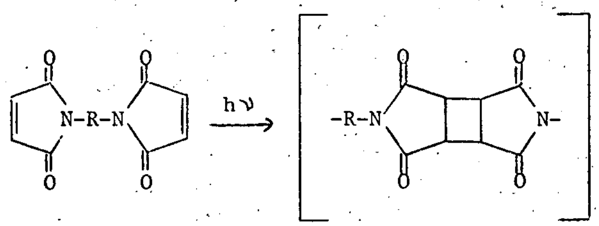
European Scientific Notes (Office of Naval Research) ESN-29(12): 515–518 31 Dec 1975

a single T_g (e.g., IPS/Polypropylene oxide (PPO)). He is also studying mixtures of polymers that can interact by hydrogen bonding. Polyethylene oxide and polymethacrylic acid exhibit sufficient hydrogen bonding to make the mixture insoluble in water. The heat of formation (H_f) for hydrogen bonding in this system is about 2 kcal/mole, about 1/2 the normal value, thus indicating that every other acidic hydrogen is interacting with an ethereal oxygen.

Professor van Beylen has a group of about seven people investigating the kinetics of ionic polymerization, mainly using relaxation techniques.

Professor De Schryver's group of ten people is engaged in photochemistry research of polymers and organic materials. De Schryver spent two years with Professor Marvel at Arizona. Studies include determining lifetimes of excited states and photopolymerization of the type:



Dr. Reynaers is engaged in small-angle x-ray scattering (SAXS) research on polymers. Much of his work supports Smets' solid state research and Berghmans' studies on polymer viscoelasticity and morphology.

Coördination and cooperation among the research programs in this Department is excellent. This interaction is conducive to well planned and thorough research. The department faculty members are all relatively young. With more maturity this group should make an even greater contribution to polymer science. (Maj. D. E. Dodds, USAF, EOARD)

ELECTRONICS

[Report on] (by D.K. Cheng)

FIFTH EUROPEAN MICROWAVE CONFERENCE: THE INVITED PAPERS

Since its inception in London in 1969, The European Microwave Conference (EuMC) has matured to be one of the major events for the microwave community. The fifth in the series, EuMC/Microwave 75, was held in Hamburg, The Federal Republic of Germany, on 1-4 September 1975. Its international character was evidenced by the participation of 644 delegates from 32 countries which included far-away non-European lands such as Australia, India, and Japan, as well as Nigeria, Brazil, Canada, and USA. Even the USSR was represented. The US contingent consisted of 32 people.

This relatively large turnout is not surprising in view of the fact that microwaves have found important applications not only in radar, navigation, traffic control, and telecommunications but also in radioastronomy, industrial heating, control, sensing, etc. The frequency range of "microwaves" is wide and loosely defined. Generally they are considered to be that part of the electromagnetic spectrum which is 100 MHz and higher (wavelength of 1 m or less), right up to optical frequencies.

The choice of Hamburg as the site of the Conference is particularly appropriate because it is the birthplace of Heinrich Hertz who contributed much to the foundation of electromagnetics upon which microwave theory and practice was built. The 271.5-meter TV tower, the tallest structure in Hamburg, was named in Hertz's honor. The city-state of Hamburg has nearly two million inhabitants, and (next to West Berlin) is the second most populous city in the Federal Republic of Germany. The Conference was held in the new Congress Centrum, a modern, air-conditioned edifice with excellent facilities.

The technical program each day led off with a session of two to three invited papers which were then followed by two parallel sessions. There were altogether 23 sessions for the four-day Conference. Professor H.B.G. Casimir, a well-known electromagnetic theorist and the President of the European Physical Society, gave the keynote address of the Conference. The title of his talk was "Waves as Man-Made Phenomena." He traced the historical development of various types of wave phenomena and expounded present-day and possible future applications of microwaves.

Because of space limitation, we will only summarize here some of the highlights of the nine invited papers. A subsequent conference report is planned which will contain more detailed discussions of some of the contributed papers.

In his paper "Optical Waveguides" Prof. H. G. Unger (Technical University at Braunschweig, FRG) reviewed the operating performance of planar optical waveguides in the form of dielectric films, strips, and ribs on substrates. When strip and ridge guides are made of low-loss material, mode attenuation arises mainly from scattering at imperfections at their boundaries. By proper design and fabrication the attenuation can be made less than 1 dB/cm, which is acceptable for many applications in planar micro-optics with short guide lengths. For transmission of optical signals over long distances, cladded-core and gradient fibers are used. An attenuation as low as 1 dB/km is attainable with high silica-content fibers. (See ESN 29-2; 56 and ESN 29-2; 68 for other articles on recent developments of glass fibers.)

A severe constraint is imposed on the core radius (usually a few μm) for single-mode propagation in cladded-core fibers. To facilitate launching and splicing for such small cores the index-difference between the core and the cladding is made as small as possible, perhaps in the neighborhood of 0.1%. The loss characteristics of such fibers are affected profoundly by curvatures and mechanical distortions. When extreme low signal dispersion and pulse broadening are not essential, multi-mode fibers with core diameters of up to 100 μm and index-differences of 1% can be used. Low delay spread between the fastest and the slowest of the guided modes is obtained if, instead of a cladded core with an index step at its boundary, the fiber has a graded index. Pulse-broadening of less than 1 ns/km is achievable. Although this Conference did not deal with optical devices, this paper gave a good overview of the present status of optical waveguide development.

A talk on "New Radar and Navigation Systems" by Dr. K. L. Hunter (Mullard Research Laboratories, England) reviewed the performance capabilities of some microwave radar and navigation systems and also dealt with certain unsolved problems. It was pointed out that the simplest solid-state microwave radar in current use is the Doppler intruder-alarm, whose basic 25 mm-cube module consists of a 10-mW 10-GHz Gunn oscillator, a common transmit/receive antenna terminal, and a receiver mixer. The challenge lies in the processing of the received Doppler-frequency signal so that false alarms due to flapping curtains and small animals are minimized. In addition to the problems of false alarms and missed targets, which are important to the simple intruder-alarm and the largest anti-missile radar complexes alike, system reliability, maintainability and electromagnetic compatibility must be considered.

Proposed microwave methods for aircraft navigation rely on geostationary satellites in one way or another. They have to compete with inertial and VLF methods in price and performance capabilities. Both inertial systems and VLF systems in the 12-25 kHz range are capable of very good accuracy with a drift rate of less than one nautical mile per hour.

The basic requirements of aircraft landing systems include precision guidance with no restrictions due to cloud base or visibility and no limitations on the approach or type of aircraft. The guidance signals should be unaffected by the local terrain and ground or air traffic. Microwave landing systems are currently under development in Australia, France, West Germany, UK and USA. A formal agreement on the standards of international microwave landing systems is expected in 1977. Microwaves have also been found useful for navigation on land and sea.

Dr. G. F. Ross (Sperry Research Center, USA) talked about "Subnanosecond Pulse Technology and Its Applications." Subnanosecond pulse technology was initially used primarily as an analytical tool to explore the properties of microwave networks and to determine the intrinsic parameters of materials. It was subsequently extended to study the time-domain behavior of straight wire antennas and other scattering objects. The generation of subnanosecond baseband pulses has been aided by recent improvements in solid-state devices. The development of inexpensive microwave delay-line ranging techniques led to the evolution of baseband radar which has found applications in auto-precollision sensing, space-ship docking, airport surface traffic control, harbor collision avoidance, etc., generally in the 2 to 1,500 m range. This review paper gave a general survey of past developments and projected further applications in the areas of high-speed computation and short-range wireless communication.

In "Microwave Tube Evolution Over the Past Decade," by P. Guenard (Thomson-CSF, France) the author noted the recent decline in the number of papers concerning microwave tubes and explained this phenomenon as an evolutionary process whereby research activities in this area have been largely replaced by development over the past decade. The appearance of semiconductor devices reduced the need for tube solutions. However, spurred by the stringent requirements of military applications and satellite usage, substantial progress in tube performance has been made, in addition to extending the operating life and improving the reliability. The efficiency of klystrons has been increased by employing non-sinusoidal velocity modulation. For traveling-wave tubes, higher power has been achieved by extending the helix-tube technology; increased efficiency has been obtained by using multi-stage depressed collectors and by employing potential pumps between different parts of the slow-wave structure; and improved phase characteristics have been made possible by adding a progressive pitch variation. Work on magnetrons includes efforts to improve efficiency and to realize electronic tuning. The use of new materials and computer-aided design methods has also contributed to the tube-evolution process.

"Design and Applications of Solid-State Microwave Amplifiers," by J. Magarshack (Laboratory of Electronics and Applied Physics, France) dealt with the subject from a circuit engineer's point of view. The design procedure of a solid-state amplifier begins with the characterization of the active device under the various operating conditions required of the system. In general, time-domain characterization is less precise, and frequency-domain characterization in terms of impedance or S-parameter measurements is more commonly used. For a complete knowledge their dependence on at least four variables; namely, frequency, added power, bias, and temperature, should be known. The choice of the circuit is then made by computer-aided optimization procedures. The author provided an outline of the general approach.

What about the choice of the active device? Depending on the application, consideration must be given to its noise performance and to its bandwidth and power capabilities. Current possibilities of avalanche, Gunn, and tunnel diodes as well as those of field-effect transistors (FEI's) were surveyed. The author appeared to think that FET's would overtake all other solid-state devices at least up to the X-band. The possibilities of a monolithic receiver front-end and integrated circuits with FET's as switching elements for high-speed (4 Gbits/sec) logic are being explored.

"Active Receiving Antennas at Microwave Frequencies" was the subject of a talk by Prof. H. H. Meinke (Munich Technical University, FRG). The author and his associates have been working on active receiving antennas for many years. Much of their work has been empirical, and some of their statements on power match and optimum noise match have been questioned in the US.

"Microwave Bioeffects: Current Status and Concepts" were discussed by Drs. P. Czerski and S. Szmigielski (Poland). Microwave bioeffects (MWBE) can be grouped into two categories: primary interactions and delayed effects. Primary interactions pertain to direct energy absorption and interference with biophysical, biomedical and bioelectrical mechanisms. Delayed effects occur because of the existence of feedback, adaptive and physiological mechanisms. Many aspects of MWBE are not well understood, and useful data are scarce. The speaker, Czerski, made an impassioned plea for more investigative efforts on microwave effects on nervous and hematopoietic systems and on genetic and chromosome aberrations. In view of the increasing use of high-power electromagnetic devices, this plea carries a degree of urgency. The interdisciplinary cooperation of biologists, biophysicists, physiologists, electronic engineers and medical research workers appears imperative.

Czerski pointed out that primary interactions of microwaves with living systems cannot be explained solely by electromagnetic theory in terms of the conversion of the absorbed energy into kinetic energy of molecules; quantum mechanical effects come into play in complex subcellar structures. Besides frequency, the type of modulation, and the duration and the repetition period of irradiation all have bearing on the total MWBE. Because of the absence of well-documented epidemiological studies, the authors expressed doubt on the relatively high (compared to USSR and Poland) safe-exposure limit (10 mW/cm^2) recommended in the US. (See also article by J.H. Schulman p.546 this issue.)

A survey paper on "Recent Advances in Radio-Wave Propagation above 10 GHz" by F. Fedi (Ugo Brodoni Foundation, Rome, Italy) focused on the attenuation and depolarization of microwaves due to rainfall and multipath transmission. Assuming spherical raindrops and neglecting multiple scattering, calculated rain-induced attenuation results are available for frequencies up to 300 GHz and for rain rates up to 150 mm/h. The attenuation per unit length increases with rain rate and with frequency, as expected. However, it levels off as the frequency increases above the 50-75 GHz range independently of the rain rate. Cross-polarization effects due to scattering from raindrops that assume the shape of oblate spheroids have also been calculated. In general, rain-induced cross-polarization increases with attenuation but decreases with frequency. Multipath transmission gives rise to selective fading and also to cross-polarization. These consequences limit the maximum hop-length (repeater spacing) and restrict the possibility of polarization diversity.

Since 1973 a joint European research program on radio propagation at frequencies above 10 GHz has been in existence within the framework of the European Community. Its purpose is to set up long-range (from one to three years) cooperative programs for assembling meteorological, attenuation, and cross-polarization statistics, to derive criteria for the design of terrestrial radio relay systems, and to plan earth-space links on a wide scale in Europe.

"Microwave Contributions to Satellite Communications" by R. Teupser (Siemens Telecommunications Group, Munich, FRG) might have been more properly entitled "European Development Programs in Application Satellites." The following programs were summarized by the author:

a) SYMPHONIE - Launched in Dec. 1974, SYMPHONIE is the first geostationary telecommunications satellite developed and built in Europe by a consortium of French and German companies. It operates in the 6/4 GHz band with intermediate frequencies around 500 MHz. Two 90-MHz-wide transponders are used. The front-end includes tunnel-diode amplifiers and the down-converters use microwave integrated circuit (MIC) technology. The system was planned to work into moderate-size earth stations with perhaps 16-m antennas, uncooled parametric amplifiers and 3-kW power transmitters.

b) Orbital Test Satellite (OTS) - Scheduled for launch in 1977, this satellite is to be used for tests of telecommunication system designs and hardware before an operational European satellite system is built. The output power amplifiers use traveling-wave tubes with two-stage collectors to deliver 20 W at 11 GHz. The earth stations will have 15 to 18-m antennas, uncooled paramps and 2-kW transmitters. All equipment is currently under development in Europe.

c) Maritime Satellite (MAROTS) - This satellite is to provide, on an experimental basis, communications capability to ships within its earth coverage from a geostationary orbit at 40°E.

d) Aeronautical Satellite (AEROSAT) Two geostationary satellites are to be positioned over the Atlantic by 1978/79 to improve communications between aircraft and the ground and to enable a more accurate determination of aircraft positions.

e) Meteorological Satellite (METEOSAT) - This is now under development as a future contribution to the worldwide meteorological program.

f) TV Broadcast Satellite - Feasibility studies have indicated that satellites can be developed to provide sufficient power for the transmission of TV programs directly to subscribers. The frequency band 11.7 to 12.5 GHz has been allocated for such services, but actual design and implementation are relatively far in the future.

The idea of scheduling invited papers which survey the states of the art and project future directions of the topical matter of the subsequent sessions appears to be a very good one. The invited talks were generally well attended and well received. (David K. Cheng)

THIRD EUROPEAN SPECIALIST WORKSHOP ON MICROWAVE ACTIVE SEMICONDUCTOR DEVICES

The "Third European Specialist Workshop on Microwave Active Semiconductor Devices" was held in Ronneby, Sweden from the 28th to the 30th of May, 1975. The conference was well organized by Bert Jeppsson and Peter Weissglas of the Royal Institute of Technology, Sweden, and provided an opportunity for informal interaction on the physics and material technology of active semiconductor devices for those scientists active in the field. Due to the informal nature of the workshop there will be no published proceedings. The discussions centered around four key areas: two terminal transferred electron devices; three terminal transferred electron devices; avalanche devices; and topics of general interest.

In the area of two terminal transferred electron devices, P. Jondrup, P. Jeppesen (Technical University of Denmark) and B. Jeppsson (Microwave Institute Foundation, Stockholm) exploited the existence of two stable states in transferred electron devices to construct a Gunn effect switch for laser modulation. The two stable states are a pre-instability high-current low-