stress and the magnitude of the applied magnetic field. In this phenomenon deviatoric strains cause changes in the atomic crystal fields which determine the magnetic anisotropy and the competition between applied magnetic field and stress-induced magnetic anisotropy. A sufficient change in magnetic anisotropy may lead to a rotation of the equilibrium magnetization direction, which is perceived as "demagnetization" by a detector aligned to sense magnetization in the direction of the applied field.

Royce first tentatively proposed that anomalous shock demagnetization observed for a nickel ferrite ceramic was the result of stress-induced magnetic anisotropy [66R2]. Subsequent work on an yttrium–iron–garnet ceramic (YIG), a ferrite with lower magnetostrictive constants, by Shaner and Royce [68S1] confirmed that stress-induced magnetic anisotropy was the dominant operative mechanism in these materials even though anomalies were noted in the high-pressure behavior. Further evidence for apparent demagnetization by this mechanism was obtained on a nickel ferrite by Seay et al. [67S1]. Wayne et al. [70W1] reported "anomalous" hydrostatic-pressure-induced magnetic anisotropy in polycrystalline nickel ferrite and YIG which was found to arise from localized shear resulting from porosity of the samples.

Since stress-induced magnetic anisotropy is an elastic shear phenomenon, detailed studies are best conducted within the elastic range. Grady [72G1] has performed a careful and detailed experimental and theoretical study of the same YIG material utilized by Shaner and Royce [68S1]. Grady considered calculation of polycrystalline magnetoelastic constants from single crystal constants with both a traditional interacting crystallite assumption and an independent crystallite assumption.

The results of Grady's detailed experimental investigation of YIG within the elastic limit [72G1] with the method of fig. 4.7d is shown in fig. 4.8. The observed demagnetizations are quantitatively modeled by the independent grain assumption and clearly show that stress-induced magnetic anisotropy is responsible for the shock demagnetization.

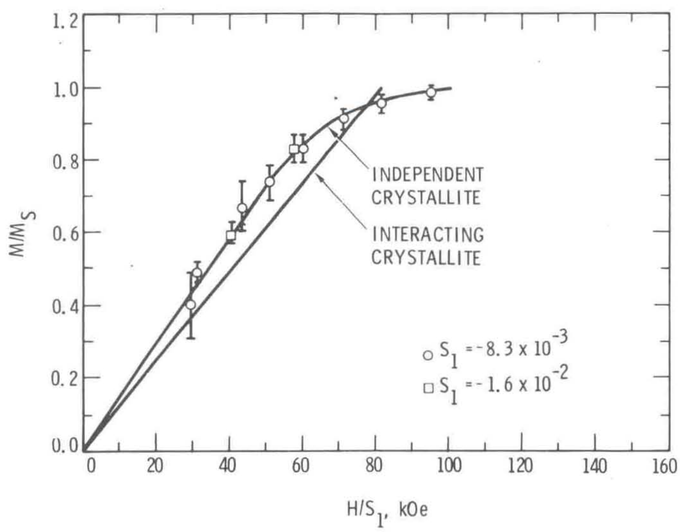

Fig. 4.8. Rotation of the magnetization direction in YIG ceramic samples causes an apparent demagnetization due to stress-induced magnetic anisotropy. Unlike shock demagnetization due to first- and second-order phase transitions, the effect is caused by elastic shear stress. The measured shock data of Grady [72G1] are all within the elastic range and are compared to his calculations with two different methods of computing the polycrystalline behavior from single crystal data.

The high-pressure measurements of Shaner and Royce still remain anomalous. Royce [71R3] proposed that their results could be explained by pressure-sensitive magnetoelastic constants such that $d \ln B/dV \approx 5.9$ per cent for each 1 per cent compression. Grady's measurements show no such effect. Heterogeneous yielding could conceivably affect the high-pressure behavior of YIG. Further studies are needed to resolve this anomaly.

Measurements on Supermendur, an iron–cobalt–vanadium alloy (see table 4.6) also indicate an anomalous behavior. Even though the material has a negative magnetostrictive constant and will not exhibit shock-induced demagnetization due to stress-induced magnetic anisotropy under uniaxial strain, a large demagnetization is observed with a sharp knee within the elastic range in the demagnetization versus stress behavior. This large effect has been identified as the result of lateral unloading waves which change the state of stress sufficiently to cause large rotations of magnetizations.

Studies to date indicate that the dominant features of shock demagnetization involving Curie point or polymorphic transitions can be treated by the compressible fluid approximation. Stress-induced magnetic anisotropy, which is inherently a shear phenomenon, is reasonably predicted by magnetoelastic constants.

4.9. Semiconductors

Electrical properties of semiconductors are sensitive to changes in energy band structure and impurities. Hence, it is possible to use fairly simple probes such as sample resistance or self-generated emf measurements or more sophisticated probes such as Hall voltage measurements to obtain reasonably direct information on fundamental properties. Static-high-pressure [63P1] and uniaxial stress [69S2, 60K1, 74B2] have proven to be effective in such studies since both the energy gap and relative level of critical points on the band structure can be changed with isotropic and anisotropic strain. Degeneracies in band structure can also be removed with application of anisotropic strain. Knowledge of such stress effects is essential for interpreting undesirable effects of stress on semi-conductor junction devices [68B4].

Unfortunately, the sensitivity of electrical properties to lattice defects makes it unlikely that measurements above the Hugoniot elastic limit will be subject to straightforward interpretation since inelastic deformation generates copious quantities of defects of essentially unknown character. Such has proven to be the case for resistance measurements above the HEL in germanium [66G1] and silicon [72C4]. Nevertheless, the large Hugoniot elastic limits of both germanium [72G5] and silicon [71G6] permit purely elastic strains of a few per cent to be applied to samples whose electrical properties are being studied.

The various investigations of shock-induced emf generation in semiconductors have been reviewed by Mineev and Ivanov [76M4] and Murri [74M3]. Emf measurements above the HEL in germanium [66G1, 70J2] and silicon [72C4, 71M4] show complex behavior of uncertain physical origin. The various investigations are summarized and reviewed by Mineev and Ivanov [76M4]. Kennedy [69K2] has performed a number of elastic shock-loading experiments on germanium with various carrier signs and concentrations. The results showed no obvious systematic behavior but signals of tenths of volts were routinely observed.

Kennedy and Benedick [67K2, 68K3] were successful in carrying out difficult Hall effect measurements in germanium samples explosively loaded at the upper end of the elastic range. The measurements did not provide sufficient information to develop a physical interpretation.