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Fine Structure of Self-reversed Thermo-remanent Magnetization: Effects of Composition Waves Produced by Ordering During Quench and Annealing of Metastable Ferri-ilmenite Solid Solutions

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Magnetic experiments on synthetic ferri-ilmenite samples in the bulk composition range Ilm 60-70, quenched and annealed at high temperatures (T), well above any magnetization temperature, throw new light on metastable chemical phenomena leading to fine-structure in the acquisition of thermoremanent magnetization. Growth of Fe-Ti -ordered domains in a disordered host, or growth and shrinking of adjacent Fe-Ti ordered domains against each other in the process of coarsening, lead to Fe-enrichment in some domains relative to others, influencing magnetization temperature. However, additional Fe-enrichment along domain boundaries during these processes produces Fe-enriched waves on the boundaries, where ferrimagnetic material near the wave crests, magnetizes at a higher T than the bulk of the sample. Because the boundaries are antiphase domain boundaries with opposite Fe-Ti ordering, opposite sides must acquire opposite magnetic moments during cooling, at a temperature above that where bulk normal magnetization begins. This is the “magnetic predestination T” or “TPD”, because it sets the stage for normal and self-reversed magnetization on opposite sides of the phase domain boundary. The Fe-enrichment waves are not uniform in different parts of a sample; neither are the compositions along the domain walls. This means “TPD” is generally not a single temperature, but a T range, but reflecting only a small volume of the sample. With further cooling in a positive field, slightly less Fe-enriched but more voluminous ferrimagnetic regions begin to magnetize, leading to a positive magnetic peak, “TMAX”. Already here, even less Fe-enriched but still more voluminous ferrimagnetic material, influenced by the domain wall, begins to acquire self-reversed magnetization. This dominates in cooling below “TMAX”, eventually leading to totally self-reversed magnetization at “TFR”. A Curie temperature obviously cannot be measured meaningfully from a cooling curve in this material of varied composition; a graphically convenient point only gives a value for a significant fraction of material of composition where the normal thermoremanent magnetization is acquired. The Fe-enriched chemical waves on phase boundaries described here, that set the stage for acquisition of self-reversed thermoremanent magnetization in further cooling, are tantalizing close in position, though not in concept, to the “x-phase” on phase boundaries that Nord and Lawson thought to be the key to self-reversal. Phase boundaries on these synthetic ferri-ilmenite samples are under study using dark field TEM imaging.