ABSTRACT

Shock induced demagnetization produced by strain induced magnetic anisotropy is considered in single crystal and polycrystalline ferromagnetic material. A consistent application of equilibrium thermodynamics in conjunction with established tools of ferromagnetic domain theory is used to develop energy expressions, magnetization curves, and domain structure in the magnetic material behind the shock wave. This approach has not previously been used to describe the shock induced anisotropy effect. In particular, specific expressions for the exchange energy and magnetic self energy are explicitly obtained. They are predicted to increase as the fourth root of the strain and are small compared to the induced anisotropy energy in the region of large elastic and plastic strain. A needle or sliver shaped domain structure oriented in the direction of shock propagation is expected to nucleate behind the shock front. These results follow from the domain theory analysis and have not previously been obtained.

In polycrystalline material, the averaging procedure required to predict the magnetic behavior is critically analyzed. The importance of magnetic grain-grain interaction is pointed out and magnetization curves for the extreme assumptions of interacting grains and independent grains are determined. The effect of porosity and finite strain is also considered. These results are compared with those obtained by Shaner and Royce (J. Appl. Phys. 39, 492 (1968)) for interacting grains and effects of finite strain.

Experimental demagnetization curves are obtained for shocked polycrystalline yttrium iron garnet at about one-third and two-thirds the Hugoniot elastic limit of the material. The results support the independent grain theory.