Phase evolution, microstructure and interfaces in Fe-based bulk amorphous alloy coatings on steel

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Recent years have witnessed an upsurge in the development of Fe-based bulk amorphous or partially crystallized alloy coatings with promising mechanical and electronic properties in combination with good corrosion resistance. However, the growth of these amorphous alloys to a desired thickness seems to be difficult owing to change of cooling rate. Within the last couple of decades, efforts have been made to develop alloys with high glass forming ability (GFA). This is important for the successful implementation of amorphous coatings over a substrate with desired microstructures.

In the present work, three Fe-based bulk amorphous alloy compositions have been synthesized through rapid solidification and thick coatings have been deposited onto steel substrates through spray forming technique. X-ray diffraction (XRD) and transmission electron microscopy (TEM) have been utilized to characterize the microstructure, structure, and interfaces. One of the three compositions turned out to be XRD amorphous whereas other two compositions displayed weak peaks confirming the presence of some crystalline phases in the powder. However, TEM observation assured the presence of crystalline phases in all the powder samples. Diffraction patterns and high-resolution (HRTEM) images obtained from the crystalline phases matched mostly with transition metal carbides belonging to face centred cubic (FCC) structures. The other two compositions were melt spun to produce ribbons. XRD results of both these ribbons depicted their amorphous nature. However, nano-crystalline phases were also detected during TEM observation. Similar kinds of crystalline phases were also found in the coatings present on the steel substrates when investigated under XRD. Moreover, the bright field image and the diffraction pattern acquired from the cross-sectional sample of the coating showed some faceted crystals in the size range 30-100 nm, represented in figure 1, which were also confirming the existence of transition metal carbides such as FeCrC, CrC and Fe_4C.

The presence of crystalline phases could be attributed to the variation in chemistry and localised fluctuation in the cooling rate during synthesis. Enthalpy contour maps have been computed in order to determine composition range for good GFA within the entire amorphous phase composition range in Fe-based ternary systems. The evaluation of contours is done on the basis of enthalpy difference values following Miedema's model, higher is the negative enthalpy difference, greater the tendency towards complete amorphous structure. The microstructural characterization and designing of Fe-based bulk amorphous alloys will be presented.

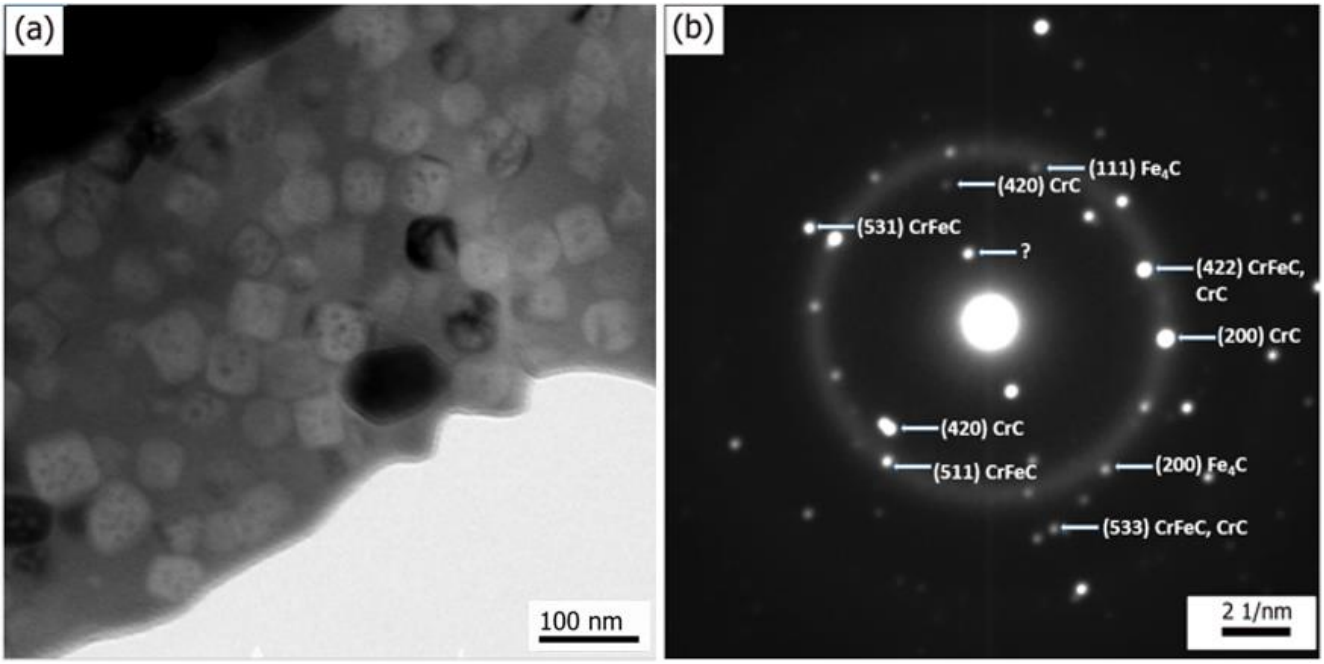

Fig.1. TEM cross-section images a) Bright field image showing the crystals of various transition metal carbides b) Diffraction pattern corresponding to bright field image confirming transition metal carbides.