure in order to eliminate parasitic conduction paths between the source and drain. The device gate length was 2 μm and the gate width was 314 μm. Source and drain contacts were formed by electron-beam evaporation of Ti/Au. Gold was evaporated on top of a 750-Å-thick layer of SiO_2 to form the gate electrode. At room temperature, the source to drain resistance was greater than 2 GΩ and the characteristics were nonlinear. This was due to a low concentration of activated carriers at room temperature. The zero gate bias drain-to-source current at 23°C was −7 nA at −20 V. Although the current levels were low, the three-terminal characteristics of the device still showed current modulation with varying gate voltage. Following room-temperature characterization, the devices were tested at elevated temperatures in atmosphere. As the temperature was increased, the current level increased significantly. At a temperature of 150°C, the zero gate bias drain-to-source current was −34 nA at −20 V and the channel resistance had dropped to 990 MΩ. The drain to source I–V characteristics were linear at this temperature. Gate voltages were applied in 8 V steps while the drain-to-source voltage was swept from 0 to −30 V. The I–V characteristics clearly showed evidence of saturation. Also, at applied gate biases in excess of 32 V, the active channel is pinched off. The peak transconductance at 150°C was 6.4 nS/mm. Device failure occurred at a temperature above 200°C and was due to failure of the gate oxide layer. Although the device characteristics are less than perfect, they are still much better than any previously reported for polycrystalline diamond FET's and indicate that there is a promising future for PCD in active electronic devices.

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VB-1 A 10-GHz Quasi-Optical Grid Amplifier Using Integrated HBT Differential Pairs

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We report the fabrication and testing of a 10-GHz grid amplifier utilizing 16 GaAs chips each containing an HBT differential pair plus integral bias/feedback resistors. The overall amplifier consists of a 4 × 4 array of unit cells on an RT Duroid™ board having a relative permittivity of 2.2. Each unit cell consists of an emitter-coupled differential pair at the center, an input antenna which extends horizontally in both directions from the two base leads, an output antenna which extends vertically in both directions from the two collector leads, and high-inductance bias lines. In operation, the active grid array is placed between a pair of crossed polarizers. The horizontally polarized input wave passes through the input polarizer and couples to the input leads. An amplified current then flows on the vertical leads, which radiate a vertically polarized amplified signal through the output polarizer. The polarizers serve dual functions, providing both input–output isolation as well as independent impedance matching for the input and output ports. The grid thus functions essentially as a free-space beam amplifier. Calculations indicate that output powers of several watts per square centimeter of grid area should be attainable with optimized structures.

Quasi-optical grid devices including oscillators, multipliers, mixers, and beam steerers have already been demonstrated [1]–[4]. Motivation for studying quasi-optical devices is twofold: free-space power combining is more efficient at high frequencies than power combining in guided wave structures, and transmitting and receiving systems based on monolithic implementations of quasi-optical elements have the potential for being smaller, lighter, and substantially less costly than conventional phased-array systems.

The AlGaAs/GaAs HBT material was grown by MBE.

Layer	Thickness (μm)	Type	Doping (cm^{-3})	AlAs Fraction
Cap	0.16	n^+	5×10^{18}	0
Emitter	0.1	n	$0.5–1.5 \times 10^{18}$	0–0.25–0
Base	0.07	p^+	$0.5–1.0 \times 10^{20}$	0
Collector	0.7	n	$3–6 \times 10^{16}$	0
Subcollector	0.6	n^+	6×10^{18}	0

The devices are implant-isolated and have an active emitter area of 40 μm^2. The transistors exhibit f_T = 65 GHz, and f_{max} = 90 GHz. Each chip contains a differential pair with 1.7-kΩ collector–base feedback resistors and a 250-Ω emitter bias resistor which also serves to supress common mode gain.

The amplifier exhibits a peak gain of 12 dB at 9.9 GHz, with a 3 dB bandwidth which extends from 9.55 to 10.3 GHz. The peak gain and bandwidth are sensitive to polarizer position, indicating that the polarizers provide good matching to free space (as a reference point, the transistors have 18-dB unilateral gain at 10 GHz). Output power is linear with input power, indicating that the grid operates as an amplifier rather than as an injection-locked oscillator. Gain saturation can be observed at low dc bias and high-input RF levels.

This amplifier represents a significant advance over the previously reported grid amplifier [5] beyond its higher operating frequency, larger gain, and wider bandwidth. Where the previous grid required both front and backside wiring on the substrate (which would be cumbersome in a monolithic implementation), this amplifier utilizes frontside wiring only. Where the previous amplifier utilized packaged discrete MESFET's, in this amplifier the contents of each unit cell are monolithically integrated with the exception of the metal lines which make up the antenna array. This amplifier therefore represents a substantial step toward monolithic integration of an entire grid, which will be required for higher frequency operation and low cost.

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VB-2 Monolithic High-Power Millimeter-Wave Quasi-Optical Frequency Multiplier Arrays Using Quantum Barrier Devices—Hong-Xia L. Liu, X-H. Qin, L. B. Sjogren, E. Chung, C. W. Domier, and N. C. Luhmann, Jr., University of California, Los Angeles, CA. 90024 (310) 206-8133.

Monolithic solid-state device arrays are under development for application as millimeter and submillimeter sources. Current efforts are focused on frequency multiplication up to $\simeq 100$ GHz at the 1-50-W power level. However, the intrinsic capabilities of several of the devices should permit the extension of this work to frequencies of several terahertz.

GaAs barrier-N-N^+ (BNN) diode arrays have been successfully designed and fabricated. Frequency doubling to 66 GHz has been successfully achieved with an output power of 2.4–2.6 W and an efficiency in excess of 10%. In addition to the BNN arrays, a number of new device concepts have been developed in the course of this research which offer the promise of more efficient frequency multipliers with both higher cutoff frequency and higher power handling capability. These include the multi-quantum-barrier varactor (MQBV), and the Schottky-quantum-barrier varactor (SQBV).

It is well known that a varactor's efficiency degrades significantly at high pumping power level, which is primarily due to the increase of the effective series resistance resulting from the electric field dependence of the electron mobility. This results in a reduction in cutoff frequency and efficiency. The MQBV and SQBV can suppress these effects dramatically. The doping profile of the fabricated MQBV array involves the epitaxial stacking of six single quantum barriers (utilizing a back-to-back fabrication method). In addition to the current work involving array fabrication for the first time instead of discrete waveguide mounted devices, it also employs epitaxial stacking which offers a number of important advantages over the single-barrier devices previously utilized. First, the stacking structure results in several capacitances in series, which significantly reduces the resultant C_{min}. Alternatively, the device area can be increased, thereby reducing the series resistance and improving the power handling ability. Second, since each single barrier only shares a portion of the pump power, the electric field in the n regions, as well as the thermionic current, can be reduced for a given total input power. This results in the reduction in series resistance associated with the maintenance of electric fields sufficiently low to provide high mobility. Third, the stacking structure also increases the overall device breakdown voltage. Finally, the symmetric structure makes the back-to-back fabrication method feasible, which doubles the number of barriers and improves the array yield.

Measured C–V characteristics of the MQBV (4×20 μm^2) show a C_{max}/C_{min} ratio of 5 with a C_{min} of 10 fF. In excess of 10 times reduction in thermionic current compared to the single-barrier device has also been obtained. The performance of the MQBV can be further improved by incorporating a Schottky-barrier structure on multi-quantum barriers to form the Schottky-quantum-barrier varactor (SQBV). The SQBV has two major advantages over the MQBV. First, the significantly higher Schottky barrier further suppresses the thermionic current. As a result, the thermal heating effect from the dc current can be neglected. Second, the Schottky contact eliminates the specific contact resistance associated with the Ohmic contact. A SQBV array with a Schottky-barrier structure in series with six quantum barriers has been successfully fabricated with a yield of 99% (1300 devices), and an output power of 3.8–10 W with an efficiency of 1.7–4% at 99 GHz has been achieved.

In addition to the thick quantum-barrier-based devices, resonant tunneling diode (RTD) arrays have also been fabricated. An output power of 33 mW at 99 GHz has been obtained.

VB-3 Picosecond Duration, Large-Amplitude Impulse Generation Using Electrical Soliton Effects on Monolithic GaAs Devices—Michael Case, Eric Carman, Ruai Yu, and M. J. W. Rodwell, Department of Electrical and Computer Engineering, University of California, Santa Barbara, CA 93106 (805) 893-3244; Masayuki Kamegawa, Shimadzu Corporation, Kyoto, Japan.

We report two devices which generate picosecond duration electrical impulses using soliton propagation effects. A high repetition-rate device has generated an