

BST layers in FRAM Industry

In FRAM industry, integration density keeps on increasing. Hence the severe demand on decreasing the storage capacitor area.

The dielectric materials currently used for these storage capacitors in DRAM are SiO₂ or oxide / nitride compound layer (commonly abbreviated as 'ONO'). As the available capacitor area decreases rapidly, there is a requirement for the capacitance-per-area unit to be increased (see formula on table 1). As the ONO dielectric thickness has reached a lower limit, a solution to keep a constant stored charge is to **increase the dielectric constant ϵ_r** .

One of the promising material being studied for FRAM capacitor is (Ba_xSr_{1-x})TiO₃ (abbreviated 'BST'). This ferroelectric material presents much greater values of ϵ_r , as shown on table 1, and can be used in metal-insulator-metal structures. An example of this structure is given on figure 1. The two electrodes are made of Platinum and TiN is used as a metal barrier to avoid interfacial reaction between polySi and the bottom electrode.

Value of planar capacitance:

$$C = \epsilon_0 \cdot \epsilon_r \cdot (\text{area} / \text{thickness})$$

Material	Dielectric constant (approx.)
SiO ₂	3.8
ONO	5
BST	> 300

Table1

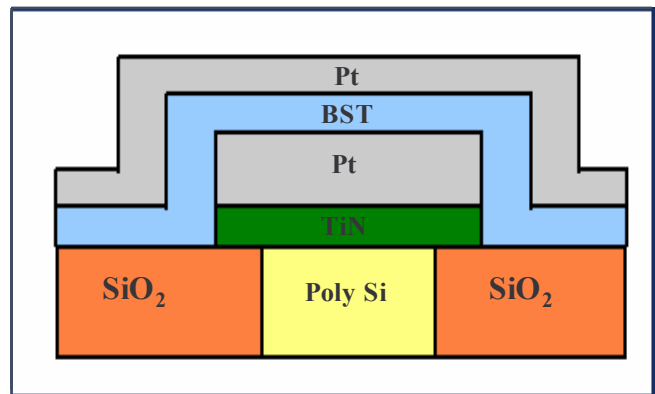


Figure 1

Improving in the deposition process for BST requires the best tools and techniques for optical characterization of the materials and deposited layers. **Spectroscopic Ellipsometry (SE) by SOPRA** is the best way to characterize thin layers.

From the measurement of two parameters $\tan \Psi$ (amplitude) and $\cos \Delta$ (phase), thickness, refractive index, N, and extinction coefficient, K, can be extracted (*).

N and K values of two BST layers (respectively 200 and 320 Å thick) are reported on figure 2.

The results show that the differences in the deposition quality between both layers can be characterized by the use of SOPRA SE.

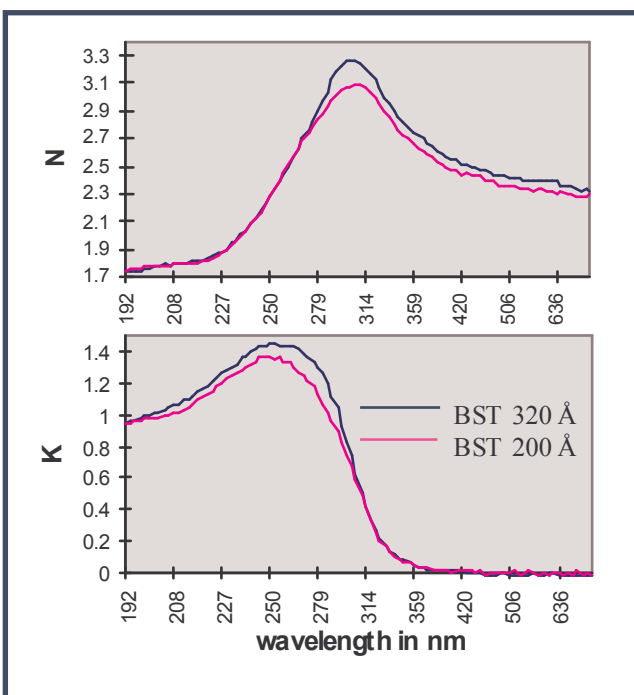


Figure 2

(*). Refer to SOPRA web page (www. SOPRA-SA.com) for tutorial on ellipsometry principles, and terminology.



Figure 3 shows measurement of the 200 Å BST layer on Pt from 191 to 775 nm. The measurement has been implemented with the scanning mode of SOPRA's SE 300 which allows fast, precise and accurate measurement in the Deep UV, down to 191 nm.

After running SOPRA's regression and analysis software, the best fit and the experimental curves are both displayed as shown on figure 3. The excellent fit between the measurement and the model is to be seen.

The result for thickness using the refractive index N and extinction coefficient K corresponding to this material completes the description of the layer (figure 4).

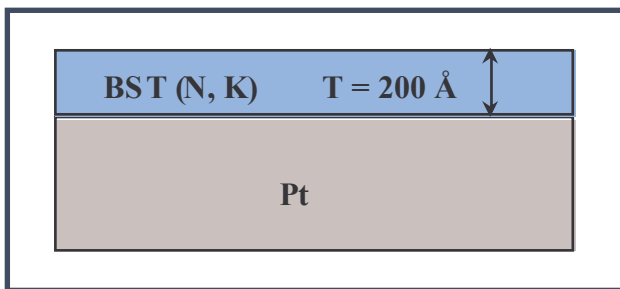


Figure 4

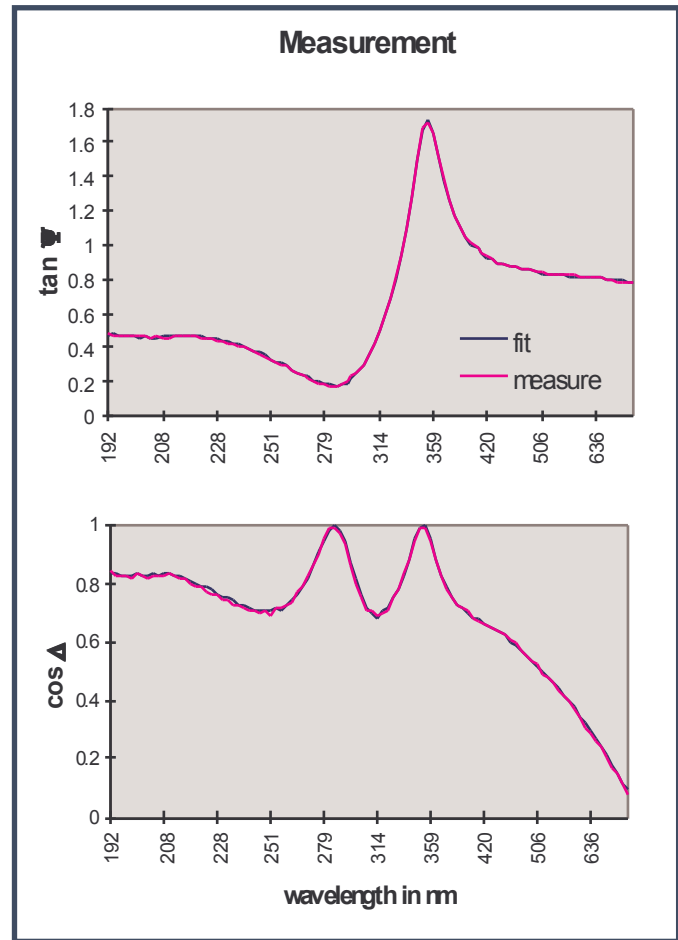


Figure 3

Using SOPRA's SE 300 Spectroscopic Ellipsometer down to 191 nm in the deep UV range allows to determine accurately the optical properties of new materials which will be used in the next generations of FRAM products. This kind of characterization can also be performed on other ferroelectric materials, such as PZT ($\text{PbZr}_x\text{Ti}_{1-x}\text{O}_3$), STO (SrTiO_3) or SBT ($\text{SrBi}_2\text{Ta}_2\text{O}_9$).

Accurate knowledge of the optical properties of BST layers allows to perform cost-effective on-line process monitoring and control for the next generation FRAM product, using the SOPRA spectroscopic ellipsometer.

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