SESSION 1: MONOLITHIC MILLIMETER-WAVE CIRCUITS

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SESSION INTRODUCTION

Current activity for millimeter-wave circuits is focusing on applications within the frequency range from about 30 GHz to 100 GHz. This activity is driven, for defense purposes, by four generic areas of application: 1) radar (e.g., fire-control); 2) communications (e.g., ground-satellite and satellite-satellite); 3) missile seekers (active and passive); and 4) electronic warfare (e.g., surveillance).

In order to effectively field such systems, research and development must provide the necessary transmitter (e.g., power amplifiers and oscillators), receiver (e.g., mixers and low-noise amplifiers), and control (e.g., phase shifters, switches, duplexers) component functions. Efforts to implement many of these functions in monolithic format are being pursued in III-V compound materials, like GaAs and InP, and silicon to ascertain whether the potential advantages of cost, size, and weight reduction and reliability improvement can be realized.

Probably the most challenging area of component development is that of providing monolithic-compatible, solid-state sources for the system transmitter functions. Recent programs have pursued (are pursuing) development of amplifiers and/or oscillators based on a variety of solid-state device concepts. Some of these concepts include: short-gate MESFETs; permeable-base transistors; opposed gate-source transistors; planar doped-barrier transistors; vertical FETs; IMPATTs; quantum-well, HEMT, and superlattice structures; and electrically-large devices (e.g., solid-state gyrotrons, solid-state magnetrons, solid-state traveling-wave amplifiers and continuously-distributed IMPATTs). The challenge of this area is not only to provide sources of performance comparable to those at microwave frequencies, but also to overcome the additional atmospheric attenuation encountered by waves propagating at frequencies within the millimeter-wave regime.

Two papers in this session describe efforts in the source area. One describes a Hughes-developed 68 GHz monolithic FET oscillator. This area of achievement impacts potential for future active aperture concepts as well as local oscillator functions for narrow and broadband receivers. The second paper associated with source activity is a contribution by MIT, Lincoln Laboratory, on GaAs monolithic multipliers. This paper describes an interesting approach to efficiently translate reasonable power levels generated at lower frequencies up to approximately 37 GHz. Amongst various possibilities this work might impact active aperture transmit concepts and local oscillator functions for receivers. Another source-related effort by Honeywell will be presented in the session "Monolithic Devices and Circuit Elements," which follows this session. That paper will describe recent results in high-efficiency power FET performance at 30 GHz.

Monolithic work on receiver-related activity has been addressing both wide- and narrow-bandwidth performance. Effort has been predominantly in GaAs, but substantive work is also progressing in InP. The GaAs monolithic work has been underway for a longer period and currently is more mature than that in InP. Millimeter-wave monolithic approaches for mixers, which have been pursued, have included single-ended, balanced, and doubly-balanced concepts. Two papers in this session describe GaAs monolithic mixer developments. One is contributed by Hughes and depicts results of a crossbar mixer designed and fabricated for broadband operation from 75 GHz to 110 GHz. The other contribution comes from Honeywell and describes a balanced mixer design in microstrip for 94 GHz. In the session to follow, a paper from TRW describes results of effort on a low-noise HEMT device for receiver-related usage at 34 GHz.

In the area of monolithic control components, effort has been considerably less intense. Phase and amplitude modulators for control components based on FETs, Schottky-barrier varactors, and PIN diodes are of interest. With the recent demonstration of GaAs PIN diodes at microwave frequencies, the prospect for higher frequency GaAs PIN switches, limiters, and phase shifters emerges. Although effort in this area lags that of source and receiver technology, it will be necessary to determine the potential for impact in fielding systems of the type described earlier.