Effect of epoxy bonds on VISAR measurements

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Background and Objective

Recent improvements in the VISAR system at the Institute for Shock Physics have revealed high frequency features previously assumed to be instrument noise, which do not occur in numerical simulations of impact experiments.

Figure 1 shows a particle velocity plot obtained during a 36.8 kbar symmetric impact of two, 3.1 mm thick LiF samples backed by a 8.1 mm thick LiF window. The window was affixed to the target using an epoxy mix of Epon 815 resin and Hysol HD 3490 hardener, commonly referred to as '815 epoxy'. The bond thickness was measured to be 1 μm. Also shown on the graph is the output of a numerical simulation using COPS. The numerical prediction of a flat top particle velocity history was not observed in the experiment. Instead, the experimental data revealed an oscillatory response.

For comparison, Figure 2 shows the velocity profile obtained during a 35 kbar symmetric impact of a 3 mm thick fused silica impactor, onto a 3 mm fused silica target backed by a 3 mm z-cut quartz window affixed with 815 epoxy. We see that the peak particle velocity is quite flat.

The fluctuations have also been observed using a CdS impactor hitting a quartz buffer backed by a quartz window, but were not seen in an otherwise identical experiment without a buffer. Figure 3 shows the velocity profile obtained for a ~0.5 mm thick CdS impactor hitting a 0.5 mm quartz buffer backed by a 3 mm quartz window at a peak stress of 49.3 kbar. The epoxy used was 815. The sharp spike at 0.95 μs corresponds to the time taken by the initial shock wave to make a round trip in the buffer. The velocity profile after this time shows more flucutations with time. This is repeatable, and a second experimental result is shown in Figure 4 for an identical arrangement impacting at 48 kbar in which the spike occurs at 0.88 μs. For comparison, a simple unbuffered impact of CdS against a quartz window at a stress of 48 kbar, which is also shown in Figure 4, does not show a marked increase in fluctuation over the same time.

LiF exhibits stress relaxation after the elastic wave. CdS, shocked above ~32 kbar, undergoes stress relaxation at the impact surface due to a structural phase transition and this will result in a stress relaxation in the wave propagating into the window. *These results suggest that the presence of a stress relaxing wave and the existence of an epoxy bond likely combine to produce the observed fluctuations.*

The purpose of this work was to determine whether changing the epoxy type affects the fluctuations. Three types of epoxy were tested in an identical arrangement of a symmetric LiF impact backed by a quartz window.

Experiments

Figure 5 shows the experimental arrangement used in all three cases. The LiF samples were 3.10 mm thick, 25.4 mm diameter and the z-cut quartz window was 3.51 mm thick, 25.4 mm diameter. The measured epoxy bond thickness in each case was 1 μm.

Epoxies

The three epoxies tested were 815, Epotek 301 and Trabond 2115. Epon 815 is the standard hard epoxy used routinely for experimental work and is the most viscous of the three. Epotek 301 is the least viscous, and is less hard when cured than the 815. The Trabond 2115 is a newly acquired type of epoxy, which combines low viscosity with high hardness after curing.

Results

Figure 6 shows the velocity profiles from all three experiments, which were conducted at a peak stress of 50 kbar. We see that there is little difference in the traces due to the epoxy type, and that they all deviate from the 'flat top' trace predicted by numerical simulations.

Discussion and Recommendations

Changing the type of the epoxy used does not qualitatively affect the fluctuations observed at the mirror surface. However, from the results shown in Figure 6, 815 epoxy appears to give a slightly smoother profile. Trabond 2115 seems to produce the most fluctuations, and so if a low viscosity epoxy is needed, for example for a thin bond between fragile samples, then Epotek 301 should be used. Without a careful examination of the shock response of each of these epoxies, the observed differences in Figure 6 cannot be analysed further.

If a buffered target window is a necessity in the experiment one should avoid using LiF or any other material that exhibits stress relaxation as a buffer. Whenever possible, an elastic buffer material (Z-quartz, sapphire) should be used.

Shot #97-506

Particle Velocity vs. Time
Symmetric Impact of LiF (100) Backed by a LiF (100) Window

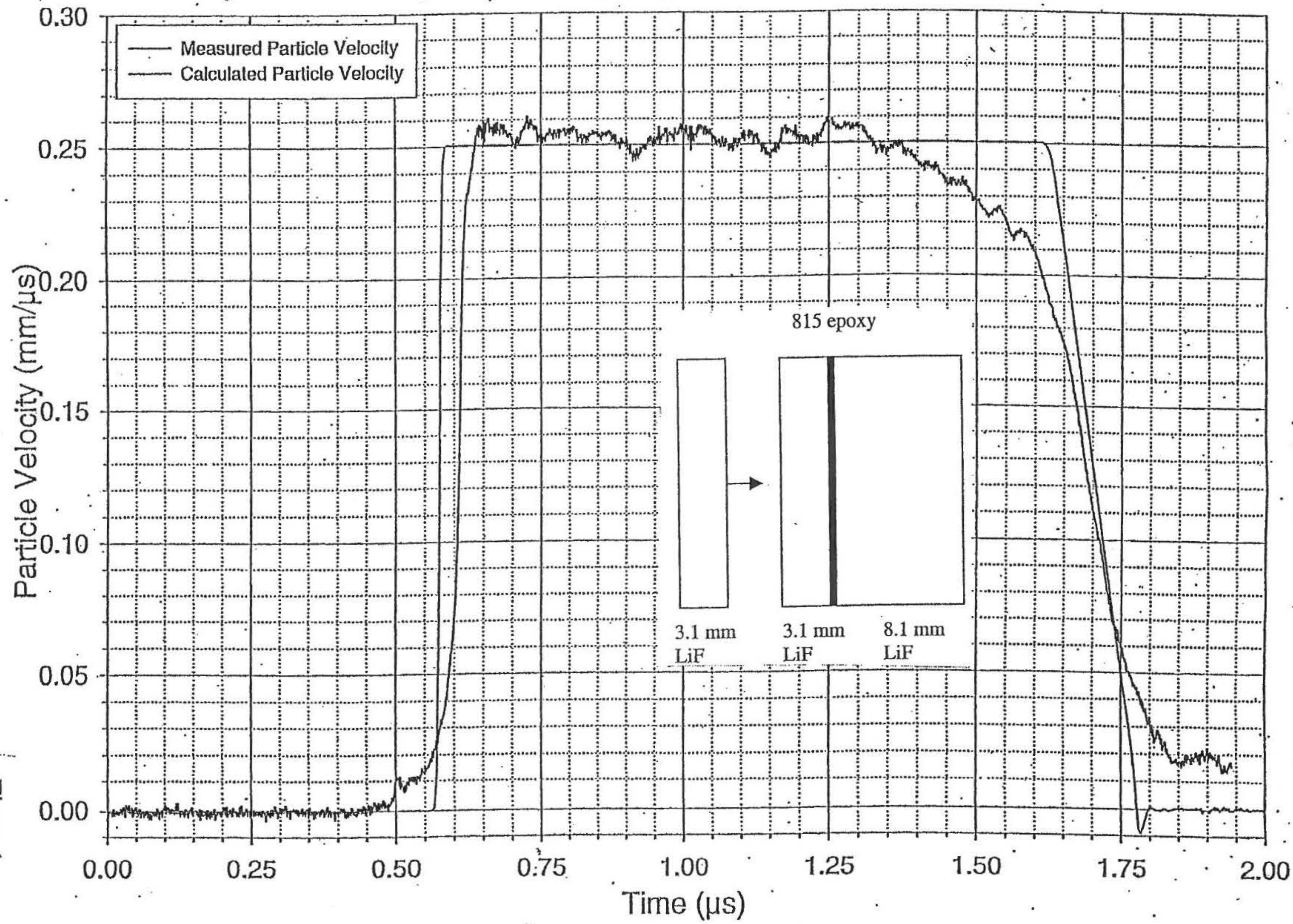

Figure 1

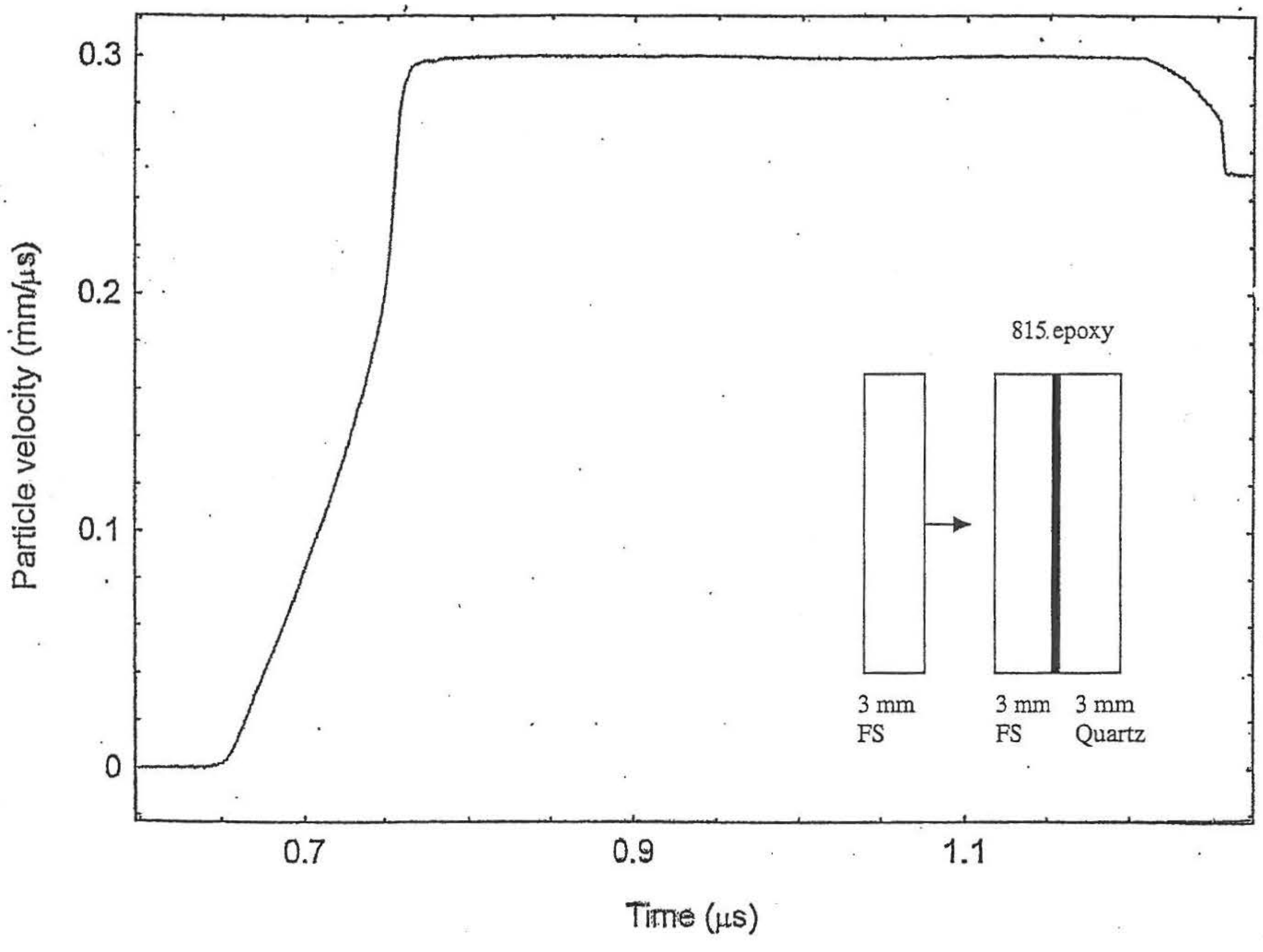
0.3
0.2
0.1
0
Particle velocity (mm/μs)
0.7
0.9
1.1
Time (μs)
815 epoxy
3 mm
FS
3 mm
FS
3 mm
Quartz

Figure 2

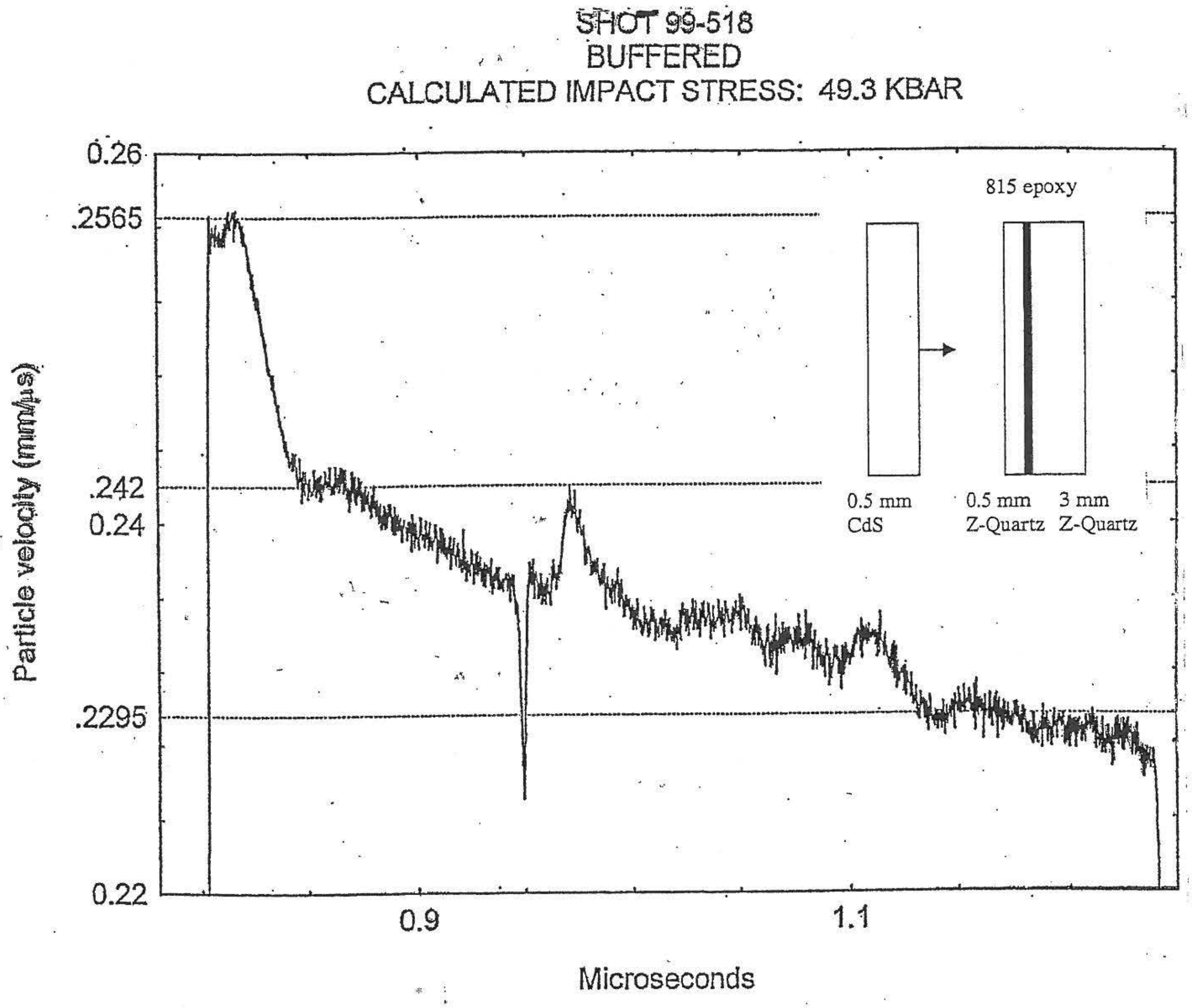
SHOT 99-518
BUFFERED
CALCULATED IMPACT STRESS: 49.3 KBAR
0.26
.2565
.242
0.24
.2295
0.22
Particle velocity (mm/µs)
0.9
1.1
Microseconds
815 epoxy
0.5 mm
CdS
0.5 mm
Z-Quartz
3 mm
Z-Quartz

Figure 3

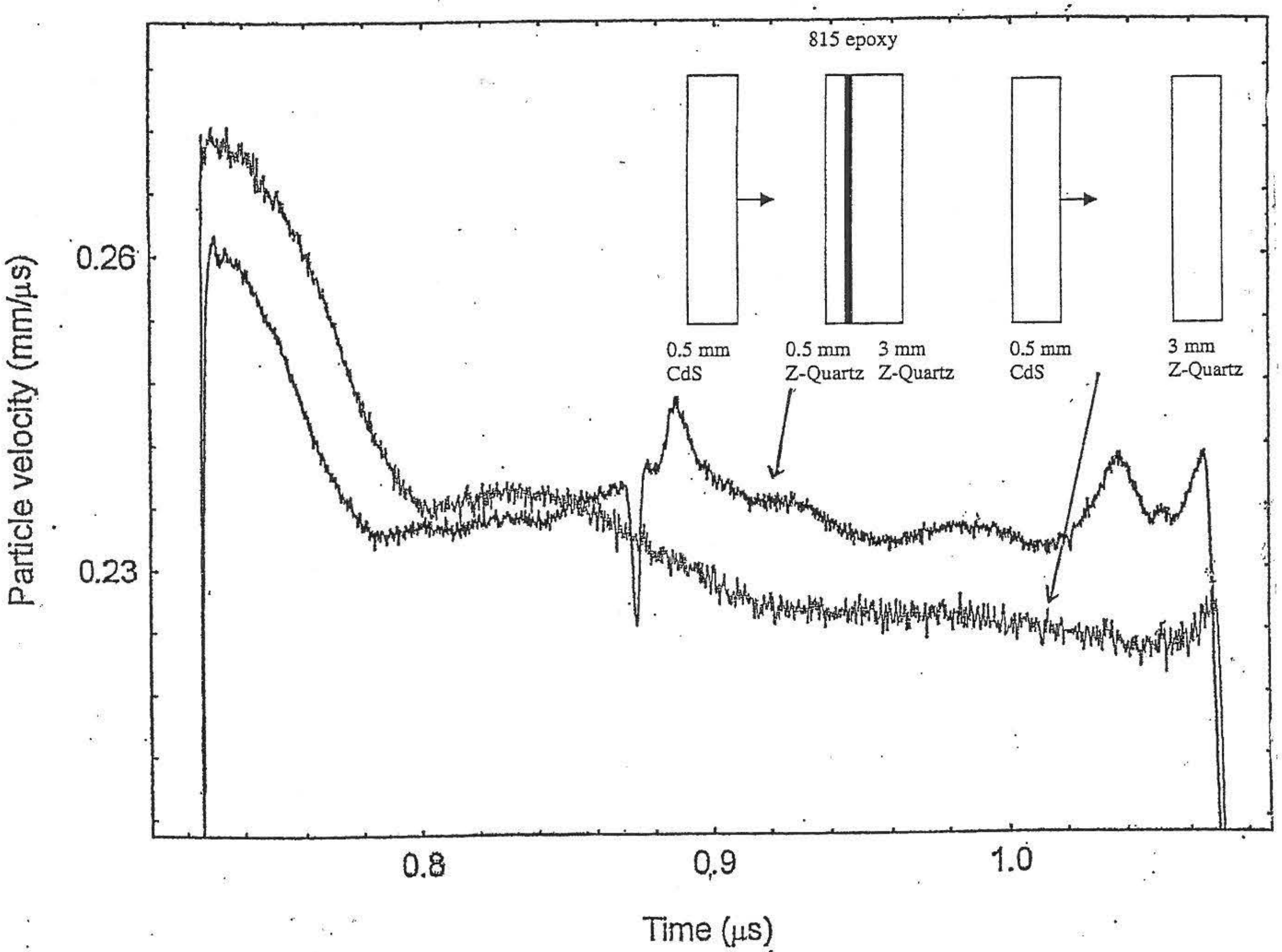
815 epoxy
0.5 mm
CdS
0.5 mm
Z-Quartz
3 mm
Z-Quartz
0.5 mm
CdS
3 mm
Z-Quartz
Particle velocity (mm/μs)
0.26
0.23
0.8
0.9
1.0
Time (μs)

Figure 4

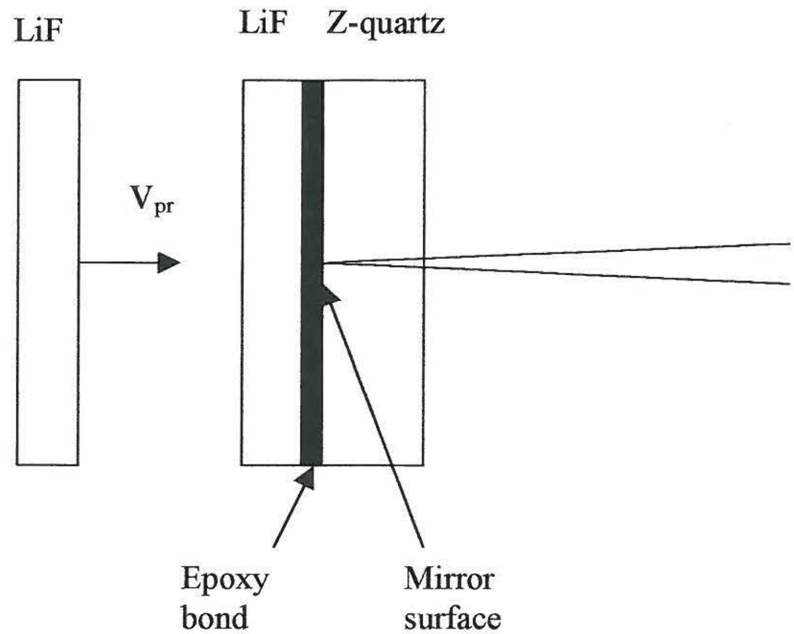

Figure 5

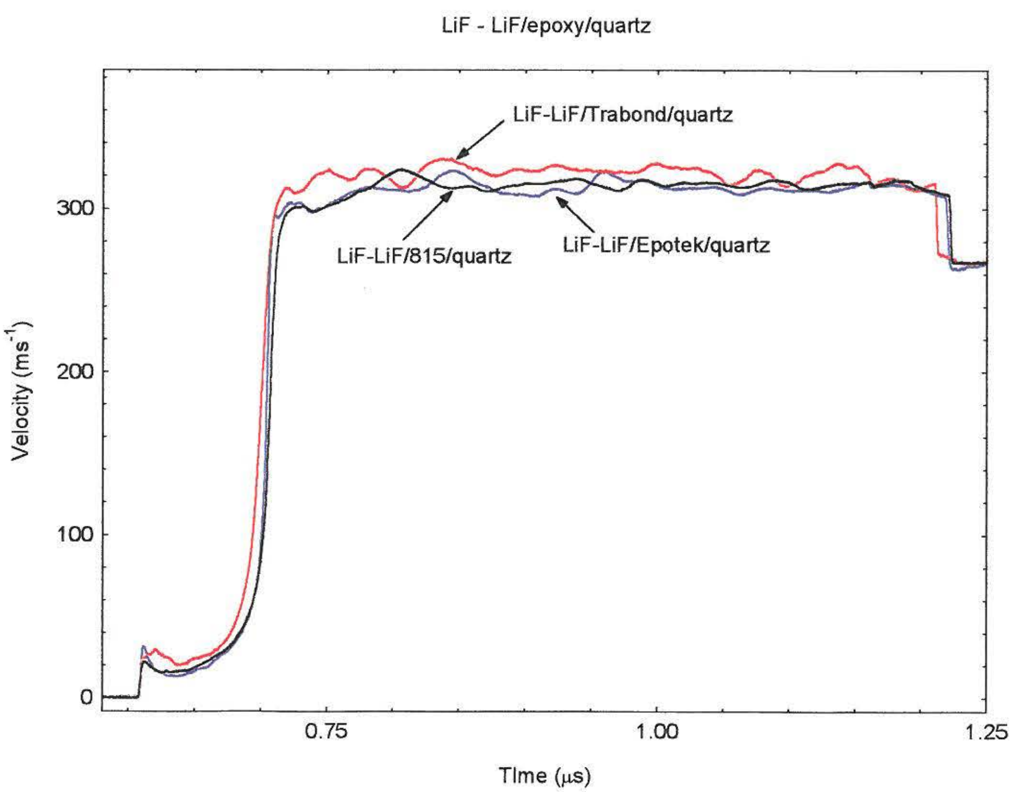

Figure 6