Barium Hexaferrite Thick Films for Microwave Absorbers and Circulators

Simona Ovtar[1,2]**, Darja Lisjak**[1]

[1] Department of Synthesis of Materials, Jožef Stefan Institute, Ljubljana, Slovenia

[2] Jožef Stefan International Postgraduate School (Nanosciences and Nanotechnologies, 3rd year)

simona.ovtar@ijs.si

Barium hexaferrite (BaHF) with the chemical formula $BaFe_{12}O_{19}$ is a hard magnetic material and has high magnetic anisotropy field (MAF), 17 kOe. The easy direction of magnetization corresponds to the crystallographic c-axis and BaHF particles orient in this direction when are exposed to an external magnetic field. Because of the high MAF, a ferromagnetic resonant frequency appears from 45 to 50 GHz. For these reasons, BaHF can be used for electromagnetic absorbers (above 40 GHz) or for millimetre-wave non-reciprocal devices (i.e. circulators, isolators). Today, most of hexaferrites for microwave and millimetre-wave electronic components are prepared using ceramic technologies. To minimize the size of the electronic components, new techniques for thick-film deposition were developed. One of the simplest techniques is electrophoretic deposition (EPD). In the EPD process, the individually charged particles dispersed in a solvent are transported to the electrode of an opposite charge, where they agglomerate and form the deposit. The dispersed particles are one of the most important conditions for the preparation of homogeneous, dense and oriented deposits.

The stable magnetic suspensions of BaHF plate-like particles with diameter from 5–20 nm and 10–250 nm were prepared with surfactant dodecylbenzensulphonic acid in 1-butanol. The suspensions were deposited on the cathode (Al_2O_3 coated with gold or platinum) by EPD. Different positions of electrodes were used. The randomly oriented deposits with thickness of 13 μm were prepared from small BaHF plate particles with vertical position of electrodes. To prepare the oriented deposits from small particles, the magnetic field was applied parallel to the electric field. With applying magnetic field 2 μm oriented thick films were prepared. In addition, the deposits with preferential orientation of the larger particles were prepared by using the horizontal position of electrodes, where the electric and the gravity fields were parallel to each other. Here, the 15 μm thick oriented deposits were formed due to the shape anisotropy. The deposits were sintered at 950 °C for 10 hours or at 1300 °C for 3 hours to prepare films. The magnetic properties of the films were obtained with a vibration-sample magnetometer and the orientation was calculated from the XRD pattern. The high-frequency properties of the BaHF films were measured with a vector-network analyzer. Significant differences in the magnetic properties between the randomly oriented and magnetically-oriented films were shown. In case of magnetically-oriented films the remanent magnetization was higher when the magnetic field was applied perpendicular to the film plane. The orientation of particles in the deposit was also observed in the XRD pattern. The intensities of (00l) peaks were enlarged in the oriented film, because the easy direction of magnetization coincides with the crystallographic c-axis. We can conclude that the randomly oriented films of hard magnetic BaHF can be formed during EPD and that the oriented films can be prepared with or without an external magnetic field. The films show increased magnetic losses at 45-50 GHz, which makes this material interesting for microwave applications.