Vibrational Spectroscopy of Laser Shocked PMMA

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Abstract

An understanding of material behavior under shock compression is important for variety of applications such as study of material dynamics and chemical reactions. Also, the insight into the pressure, volume and temperature of the materials under shock compression are important. Particularly, in deriving the equation of state of the materials and predicting materials response under extreme temperature and pressure conditions.
Several studies on polymethyl methacrylate (PMMA) under static pressure using Diamond Anvil Cell (DAC) has been carried out. However, the literature on response of PMMA under shock compression still has to be elaborate. The objective of this paper is to understand the response of PMMA under shock compression at molecular level using a pump probe experimental set up. The experiments were performed on confined geometry target assembly by pump and probe technique using high power pulsed laser. The target assembly consists of a cover glass (100×100×5 mm3), a PMMA film sheet (200μm thick), an aluminum foil (50μm thick) and a back-up glass (100×100×5 mm3). The time resolved studies of shock affected region were done by providing delay between pump and probe beam.

The pressure responses of the C-H stretching modes of PMMA in the range 0 to 1.94 GPa range were analyzed. The C-H stretching mode of PMMA observed in this study show inhomogeneous broadening, shift to higher frequency and decrease in intensity with pressure. To estimate the maximum shift under shock compression, it is needed to decompose the Raman spectra and calculate the pressure induced Raman blue shift. The obtained spectra under shock compression are analyzed by fitting double Gaussian peaks.
Both of the observed modes i.e. at 2954 and 2977 cm-1 show increase in the Raman shift with pressure. These shock compressed states are also compared with the static compression data, to see if any general trend can be established. All observed results indicate that the PMMA is stable for the present experimental conditions, with no phase changes or degradation under shock compression. The results of this type are very helpful for benchmarking the theoretical model of materials under high amplitude shock wave compression.

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