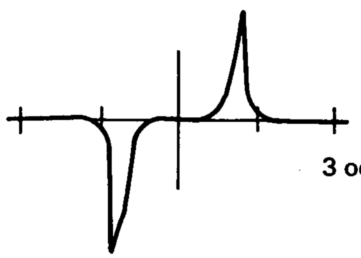
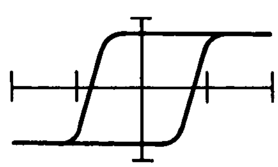
NASA TECH BRIEF

Thin-Film Ferrites Vapor Deposited by One-Step Process In Vacuum



3 oe/Div Horizontal

$\frac{dB}{dt}$ Peaks



6500 Gauss/Div Vertical

3 oe/Div Horizontal

B-H Loop

The problem:

To devise a simple vapor deposition process of forming thin-film ferrites (e.g., Fe_3O_4) on a substrate entirely in vacuum. Previously, ferrite films have been formed in vacuum by sputtering, oxidation of the vapor during deposition in a partial pressure of oxygen, or deposition of films consisting of free metals or metal compounds and conversion of the deposited films to ferrites by oxidation.

The solution:

Films vapor deposited from a mixture consisting of powdered Fe_3O_4 and a small percentage of powdered B_2O_3 at controlled temperatures under a pressure of 2×10^{-5} torr exhibited magnetic properties and physical structure characteristic of iron ferrite or magnetite (Fe_3O_4).

How it's done:

The powdered materials, obtained from commercial sources, are mixed in a weight ratio of 95 percent of Fe_3O_4 (99-percent purity) to 5 percent of B_2O_3 (99.999-percent purity). The oxide mixture is placed in a tungsten boat, which is then heated to a temperature of 1360°C in a vacuum chamber (at a pressure of 2×10^{-5} torr) containing substrates of fused silica. Films ranging in thickness from 0.3 to 20 microns were deposited onto the substrates (maintained at various temperatures) at a rate of approximately 500 angstroms per second.

Films deposited on the fused silica substrate at temperatures up to 500°C were found to be amorphous by X-ray diffraction analysis. X-ray diffraction patterns characteristic of the magnetite crystal structure

(continued overleaf)

were exhibited by films that were deposited on the substrates at 200°C and then annealed in the vacuum for 15 minutes at 550° to 700°C. In situ electron beam diffraction analysis of films deposited at room temperature on silicon monoxide coated copper grids showed that the films remained amorphous at temperatures up to 420°C.

The films deposited on substrates at 200°C exhibited a coercivity of 2.7 oersteds at 600 cps, and a saturation magnetization of approximately 6000 gauss. The films deposited at higher substrate temperatures, with and without annealing, were magnetic, but the maximum field strength (50 oersteds) obtained from a modified Helmholtz drive coil used in the measurements was not sufficient to cause switching. For the low coercivity films, integration of the dB/dt peaks by an RC network yielded the B-H hysteresis loop shown in the figure. The films were found to have a resistivity of approximately 2 ohm-cm, which is several magnitudes greater than that of magnetite.

Notes:

1. Spectrographic analyses of the films (deposited on carbon rods) showed that the concentration of impurities (Co, Ni, Al, B, Ca, Cr, and Mg) originally present in the powdered Fe_3O_4 was only slightly greater in the films. There was no detectable trace of tungsten (from the tungsten boat) in the films. A separate chemical analysis showed a 0.1- to 0.3-percent content of elementary iron in the films deposited on the fused silica substrates.
2. These films may find application in magnetic memory devices for computers and as thin film inductors in communications and telemetry systems.
3. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Manned Spacecraft Center
   Houston, Texas 77058
   Reference: B66-10398

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: Michael Hacskaylo
of Melpar, Inc.
under contract to
Manned Spacecraft Center
(MSC-259)