Meetings

Nonlinear Magnetics and Superconductivity

Current research on nonlinear magnetic phenomena and their applications was reviewed at the 2nd International Conference on Nonlinear Magnetics (INTERMAG), held in Washington, D.C., 6–8 April 1964. This meeting is significant in that it was the first time that the subject of superconductivity was included in a conference of this type.

The natural extension of the field of nonlinear magnetics to embrace superconductivity was made because it has been realized for some time that in the application of superconductivity to useful devices the circuit principles are very similar to those used in the field of nonlinear magnetics. In discussing superconducting devices, the speakers (C. P. Bean, General Electric Company); J. E. Kunzler, Bell Telephone Laboratories; F. B. Hagedorn, Bell Telephone Laboratories; and T. A. Buchhold, General Electric Company) covered, in a tutorial manner, computing devices, electromagnetics, gyros, and technological applications of superconductivity phenomena in memories and amplifiers.

As pointed out by J. E. Kunzler, our understanding of high-field superconductivity has advanced considerably within the past 3 years and operational models of solenoids capable of operating with fields of at least 100 kilogauss seem likely at this time. He pointed out that high-field, high-current superconductors are too new for many of their potential applications to be apparent. However, some more obvious applications include magnets for particle accelerators and bubble chambers, magnets for magnetohydrodynamic power generation, and high-field, high-current superconductors for high-power direct-current transmission systems.

The INTERMAG conference has become established as a forum for presenting advances in magnetic recording. Steady progress in the continuing trend toward high-density recording and development of new materials for magnetic tapes was evidenced by the papers presented this year. The subject of noise in magnetic recording received the greatest emphasis, particularly with respect to the use of alternating-current bias in audio recording. In addition, recording properties of electrodeposited cobalt-phosphorus coatings were compared with existing oxide tapes and indicated an improvement in output and resolution because of the thinner coating with its higher coercive force. Interest in these sessions was so intense that an informal get-together was scheduled after they had taken place. A vigorous discussion of the limitations of resolution and means for its improvement ensued.

Magnetic logic continues to be of interest especially for applications which require reliability and where severe environmental conditions exist. Laboratory development of a core-diode shift register for a 5-megacycle bit rate in a nuclear radiation environment of 10^{18} nvt for neutrons was reported by Briggs (R.C.A.); a balanced-core, flux-steering mode of operation and backward diodes were used. Other advances in the field of magnetic logic include the development of balanced magnetic circuits; Brown and Newhall (Bell Telephone Laboratories) described the manufacture in substantial quantity of a converging switch for a data-processing system. The common supposition that all-magnetic shift registers require at least three drive phases to insure unilateral flow of information was disproved by Mina and Walters (BTL) when they reported on the laboratory development of a two phase, all-magnetic shift register.

Perhaps the greatest interest in nonlinear magnetics today is in the area of random-access magnetic memories. About one-third of the papers dealt with some aspect of this subject—materials, phenomena, devices, or systems. For instance, a novel coupling phenomenon between the magnetization of two thin ferromagnetic films separated by a thin metallic film was the subject of papers by J. J. Bruyere, O. Massenett, R. Montmory, and L. Neel (Centre Nationale de la Recherche Scientifique, France).

Memory systems involving plated wires, woven wires, ferrite cores, transfluxors, twistors, thin films, and batch fabricated ferrite arrays were discussed. Other papers included an analysis of a 10^8 bit memory and a description of high-density techniques.

Vigorous discussions were generated at the informal evening session. The capabilities of planar magnetic films were compared with those of laminated ferrites. Several approaches to batch fabrication of memory cells in order to obtain large capacity and low-cost memory were evaluated. Both performance and yield data were compared by representatives of the two major approaches. Operating arrays with multilayer films were discussed by T. Matcovich (Sperry Rand) and information on waffle iron and twistor memories was presented by U. Gianola (BTL). While discussing some cost data on ferrite memories, R. Petschauer (Fabritek Corporation) reported on the yield of thin films. Some comparisons between memories were made on the basis of the relative attenuation of power in passing through the memory from the driving to the sensing element. It was pointed out that the cost of electronics is comparable and, in many cases, exceeds the cost of the memory array itself; the importance of finding low-cost circuitry was emphasized and is leading to investigation of magnetic circuitry as well as integrated semiconductor circuits. The potential of cryogenic memories for capacities of 10^7 to 10^9 bits was discussed by L. Burns (R.C.A.) and W. Ittner (I.B.M.).

The sessions on materials ranged between the materials for memory and recording and those required in the more established technologies of transformers, inductors, and power control elements. A comprehensive paper on the quasi-static flux reversal in thin films was presented by S. Middelhoek (I.B.M.). In a paper by E. B. Spencer and J. P. Remeika (BTL), the effects of chemical purity on the physical properties of magnetic and other compounds was discussed.

The sessions on combined magnetic

and semiconductor devices were devoted largely to the switching of the silicon controlled rectifier in power-control and conversion circuits. Considerable interest was expressed by the audience in time-ratio control; this was evidenced by a stimulating discussion period in which many persons participated and which finally had to be cut off by the session chairman.

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Optical Masers

Topics on the preparation of laser materials and sensitized luminescence were emphasized at the Optical Maser Symposium held at the Toronto (Canada) meeting of the Electrochemical Society, 6–7 May 1964.

K. Nassau (Bell Telephone Laboratories) summarized the successful optically pumped, inorganic, solid state laser materials which he considered to be well authenticated. His list included four categories: ruby, fluorides, scheelites, and glasses. With the exception of ruby, all these hosts are activated with rare earths. Nassau emphasized that after 4 years of laser research there are still no reliable guidelines that one can follow in developing a new laser material. For example, one might expect the emission lines of neodymium-doped lanthanum fluoride to be narrower, hence better suited for a laser, than the emission lines of neodymium in $CaWO_4$. This is not the case even though there is a closer chemical and physical similarity between Nd^{+3} and La^{+3} than between Nd^{+3} and Ca^{+2} and no need exists for charge compensation in LaF_3. Laser materials research is still at the point of growing a crystal, preparing a laser rod, and testing it.

Most of the chemical problems of laser materials development relate either to the necessity of compensating for the excess positive charge when a trivalent activator ion is substituted for a divalent host lattice cation or to the difference of the solubilities of the activator ions in the solid and liquid host. As the method of charge compensation changes, the spectrum of the laser material changes. The preparative problem is to find that technique which yields the spectrum best suited for laser action. The segregation of the dopant ions from the crystals, as they are grown from molten material, complicates the problem of producing a homogeneous, properly compensated laser rod.

L. G. Van Uitert and J. E. Geusic (Bell Telephone Laboratories) discussed the preparation and observation of laser action in garnets doped with neodymium. They believe that this material is potentially better than previously developed materials because of its lower threshold, simple preparation, and higher quality output.

Work at the Airtron Division of Litton Industries on the growth of ruby crystals by hydrothermal and molten salt solution techniques was described. Nearly all the ruby laser crystals have been grown in the past by the flame fusion technique, in which the material in powder form is dropped onto a seed and fused by a flame directed onto the seed. The crystals that result from this comparatively violent method of growth tend to be optically inhomogeneous, and consequently the laser performance is considerably less than ideal. Because ruby is one of the most widely applied laser materials, there is an interest in developing the techniques of growth from solutions, which should be more controllable. The apparatus used in this work, particularly for the growth from molten salt solvents, is impressively large; the furnace is several feet in diameter. Unfortunately, the ruby crystals are still small compared to those grown by the flame fusion technique and vary in chromium content, which is the active ion in the ruby laser. The crystals grown from solution do have fewer strains and thus better optical homogeneity.

Because of their narrow emission lines, rare earth ions have been the activators in nearly all optically pumped lasers. However, most rare earth ions do not also have broad absorption bands in suitable regions of the spectrum. Consequently, the exciting lamp radiation is frequently utilized in an inefficient manner. For this reason, other species with the desired absorption spectra have been added to the laser material in the hope that the second dopant would transfer some of the energy it absorbs to the rare earth ion, thus "sensitizing" the rare earth emission. With the exception of systems in which rare earth ions are chelated to organic compounds and the latter acts as the sensitizer, this scheme has not generally proven useful in laser systems.

There is currently a strong interest in rare earth chelates. Two of the more serious problems encountered with these systems are (i) the variation with temperature of the refractive index of the solvent in which the chelates are dissolved and (ii) the difficulty of producing a nearly uniform absorption strength throughout the volume of the laser cell. Because several joules of energy are absorbed by the chelate and its solvent during the laser pulse, a fairly large temperature increase occurs. This increase produces a significant change in the refractive index and distorts the laser beam. E. P. Riedel and R. Charles (Westinghouse Research Laboratories) proposed solving this difficulty by using as the solvent heavy water at 8°C, just above the freezing point. At this temperature the refractive index varies by only 10^{-5} for a temperature variation of 4°C.

The laser cell must contain enough rare earth ions to provide sufficient amplification of the laser signal. This amplification then fixes the chelate concentration and the strength of the absorption due to the organic molecules, at a value that is usually too large to permit the exciting radiation to penetrate to the center of the laser cell. Reidel and Charles propose to solve this problem by adding a second sensitizing species (sodium *p*-benzoylbenzoate) which absorbs in a different spectral region. The concentration of this sensitizer can be varied independently from that of the chelate.

Sensitization studies of rare earth ions in glasses were described by N. T. Melamed (Westinghouse) and Shigeo Shionoya (University of Tokyo). Melamed sensitized Nd^{+3} with Mn^{+2} and Shionoya sentitized Tb^{+3} with Ce^{+3}. W. W. Anderson (Stanford University) discussed host sensitization in ZnS:Tb.

Although the emphasis of the meeting was on preparation of materials, there were a few very interesting papers on subjects related to laser characteristics and applications. John Armstrong (IBM) summarized the studies of nonlinear optical properties of materials which have been performed with laser sources. His recent work in this area has been the study of the reversible bleaching of pthalocyanine dyes. This bleaching may be applied to the shutter action in high-power optical systems,