8-6-2010

Multiferroic $Pb(Fe_{1/2}Nb_{1/2})O_3$ Single Crystals: A Raman Scattering Study

A. F. García-Flores
Pennsylvania State University

Dmitri A. Tenne
Boise State University

W. J. Ren
Chinese Academy of Sciences

X. X. Xi.
Pennsylvania State University

S. -W. Cheong
Rutgers University

Multiferroic $Pb(Fe_{1/2}Nb_{1/2})O_3$ Single Crystals: A Raman scattering study

A.F. García-Flores[a,b,c], D.A. Tenne[b], W.J.. Ren[e], X.X.X. Xi[a], and S.-W. Cheong[d]

[a]*Department of Physics, the Pennsylvania State University, University Park, Pennsylvania 16802*
[b]*Department of Physics, Boise State University, Boise, Idaho 83725-1570*
[c]*Instituto de Física "Gleb Wataghin", UNICAMP,C.P. 6165, 13083-970, Campinas-SP, Brazil*
[d]*Department of Physics and Astronomy, Rutgers University, Piscataway, New Jersey 08854, USA*
[e]*Shenyang National Laboratory for Materials Science, Institute of Metal Research and International Centre for Materials Physics, Chinese Academy of Sciences, Shenyang 110016, People's Republic of China*

Among complex perovskite-type structure multiferroics [$A(B'B'')O_3$], lead iron niobate $Pb(Fe_{1\backslash 2}Nb_{1\backslash 2})O_3$ (PFN) discovered by Smolenskii *et al.*[1] is currently of interest because of its high dielectric constant diffuse phase transition[2] and magnetoelectric effect[3,4]. PFN presents ferroelectric transition below T_C~350-395 K and antiferromagnetic transition below T_N~145 K[1-4].

In PFN, the Pb2+ cations with a lone electron pair in *A* site and the relative displacements of oxygen and Fe^{3+}/Nb^{5+} ions in the octahedral *B* sites favor the electric ordering whereas the Fe^{3+} cations with partially filled *d* orbitals contribute to the magnetic ordering. Because of its complex structure, still exists a disagreement about the crystalline structure of PFN: monoclinic (space group Cm), rhombohedral (space group R3m), and cubic (space group Pm3m) structure symmetry at room temperature were reported[3,5,6].

In this work, we report temperature-dependent Raman spectra (10-500 K) in the frequency range of 150-1250 cm^{-1} of cubic PFN single crystals, complemented with magnetization measurements. We want to provide microscopic information in this material.

Over the range from 150 to 950 cm^{-1}, very broad and overlapping peaks (first-order character) were observed in the overall studied temperature range possibly due to local distortions which are characteristic in this kind of Pb-based complex perovskite. Also, a prominent high-frequency peak at ~1130 cm^{-1}, which we assign as a two-phonon peak, was observed (see Fig. 1).

Temperature dependence of the Raman spectra showed an anomaly in a characteristic temperature T* ~ 330 K. Here, drastic changes in the Raman scattering intensity and spectral shape were observed with temperature variations, such as the appearance of new first- and second- order peaks below T*. The temperature behavior of the two-phonon peak shows a strong electron-phonon interaction in PFN. Also, since it was reported weak magnetic ordering at and even above room temperature in

this material, the anomaly at T*~330 K by Raman scattering could be possibly suggesting an interplay between magnetic e ferroelectric orders.

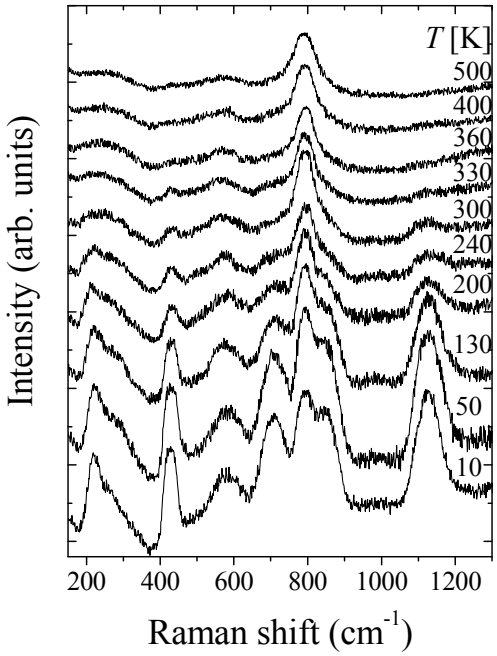

Figure 1: Raman spectra as a function of temperature in $Pb(Fe_{1\backslash 2}Nb_{1\backslash 2})O_3$.

ACKNOWLEDGMENTS

This work was supported by the DOE under Grant No DE-FG02-01ER45907 and CNPq-Brazil.

REFERENCES

1. G.A. Smolenskii, A. Agranovskaya, S.N. Popov, and V.A. Isupov, Sov. Phys. Tech. Phys. 28, 2152 (1958).
2. V.V. Bhat, A.M. Umarji, V.B. Shenoy, and U.V. Waghmare, Phys. Rev. B 72, 14104 (2005).
3. Y. Yang, J.M. Liu, H.B. Huang, W.Q. Zou, P. Bao, and Z.G. Liu, Phys. Rev. B 70, 132101 (2004).
4. R. Blinc, P. Cerv, A. Zorko, J. Holc, M. Kosec, Z. Trontelj, J. Pirnat, N. Nalal, V. Ramachandra, and J. Krzystek, J. Appl. Phys. 101, 033901 (2007).
5. X. Hu, X.M. Chen, S.Y. Wu, J. Europ. Cer. Soc. 23, 1919 (2003).
6. S.P. Singh, D. Pandey, S. Yoon, S. Baik, and N. shin, Appl. Phys. Lett. 90, 242915 (2007).