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Laser-induced breakdown spectroscopy using laser pulses delivered by optical fibers for analyzing Mn and Ti elements in pig iron

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Abstract

A portable fiber-optic laser-induced breakdown spectroscopy (FO-LIBS) system was developed and employed to quantitatively analyze Mn and Ti elements in pig iron. The ablated craters produced by FO-LIBS are shallower with flatter bottom surfaces as compared with those produced by a conventional LIBS system without using optical fibers to deliver the laser pulses. This is beneficial on the special occasions requiring shallower destruction. The time-resolved images of plasma plumes were obtained and compared using both LIBS systems. Plasmas with lower temperature and electron density generated by the FO-LIBS system were thinner and more uniform, which means a lower self-absorption. Using the FO-LIBS system, the coefficients of determination (R^2 factors) of calibration curves for Mn and Ti elements were 0.997 and 0.998, respectively. The leave-one-out cross-validation (LOOCV) method was used to evaluate the detection accuracy. The root-mean-square errors of cross-validation (RMSECV) for Mn (concentration range 0.072–2.06 wt%) and Ti (concentration range 0.006–0.399 wt%) elements were 0.0501 and 0.0054 wt%, respectively. These results are comparable with or even slightly better than those obtained by conventional LIBS. Furthermore, the FO-LIBS system is more compact and cost effective, more suitable for harsh environments, and hence more promising for industrial applications.