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Indentation of a Melt-Quenched Zeolitic Imidazolate Framework Glass

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Recently, a new family of melt-quenched glasses has emerged, namely, the melt-quenched zeolitic imidazolate framework (MQ-ZIF) glasses [1, 2]. Despite several breakthroughs in understanding the nature of these glasses, their mechanical properties have not been well characterized and understood, such as ultrahigh Poisson's ratio [2]. Indentation is a sensitive method for revealing the deformation mechanism and crack propagation of glasses [3, 4]. The nano-indentation has proven to be especially useful in characterization of glass materials with limited size, e.g., glass fibers [5].

In this work, we employed both micro- and nano-indentation to characterize the deformation mechanism of the MQ ZIF-62 ($Zn(Im)_{1.75}(bIm)_{0.25}$) glasses. Vicker's micro-indentation was performed at various loads to assess the scaling effect's influence on hardness, fracture behavior, and indent morphology. Cross-sections of the indents were analyzed to reveal the deformation mechanism and the sub-surface cracking pattern. Nano-indentation studies were conducted to compare nano- and microscale behavior of the samples. The load-displacement curves were used to analyze the elastic and permanent deformation during indentation. Nanoindents were characterized by Atomic Force Microscopy to evaluate the volume of the indent and pile-up pattern, and determine the contribution of the shear flow to indentation-induced deformation of MQ ZIF-62. The deformation mechanism and cracking pattern are found to be similar to those of the fully polymerized oxide glasses like fused silica [4], yet the pile up is minimal. This implies that shear flow has little contribution to the indentation-induced deformation of ZIF-62 glass.

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