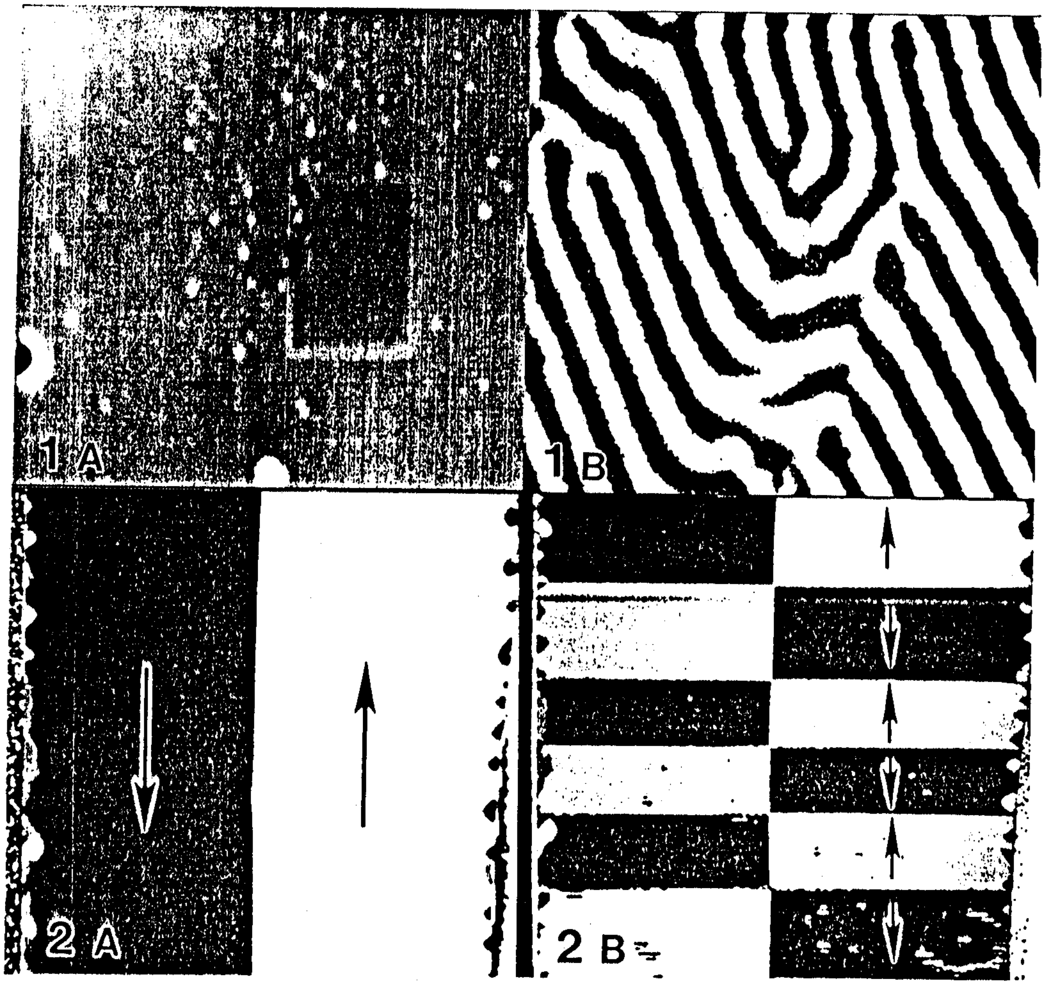

FIG. 1.--SEMPA measurement of Fe garnet coated with 2 nm thick Fe film. (A) is topographic image and (B) is simultaneously measured magnetization image from same region. Images are 40 um across.
FIG. 2.--SEMPA measured magnetization of a clean Fe crystal in (A) and after growing a Fe/Cr/Fe multilayer in (B). Cr spacer layer thickness varies from 0 near the top of the image to 5 nm at the bottom. Domain reversals show reversals in magnetic coupling with Cr thickness variation. Arrows indicate magnetization directions. Images are 400 um across.

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TITLE ➡

SCANNING ELECTRON MICROSCOPY WITH POLARIZATION ANALYSIS: AN UPDATE

J. Unguris, M. W. Hart, R. J. Celotta, and D. T. Pierce

National Institute of Standards and Technology, Gaithersburg, MD 20899

Over the past ten years the technique of scanning electron microscopy with polarization analysis (SEMPA) has rapidly evolved from a scientific curiosity to a useful analytical tool for looking at a material's magnetic microstructure. Several reviews of the technique have been published elsewhere[1,2,3]. SEMPA has been successfully used to analyze various technological problems such as: noise in magnetic and magneto-optical recording media, domain wall motion in thin film recording heads, and domain structures in small Permalloy shapes. Basic science applications of SEMPA include quantitative studies of the influence of the surface on the structure of magnetic domains and domain walls, and studies of magnetic microstructures in ultra-thin (0.1 - 1 nm) ferromagnetic films. Many current applications of SEMPA make use of the technique's surface sensitivity to probe the magnetism of thin films and multilayers.

The SEMPA experimental set-up has been described in detail elsewhere[4]. Basically, a SEMPA apparatus consists of a scanning electron microscope, an ultra-high vacuum specimen chamber, and a detector for measuring the spin polarization of the secondary electrons. For conventional transition metal ferromagnets, the electron spin polarization is directly proportional to the specimen's magnetization. A SEMPA measurement therefore provides a direct image of the magnitude and direction of the magnetization. This image is also independent of the samples's topography. SEMPA is easily combined with other ultra-high vacuum compatible surface analysis tools such as Auger electron spectroscopy, reflection high-energy electron diffraction (RHEED), ion milling and thin film evaporators. With these additional tools SEMPA can be used to study the magnetic microstructure of thin films and multilayers prepared in situ.

Two examples of in situ deposited thin films are presented in the figures. Fig. 1 shows the magnetic domain pattern of an electrically insulating Fe garnet film that was coated with a 2 nm thick Fe film. The Fe film eliminates charging and the magnetization of the Fe replicates that of the garnet. Fig. 2 shows a SEMPA measurement of an Fe/Cr/Fe sandwich. The magnetic coupling of the Fe/Cr/Fe system was studied as a function of Cr thickness by depositing a Cr wedge. Fig. 2a shows the domain pattern of the Fe crystal substrate. Fig. 2b shows the domains in the Fe/Cr/Fe sandwich. The domain reversals show that the coupling oscillates between ferromagnetic and antiferromagnetic as a function of Cr thickness.

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5. This work was supported in part by the Office of Naval Research.