a direct measurement of irreversible effects, most likely attributable to shock-induced defects. Their data, shown in fig. 4.11, indicate that if the defects are not taken into account, poor agreement is observed between their predicted piezoresistive, elastic-plastic model and other observations. Accounting for the observed residual effects brings their results in good agreement with calculations. The synchronous measurement of resistance of the decompressed material adds an additional important diagnostic tool which could be effectively utilized in future studies. Although there are only limited quantitative studies of such residual resistances after Manganin is unloaded [78K2, 79S3], it is recognized that such effects are commonly observed [74M3].

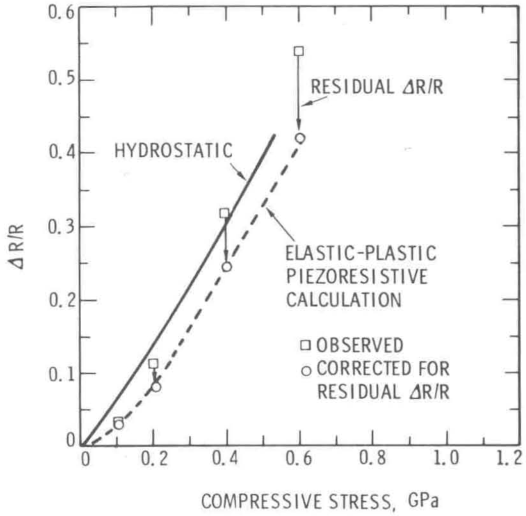

Fig. 4.11. Measurements of resistance change of ytterbium samples subjected to controlled shock compression and decompression show evidence for the change in resistance resulting from shock-induced defects [73G3, 77G3]. When the data describing resistance-change upon loading are corrected for the residual resistance change measured upon decompression, the result is in good agreement with the resistance change computed from elastic-perfectly plastic piezoresistive calculations. The measured resistance change for hydrostatic loading is shown for reference. This investigation provides quantitative data on effects of shock-induced defects on resistivity in the shock-compressed state.

4.11. Thermoelectric junctions

Metallic or semiconductor junctions are of interest for thermoelectric temperature measurements under shock compression. The first measurements of emf values from such junctions were reported by Jacquesson [59J1] in 1959 with a more complete account in 1965 [65C3]. This work and subsequent work by Jacquesson, his coworkers and a number of Soviet scientists showed the existence of emf values twofold or threefold larger than those observed in static-high-pressure studies. After years of experimentation and the development of theories for nonequilibrium electronic effects to account for the anomalously large emf values, it has recently become clear that experimental artifacts are responsible for the anomalously large signals.

Mineev and Ivanov [76M4] have given a summary of experimental observations. Nesterenko [75N2] has summarized and evaluated various theories used to explain the anomaly and pointed out the importance of the interface. Bloomquist and coworkers [78B5, 78B6] have reviewed the literature and measured signals close to predicted values in experiments with precisely-controlled interfacial conditions.

Buzhinskii and Samylov [70B6] were the first to call attention to dominance of interfacial details in their measurements on ground and polished surfaces and on diffusion-bonded interfaces which showed emf values only about 60 per cent greater than predicted. Furthermore, with good time resolution, they observed emf "flashes" as shock waves crossed interfaces. In careful, detailed optical measurements Urtiew and Grover [74U2] observed high local temperatures at interfaces between transparent and opaque solids. Nesterenko and Staver [74N1] compared emf measurements from polished and slightly roughened interfaces and found that coarse interfaces exhibited emf values about twofold greater than the polished interfaces. Bloomquist [78B5] worked with very carefully prepared diffusion-bonded interfaces with guard rings and measured emf values only about 20 per cent higher than predicted.

Although a significant discrepancy may still exist, it is clear that localized nonequilibrium heating provides the explanation for the anomalous emf values and that the classical thermoelectric effect is the dominant mechanism for the generation of emf at metallic contacts. Given the critical nature of the interface, it remains problematical whether a "perfect" preshock interface can be achieved and if so, whether the localized shock deformation around grains boundaries or other defects will cause significant localized heating. Even though the viability of absolute temperature measurements with metallic contacts is open to question, it should be observed that Mikhailov et al. [76M3] have effectively used thermoelectric measurements to evaluate explosive welding parameters.

The effect of electron heating in most metals is expected to be localized at the shock front, the long electron mean free path and low effective mass in bismuth can lead to electron heating ahead of the shock at low temperatures. Measurements in bismuth at 20 K have shown such an effect [74N2]. Nesterenko and Staver [74N2] show that for most metals at 300 K the electron heating is no more than 10^{-8} m in advance of the shock front.

5. Optical properties

Physical conditions within transparent shock-loaded solids can be effectively probed with optical techniques, yet such work is quite limited. There have been few systematic optical investigations but a variety of measurements have been made and investigators in the Soviet Union have carried out persistent studies on optical properties of alkali halides and fluids at very high pressure. Optical studies up to 1968 are thoroughly reviewed by Kormer [68K5] and limited information is contained in the review by Doran and Linde [66D3]. This information was brought up to date by Murri et al. [74M3]. Because of these reviews, it is sufficient to call attention to important trends and more recent work, particularly refractive index measurements within the elastic range. A summary of measurements and theory of the photoelastic effect are given in the Landölt–Börnstein series [69B1]. Vedam and coworkers have carried out extensive studies of piezooptic effects under static high pressure [66V2, 65V1, 69V1, 76V2] and under uniaxial stress [72S1].

Kormer's review emphasizes investigations at pressures sufficient to produce compression of about 30 to 50 per cent. At these compressions, the samples are subjected to shock heating leading to temperatures ranging from about 500 to 20000 K. Optical measurements summarized include: (1) structure of the shock front. It is found that the optical thickness of the shock is about