RARE EARTH - Fe_2 THIN FILMS Study With STRATA™

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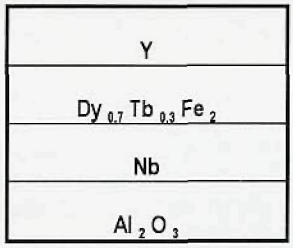
The Rare-Earth Laves phases RE-Fe_2 (RE represent the Rare-Earth) show large magnetostrictive properties, especially at room temperature. These materials are well characterized when in bulk form, but they have rarely been studied as thin films and one can expect some important effects due to epitaxial growth.

A few single crystal layers of RE-Fe_2 have been studied (YFe_2, $TbFe_2$, $DyFe_2$, $ErFe_2$ and $Dy_{0.7}Tb_{0.3}Fe_2$ known as Terfenol-D). The thickness of these different layers are between 5 and 20 nm and with [110] as a growth direction have been epitaxied. They have been deposited with a Molecular Beam Epitaxy (MBE) in an ultra high vacuum chamber. A [1120] sapphire substrate is recovered by a [110] niobium buffer. The RE and the iron are then co-deposited on the substrate which is maintained at 500°C. Lastly, an Yttrium layer is deposited on the Rare Earth material at a temperature close to ambient.



It is then very important to verify that the composition of the RE-Fe_2 layer is as close as possible to the stoichiometry, a deviation from stoichiometry would indicate "parasite" phase (RE-Fe_3 or pure RE). Furthermore the thickness of the RE-Fe_2 layer cannot easily be measured by reflectrometry because of the number of layers and the roughness of the material.

A STRATA study has been done on all RE-Fe_2 layer and the results of the Terfenol-D phase will be discussed below. All elements, except Oxygen, have been measured. The measurement of the X-ray intensities have been done on an EPMA (Take Off = 40°) at 10 & 15 kV. The standards used for the measurements were pure elemental standards for Y, Nb and Al while coumpound standards were used for Tb ($Fe_2Tb_1Si_2$) and Dy ($Dy_1Ru_2Ge_2$). The table below gives the relative intensities:

kV	Y La	Tb La	Dy La	Fe Ka	Nb La	Al Ka
10	.0846	.3022	.9313	.3503	.0734	.0256
15	.0404	.1729	.5651	.1981	.0780	.0831

The goal with STRATA is to calculate the composition of the $Dy_xTb_yFe_z$ layer and the thickness of the Yttrium, RE-Fe_2 and Nb Layers. As said before all elements except Oxygen have been measured (the composition of the Sapphire substrate is given as Al_2O_3). The table below gives the results found by the STRATA automatic iteration:

Layer / Elements	Expected Composition (Atomic)	Expected Thickness (nm)	Calculated Composition (Atomic)	Calculated Thickness (nm)
Y	Pure	30	pure	30.1
Dy, Tb, Fe	0.7, 0.3, 2.0	130	0.69, 0.31, 2.00	133
Nb	Pure	50	Pure	57
Al_2O_3	Known	n/a	Known	n/a

This application shows that STRATA can successfully be used to characterize the growth of epitaxial thin films both in composition and thickness. More generally and since the method is non-destructive, it can also be applied to a wide range of thin films grown on a variety of substrates. For additional information on STRATA, please contact:

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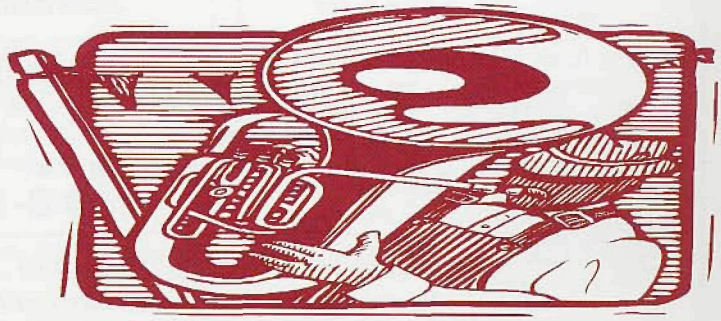

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STRATA, Thin Film Characterization

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- **STRATA** can be applied to either single or multi-layer specimens.
- **STRATA** uses either WDS or EDS data.
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