

Towards the Development of a New Iron Age

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ABSTRACT

Steel in its various forms is the most widely utilized metallic alloy and comprises over 80 % by weight of all metallic alloys in industrial use. The development of steel microstructures is based on manipulation of a very specific solid/solid state transformation called an eutectoid transformation (i.e. $\gamma_{\text{austenite}} \rightarrow \alpha_{\text{ferrite}} + \text{Fe}_3\text{C}_{\text{cementite}}$). The control of this transformation is the primary factor resulting in wide variety of microstructures and resulting properties found in commercial steel alloys. However, the full benefit of its main constituent, iron has never been realized. Based on the metallic bonding in iron, the theoretical tensile strength has been calculated to be 13.2 GPa but ultra high strength steels, even today, only achieve maximum tensile strength levels from 1 to 1.5 GPa. Thus, our modern technological society has been established utilizing approximately only ~ 10 % strength level of iron. Here we demonstrate that a high level of strength (6.2 GPa) and strength to weight ratio of $8.3 \times 10^4/\text{m}^3$ may be obtained in iron-based alloys by their solidification into metallic glasses, as well as, by employing another solid state transformation called glass devitrification.