Post mortem examination of the shocked BaF_2 specimens by x-ray diffraction techniques showed that the materials were in the β-BaF_2 phase. There was no trace of the α-BaF_2 in either specimen.

V. DISCUSSION OF EXPERIMENTAL RESULTS

In the previous section we established that (1) stress profiles observed in BaF_2 reflect its mechanical properties within the limitation of the recording instruments, (2) shock recovered specimens of BaF_2 were found to be in the β- phase and (3) information from the transmission shots is too meagre to yield any significant insight in interpreting the data.[22] In light of the above, we shall try to elucidate the behavior of BaF_2 on the basis of experimental observations resulting from front surface impact and recovery experiments.

It is useful to make some remarks about the time scale of the events recorded in these experiments. The minima occur between 5 and 12 nsec after impact, and their times of occurrence decrease with increasing impact pressure. These minima are sharp and have no temporal spread. The times taken to reach steady state bear no relation to the value of the steady state impact stress. The steady state stress is reached within a time interval of 23-62 nanoseconds for impact stresses above 25 kbars. These time intervals which add to less than 80 nsec, are well within the time at which the disturbing effects of using shorted quartz gages would seriously affect the recorded stress-time profile in these experiments.

If the presence of a cusp is taken to indicate the onset of a transition in BaF_2, one may conclude that the observed transition in BaF_2 is shear induced. This is because in a fluorite structure shear stresses developed in specimens oriented along the <111> and the <100> directions are equal to 26.1 and 0.0 per cent of the applied normal stress, respectively.[23,24,25] Since recovered specimens of BaF_2 were found to be in β-phase, one may conclude that the transition is a reversible one. Thus, in this regard, the response of BaF_2 to shock compression is like the response of BaF_2 to a hydrostatic stress environment.

Information available from experiments reported here is not enough to enable us to characterize the BaF_2 under these conditions. We do note, however, that the upturn of stress following its initial decay, shown in Fig. 2, is consistent with a simple relaxation model of the material. To see this, consider the configuration in which a stationary quartz gage is struck by a moving BaF_2 sample. Let the constitutive relation for BaF_2 be of the form[26]

$$\frac{d\sigma_x}{dt} - a^2 \left(\frac{d\rho}{dt}\right) = -F \qquad (3)$$

where a is the speed of elastic compression in material of density ρ, σ_x is the longitudinal stress, and F is a function characterizing the rate at which an equilibrium stress is reached in the shocked material. The specific form of F depends upon the type of process or processes through which the material relaxes. In general F can be a function of static as well as rate dependent variables. Let h be the Lagrangian space coordinate for the problem. Then for arbitrary h, equation (3) becomes

$$(\partial\sigma_x/\partial t)_h - a^2(\partial\rho/\partial t)_h = -F. \tag{4}$$

The equations expressing mass and momentum conservation, in Lagrangian coordinates are, respectively

$$(\rho_o/\rho^2)\cdot(\partial\rho/\partial t)_h + (\partial u/\partial h)_t = 0, \tag{5}$$

$$(\rho_o/\rho)\cdot(\partial u/\partial t)_h + (1/\rho)\cdot(\partial\sigma_x/\partial h)_t = 0. \tag{6}$$

Combining Eqs. (5) and (4) we obtain

$$(\partial\sigma_x/\partial t)_h = -(a\rho)^2\cdot(1/\rho_o)\cdot(\partial u/\partial h)_t - F. \tag{7}$$

At the interface, we have, referring to Fig. 1,

$$(\partial\sigma_x/\partial t)_{h=0} = Z_q\,(\partial u/\partial t)_{h=0} \tag{8}$$

where $Z_q = \rho_q D_q$. Substituting the value of $(\partial\sigma_x/\partial t)_{h=0}$ from Eq. (8) into Eq. (7) we obtain

$$Z_q(\partial u/\partial t)_h = -(a\rho)^2\cdot(1/\rho_o)\cdot(\partial u/\partial h)_t - F. \tag{9}$$

The stress profile obtained for BaF_2 indicates that after the initial rise, say at time t = 0, stress and particle velocity decrease up to a time τ_1 where they both attain an extremum value. From time τ_1 to some time τ_2, stress and particle velocity increase and beyond τ_2 the stress and particle velocity are constant. For these time intervals, we have

$$(\partial u/\partial t)_{h=0} < 0 \qquad 0 \le t < \tau_1 \tag{10a}$$

$$(\partial u/\partial t)_{h=0} = 0 \qquad t = \tau_1 \text{ and } \tau_2, \text{ and} \tag{10b}$$

$$(\partial u/\partial t)_{h=0} > 0 \qquad \tau_1 < t < \tau_2 \tag{10c}$$

Since F is always positive, it implies that in order to obtain the observed profile one must have for

$$0 \le t < \tau_1, \qquad (a\rho)^2\cdot(1/\rho_o)\cdot(\partial u/\partial h)_{t,h=0} < F \tag{11a}$$