1.06 μm → 532 nm SECOND HARMONIC GENERATION BY FERROELECTRIC NANOPARTICLES OF STRONTIUM BARIUM NIOBATE

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There is an increasing interest in optical imaging for biomedical applications under infrared light excitation (multi-photon illumination). The main advantages of these imaging methods are a much better spatial resolution and less scattering of the excitation radiation. This has strongly encouraged the study of new infrared to visible up converting nanoparticles which can be easily incorporated in biological systems. Recent efforts have been made on dielectric crystals doped with pairs of trivalent rare earth optically active ions, such as Pr^{3+} and Yb^{3+} in $Gd_3Ga_5O_{12}$ nanocrystals [1]. These systems can produce visible fluorescence under infrared excitation by means of different up-conversion processes. Alternatively infrared excited optical images can be produced by means of second harmonic generation, using suitable non-linear crystals. Strontium Barium Niobate, $Sr_xBa_{1-x}Nb_2O_6$ (abbreviated SBN), is a family of ferroelectric crystals of great interest from the basic and applied viewpoints. This has been recently considered as a “photonic glass”, because it is able to efficiently produce multi-directional second and third harmonic generation for a variety of geometries and in a broad wavelength range [2]. Moreover SBN can be doped with a variety of luminescent ions. In fact, a self-frequency doubling SBN:Nd solid state laser has been recently demonstrated [3]. Thus SBN appears as an excellent candidate for the production of nanoparticles, having the possibility of incorporation in biomedical samples for optical imaging purposes.

In this work congruent (x=0.6) SBN nanoparticles of different sizes have been produced by different synthetic techniques [4, 5]. Then second harmonic 532 nm green light has been generated from SBN powdered crystals of different sizes, from bulk (microcrystals) to 40 nm nanoparticles, using the 1.06 μm pulsed radiation of a Nd:YAG laser as a fundamental wave. It is demonstrated that SBN nanoparticles are still ferroelectric (and so non-linear) materials, so that 532 nm green radiation can be produced because of random phase matching processes.

Figure 1 show, for the sake of comparison, the second harmonic spectra obtained for different SBN particle sizes. It can be seen that the efficiency is clearly reduced as the particle size decreases (notice that the SH signal is almost unobserved for 40 nm SBN particles). This fact is due to the absence of ferroelectric microdomains that contribute to second harmonic generation by quasi phase matching and to the shorter length of the active material. However the green signal generated by the nanoparticles is still measurable and can be increased by using more powerful infrared lasers, such as fs lasers.

The stability of the SBN nanoparticles to laser fluence and input laser power has been systematically investigated. The SH intensity remains constant with fluence for those samples having a single SBN phase. However in the way of preparation it is often observed the presence of two phases: SBN and Strontium Niobate. In those cases the SH intensity diminishes with laser fluence and optical damage is observed.

References:

[1] R. Naccache, F. Vetrone, A. Speghini, M. Bettinelli and J. A. Capobianco, J. Phys. Chem. C, **112** (2008) 7750.
[2] P. Molina, M.O Ramírez and L.E. Bausá, Adv. Funct. Mat. **18**, (2008) 709.
[3] M.O. Ramírez, D. Jaque, L.E. Bausá, J. García Solé and A.A. Kaminskii, Phys. Rev. Lett. **95**, (2005) 267401.
[4] Y. Li, J. Zhao and B. Wang, Mat. Res. Bull. **39** (2004) 365.
[5] M. Daldosso, A. Speghini, P. Ghigna, M. O. Ramirez, D. Jaque, L.E. Bausá, J. García Solé and M. Bettinelli, J. Alloys and Comp. **451** (2008) 12–17

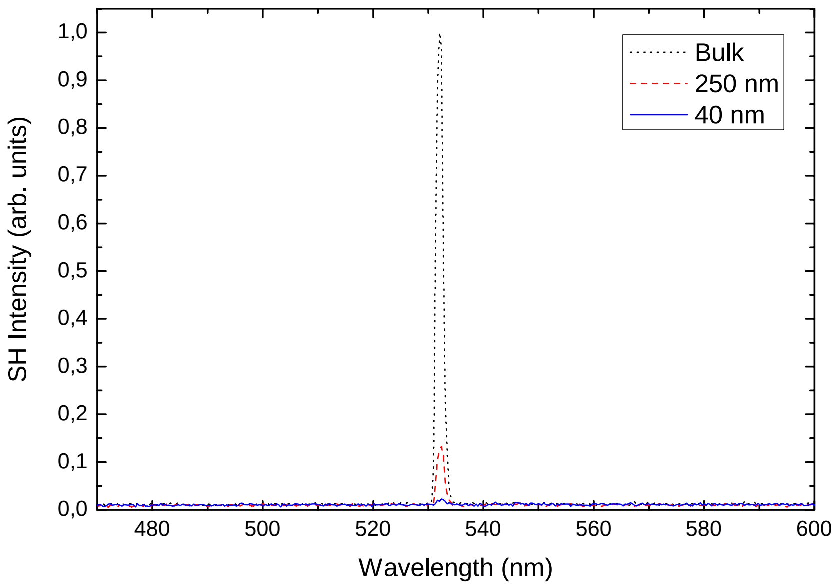

Figure1.- SH spectra for three different SBN particle sizes.