Fracture behavior of a tough bulk metallic glass at micrometer dimensions

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Bulk metallic glasses (BMGs) are a promising material group for applications in micro- and nano-electro-mechanical-systems due to their unique physical properties, such as a comparably high hardness and elastic limit, paired with amorphous structure and certain glass specific traits. Despite significant research efforts performed on BMGs to date, spare data is available for mechanical properties at the micrometer size regime, as required for the above mentioned usage. While glasses commonly suffer from shear localization, leading to macroscopic brittle behavior, inherently ductile metallic glasses exist, which show extraordinary high resistance to crack propagation under bending load.

This special case of crack tip plasticity poses an issue to the conventional description of fracture toughness and therefore further detailed investigation on the fracture process is require. The present work strives for a deeper insight into the deformation mechanism and fracture behavior of a strong and ductile BMG, namely $Pd_{77}Cu_6Si_{16}$, in the micrometer regime. Multiple notched micro-mechanical samples in the shape of cantilevers were prepared by focused ion beam milling with different ligament sizes of 1, 2 and 5 µm, which were subsequently tested in-situ in a scanning electron microscope to observe the fracture process.

The specimens showed excessive blunting, which was captured by visual measurement of the crack tip opening displacement. Standardized fracture toughness models could not be applied due to a lack of significant crack propagation. Nevertheless, a significant size dependence in fracture behavior in the investigated regime was documented.