have been conducted, but the available evidence demonstrates that shock-induced conduction is a commonly observed but poorly understood effect. It has been attributed to a variety of physical effects, most unique to shock loading, and may also appear as an experimental artifact.

Shock-induced conduction plays a crucial role in the operation of many electrical devices in which insulating material is subjected to impact or other rapid loading. Piezoelectric and solid-dielectric gauges are limited in their performance by shock-induced conduction. The performance of pulse power supplies based on shock compression of piezoelectric or ferroelectric materials is similarly limited. Knowledge of the behavior of insulators under shock compression is required for interpretation of measurements made using piezoresistant gauges embedded in conducting samples [78B1], for insulation of magnetic compression devices [78H1], and for design of switches operating on the basis of a shock-induced switching between insulating and conducting states. From the scientific standpoint, shock-induced conduction is not only a phenomenon of intrinsic interest, but also one that must be understood in some degree if other shock-induced electrical effects are to be interpreted with assurance.

The literature on conduction under shock loading has been thoroughly reviewed through 1969 by Styris and Duvall [70S3], with less complete treatments being offered by Doran and Linde [66D3] and Keeler [71K2]. Experimental methods have been reviewed by Yakushev [78Y1]. Other related reviews include that of Kormer [68K5] on optical effects and that of Mineev and Ivanov [76M4] on conduction as related to interpretation of shock-induced polarizations. With these prior reviews as a guide to the literature, the present review can more profitably concentrate on general observations. In that regard it is well to observe that most of the work is fragmentary and largely exploratory. Careful and persistent work has been reported for the fluids CCl_4 [68M3] and xenon [71K2] in which detailed comparison between theory and conductivity measurements has been carried out. Such studies in fluids do not experience difficulties with measurement or interpretation which are found in solids.

Except for the thorough analysis developed for NaCl by Kormer [68K5], conduction measurements on alkali halides are summarized by Styris and Duvall [70S3] who also report important unpublished work of Murri and Doran and Doran and Ahrens. Much of the work on alkali halides has been interpreted in terms of intrinsic semiconduction which neglects shock-induced defects. Conductivity is assumed to result from a thermally-activated process and activation energies are determined from resistance measurements at the different temperatures resulting from compression by shocks of various strengths. The activation energies so determined have been used to compute energy gaps.

Such interpretations are open to considerable question and apparently disagree with calculations of the effect of pressure on energy bands. Most of the data are fragmentary (often there is only a single experiment) and the most thorough work (on CsI) consists of only seven experiments. Such limited data not only leave questions of representative material behavior unanswered, but do not permit examination of the question of experimental artifacts, ohmic behavior, transient behavior, sample size effects or heterogeneities caused by shock loading. It appears more likely that the activation energy values cited above are measures of extrinsic semiconduction dominated by shock-induced defects; a strong case for such behavior based on both optical and electrical data is given by Kormer [68K5] (see section 5). Such an electronic configuration can also lead to localized dielectric breakdown at high temperature [69K3]. Even the interpretation in terms of extrinsic semiconduction rests on the assumption that defect concentrations are fixed and independent of compression over the large range of compressions used to achieve the shock heating. It will be a difficult and demanding job to develop a quantitative physical interpretation of the observed conduction in the alkali halides.

Polymeric materials are widely encountered in shock experiments, yet there are few studies of their electrical resistance in states of shock compression. The most thorough work on polymers is that of Champion [72C1] who measured the resistance of Teflon (polytetrafluoroethylene), low-density polyethylene and high-density polyethylene at pressures from 10 to 55 GPa. Effects of variations in both sample area and thickness were studied and experiments were conducted at several applied voltages. Low-density polyethylene showed a three order-of-magnitude decrease in resistance from 15 to 38 GPa, while high-density polyethylene shows about a two order-of-magnitude decrease in resistance over the same pressure range. The resistance of Teflon remains an order of magnitude higher than that of high-density polyethylene at the same pressures. All materials apparently exhibited a large decrease in resistance at pressures less than 10 GPa. An anomalous absence of any change in resistance was noted for thin (0.6 and 1.3 mm thick) samples, with the observations being confirmed for high-density polyethylene by Hauver [70H2] and for Teflon by Kuleshova [69K4]. Of the polymeric materials studied, Teflon appears to exhibit the highest resistivity under strong shock compression; the apparent resistivity of thick samples is 100 Ωm at 55 GPa. Kuleshova and Pavlovskii [77K3] have recently reported transverse resistance measurements in Kaprolon ($\rho_0 = 1140\ \mathrm{kg/m^3}$) which they have interpreted in terms of a time-dependent resistivity. Electrical breakdown studies on Kapton, a polyimide film, have recently been reported [78G3, 79G6]. Polymorphic phase transitions observed in a wide variety of polymers [78C2] must be considered in interpretation of resistance measurements in these materials.

Other dielectric materials given limited study are summarized by Styris and Duvall [70S3]. Two materials, MgO and Al_2O_3, are of particular interest. Ahrens [66A1] measured electrical resistances of MgO crystals shock loaded along the [001] direction to a pressure of 92 GPa. He observed an apparent resistivity of only about 10 Ωm, a value that cannot be explained in terms of pressure-induced reduction of energy gap. It appears that shock-induced defects or localized heating due to heterogeneous yielding or localized effects at grain boundaries (see section 3.4) are required to explain the results. The shock-induced polarizations in this material are sufficiently high that self-generated electric fields may cause localized dielectric breakdown and lead to the observed conduction.

The large decreases in resistance observed in shock-loaded crystalline and polycrystalline Al_2O_3 have been summarized by Hawke et al. [78H1]. Although a number of different investigators have reported shock-induced changes in resistance, the measurements are quite limited; nevertheless, they all demonstrate that shock loading of samples with initial room-temperature resistivity greater than 10^{10} Ωm lowers the effective resistivity to between 10^3 and 10^{-4} Ωm [78H1].

Shock-induced conduction in piezoelectrics is differentiated from that in other dielectrics because it is observed under the unusually high electric fields produced by the piezoelectric effect in the thick-sample configuration. Shock-induced conduction observed in quartz and lithium niobate has been identified as dielectric breakdown or a prebreakdown electrical process associated with electric fields in the range of 10^7 to 10^8 V/m. The dielectric strengths under shock loading are less than 10 per cent of the atmospheric-pressure values. Given the high shear stress present in these experiments, it is not difficult to believe that dielectric strength could be reduced, but the physical mechanisms responsible for the observations have not been identified. In spite of interest extending over fifteen years and the conduct of a number of detailed investigations, no physical model for shock-induced dielectric breakdown has been developed. Fortunately, the breakdown