**Abstract**

Multiferroics with chemical formula BiAl*x*Fe1−*x*O3 (*x* = 0, 0.1, 0.2, and 0.3) and substituted by Al are synthesised using sol–gel auto-combustion. The materials are sintered at 500 °C for 5 h. In the ongoing study, the crystal structure of BiAl*x*Fe1−*x*O3 was investigated by X-ray diffraction. After confirming the rhombohedral single-phase crystal structure, various characterisation techniques, such as scanning electron microscopy (SEM), energy-dispersive X-ray (EDX) spectroscopy, elemental mapping images, electrical properties, Fourier transform infrared spectroscopy, and vibrating sample magnetometry (VSM), were used to investigate the synthesised samples. The grain size estimated from SEM images decreased as Al contents increased. Elemental composition was confirmed by EDX spectra. Direct current electrical resistivity increased whereas drift mobility decreased with increasing Al contents. The VSM results of Al-doped BiFeO3 (BFO) demonstrate that BFO crystals with size >60 nm show anti-ferromagnetic behaviour, which is evident in the present study. The increase in Al doping results in an increase in coercivity, as grain size and coercivity are inversely related with each other. This is because of the replacement of Fe3+ by Al3+ ions, which weakens the sub-lattice interactions. It has been observed that BFO materials with such parameters are favourable for ferroelectric random access memories where data can be written electrically and read magnetically.