Functional study of $Bi_{(1-x)}Dy_xFeO_3$ thin film grown by MOCVD on single crystal

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Summary

MOCVD of $Bi_{(1-x)}Dy_xFeO_3$ thin films have been performed for various Dy doping amounts. Single crystal Nb-doped $SrTiO_3$ has been chosen to be in the same time the film substrate and his bottom electrode, the top electrode was deposited by sputtering. Then, structural and functional properties of the films are investigated and their relations with Dy concentrations established.

Motivation and results

The deposition of $BiFeO_3$ has been widely investigated in the recent years. Among multiferroic materials it is of a special interest since its ferroelectric and magnetic transition temperatures are well above the room temperature ($T_C \approx 1100$ K and $T_N \approx 650$ K) [1]. Depositions of $BiFeO_3$ films by sol-gel, chemical solution deposition (CSD) and pulsed laser deposition (PLD) on single crystals such as $SrTiO_3$, $LaAlO_3$ or YZT are well developed. On the other hand, the use of MOCVD is not as much spread, but this process has the major advantage to be easily scaled up. Recent work has focused on A-site doping with rare-earth ions, and in particular on partial substitution of Bi^{3+} ion with Dy^{3+} has been considered. [2]

This work reports a simple MOCVD process for Dy-doped $BiFeO_3$ thin films on conductive Nb-doped $SrTiO_3$ (100) substrates. Films have been deposited using a multicomponent mixture, consisting of the $Bi(phenyl)_3$, $Dy(hfa)_3$diglyme and $Fe(tmhd)_3$ (phenyl = $–C_6H_5$, H-hfa = 1,1,1,5,5,5-hexafluoro-2,4-pentanedione, diglyme = 1-methoxy-2-(2-methoxyethoxy)ethane, H-tmhd = 2,2,6,6-tetramethyl-3,5-heptandione), as precursor source [2]. Nb-doped $SrTiO_3$ is acting simultaneously as a substrate and a bottom electrode.

The piezoelectric, pyroelectric and ferroelectric properties are correlated to the structural and compositional properties of the deposited layers with attention to the Dy doping. This correlation has been done using X-ray diffraction (XRD), Fig.1.a, for the structural characterization, field-emission scanning electron microscopy (FE-SEM), Fig.1.b/ atomic force microscopy (AFM), Fig.2, and energy dispersive X-ray (EDX)/wavelength-dispersive X-ray spectroscopy (WDX) analysis for the morphologic and chemical characterizations, respectively. After top electrode sputtering, the permittivity, piezo-, pyro- and ferro-electric response of deposited films have been investigated by impedance spectroscopy, Piezoelectric Force Microscopy (PFM), pyroelectric measurement and P-V loop, respectively. Strong correlation between Dy doping and film properties have been observed and important pyro-electric coefficients were measured.

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References

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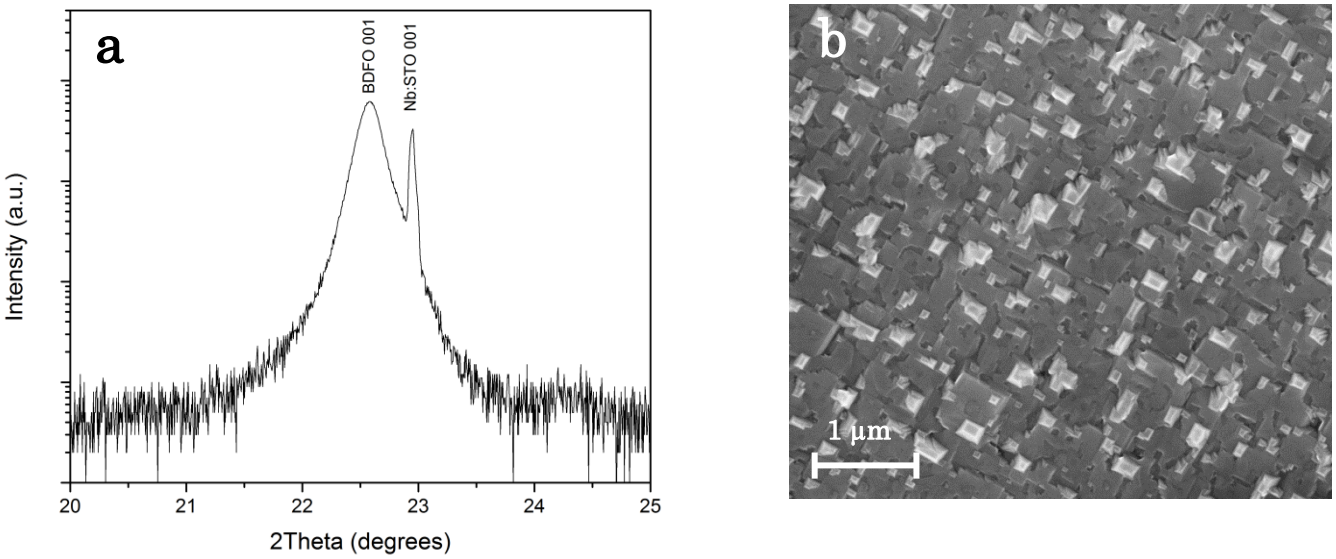

Figure 1. XRD pattern of BDFO thin film on Nb:$SrTiO_3$ in the 20°-25° region. (a) and FE-SEM image of the BDFO thin film (b)

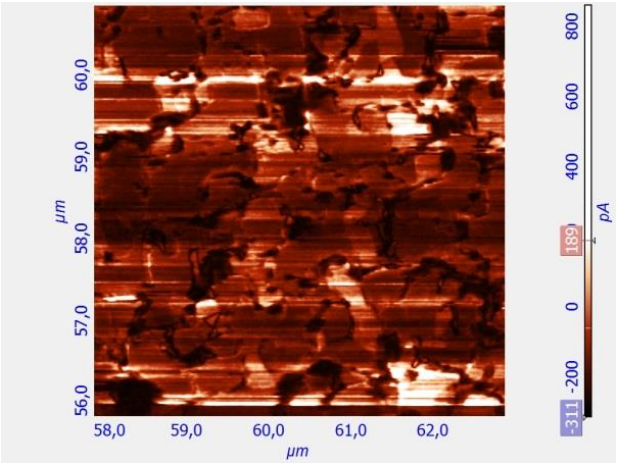

Figure 2. PFM scan of BDFO thin film.