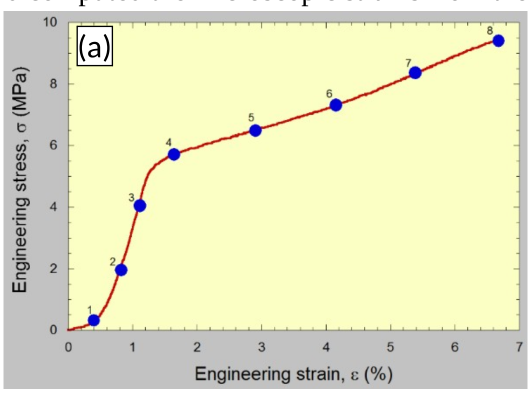
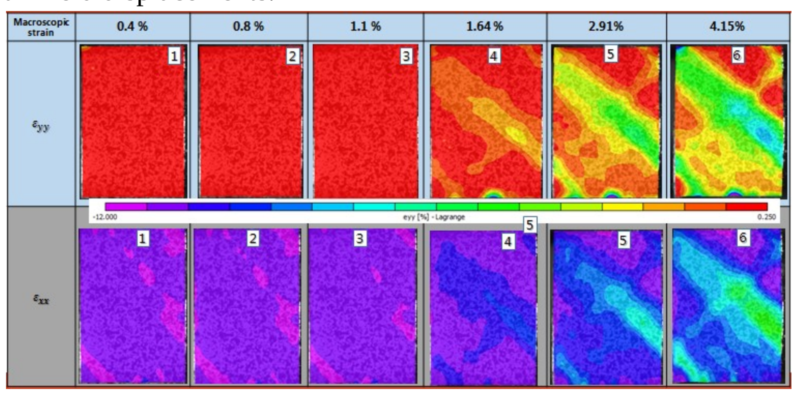
Evaluating deformation heterogeneity of Magnesium using digital image correlation

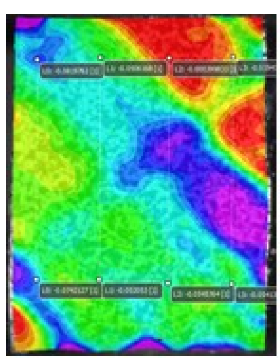
Research highlight from Mechanics of Materials (MoM) group at MEMS, IIT Indore

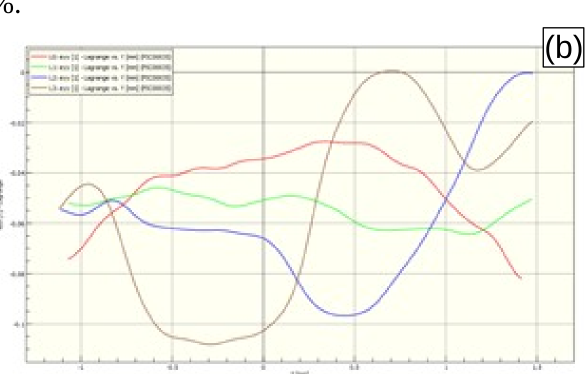
Magnesium and it alloys are considered as potential replacement of steel and Al alloys owing to their high specific properties. While their density is approximately 1/5th of steel and 2/3rd of Al alloys, the strengths are comparable. Thought they offer excellent die-casting properties, their widespread applicability is limited by the poor formability which is attributed to their low symmetric hexagonal close packed (HCP) crystal structure. HCP materials, at room temperatures, do not contain five independent slip systems needed for homogenous plastic deformation. Hence twinning, besides slip, plays a dominant role in the plastic deformation which makes the deformation highly inhomogeneous. Inorder to develop new Mg based alloys, it is important to characterize and quantify the heterogenous nature of deformation. Conventional contact-based strain measuring techniques (e.g. extensometer or strain gauge) are only useful in computing the macroscopic strains and hence we resort to the digital image correlation (DIC), a non-contact strain measuring technique to evaluate the localized deformation. This method involves computing the strains with the help of suitable correlation functions from a series of images recorded during deformation. Therefore, it is possible to obtain full field strain maps at any instance of deformation. We have carried out compression experiments on single crystal Mg samples oriented for basal slip and computed the microscopic strains from the full field displacements.





The engineering stress vs. strain curve along with the points where the local strains are obtained is presented in Fig a. The difference between macroscopic strain (computed with the extensometer reading and dimensions of the specimen) and microscopic strain (obtained from DIC measurements) along the y-direction (ε_{yy}¿ is evident from the strain contour maps. The red color indicates the lowest strain while pink indicates the highest strain. The deformation is localized in thick slip band which is about 45^{o} to the loading axis. At a macroscopic strain of 4.15 %, the strain in this localized band is about 12 %.





The local variation of strain along the compression axis further substantiates the heterogeneous nature of deformation as shown in Figure **b**. The macroscopic strain corresponding to this deformation is 6% while local strains at the platen-sample interface reached as high as 14%. Further, it is also possible to witness a large deformation at the sharp corners of the cuboidal samples due to the geometry effects.