MEDNARODNA PODIPLOMSKA ŠOLA JOŽEFA STEFANA

JOŽEF STEFAN INTERNATIONAL POSTGRADUATE SCHOOL

Innovative Approach to Synthesis of $Pb(Mg_{1/3}Nb_{2/3})O_3$ Based Materials using Colloidal Interactions

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Scientific Part

Problem

- in the conventional solid-state synthesis of perovskite $Pb(Mg_{1/3}Nb_{2/3})O_3$ (PMN) based compounds lead and niobium oxide prefferentially react to the pyrochlore phases

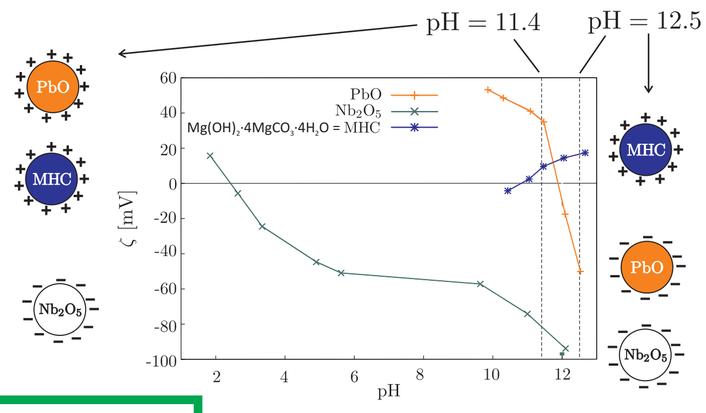
- after the reaction in addition to the perovskite secondary pyrochlore phases are present in the product and they largley deteriorate the electrical properties of the perovskite material

- to avoid the formation of pyrochlores usually two-step solid-state synthesis is used

Idea

- to prepare the pyrochlore-free PMN based materials in one-step solid-state synthesis by avoiding the contacts between lead and niobium oxide particles in the reaction mixture and thus slow down the reaction to pyrochlore

- the charge of the starting material particles was measured in dependence on pH

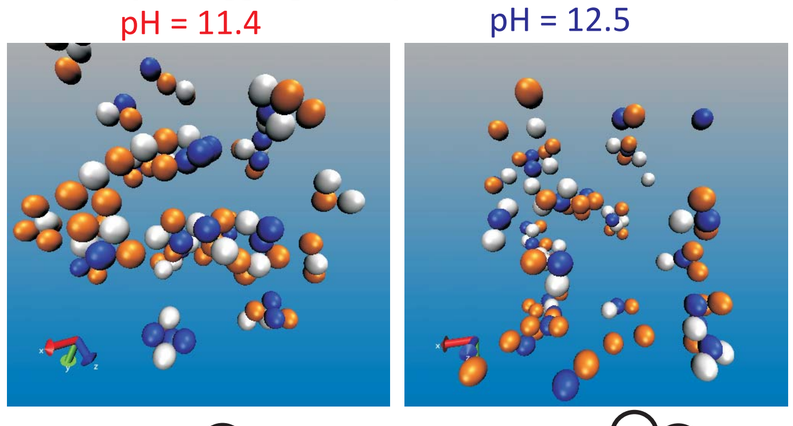


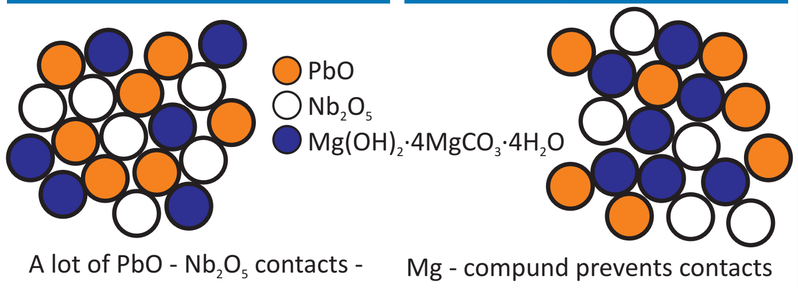
- two pH values were chosen for further investigation:
1. **pH = 11.4**, where PbO and Nb_2O_5 posess opposite charge and they are attracted

2. **pH = 12.5**, where PbO and Nb_2O_5 both posess negative charge and therefore they are repelled

Use of simulations - to get an insigth in the complex aggregation process

pH = 11.4 pH = 12.5

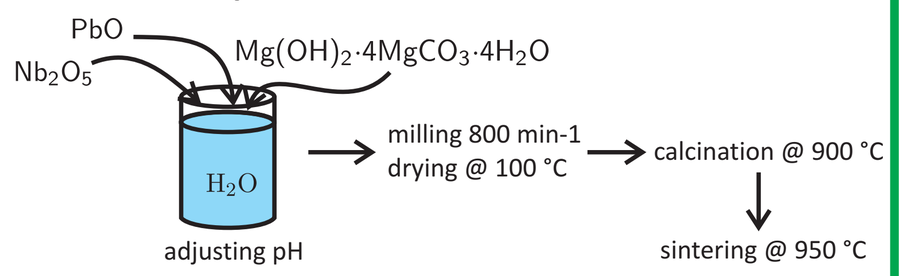




A lot of PbO - Nb_2O_5 contacts - the unvanted reaction to pyrochlore is enhanhed.

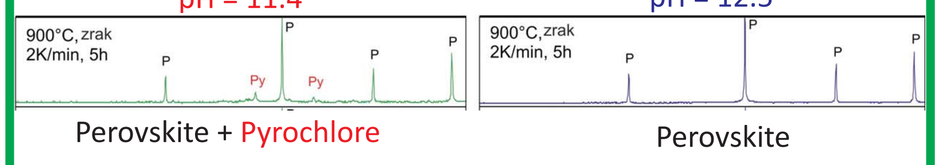
Mg - compund prevents contacts between PbO and Nb_2O_5 - unwanted reaction to pyrochlore is slowed down.

Results - Experiment



XRD Results

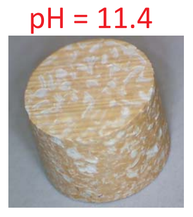
pH = 11.4 pH = 12.5



Perovskite + Pyrochlore Perovskite

Samples after sintering

pH = 11.4 pH = 12.5

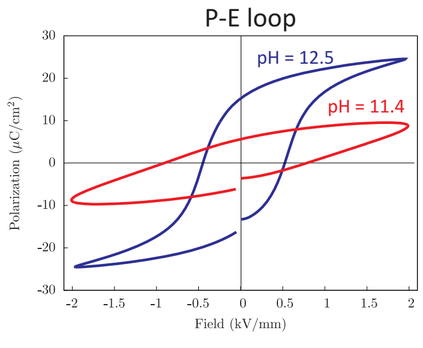


85 % of theroetical density

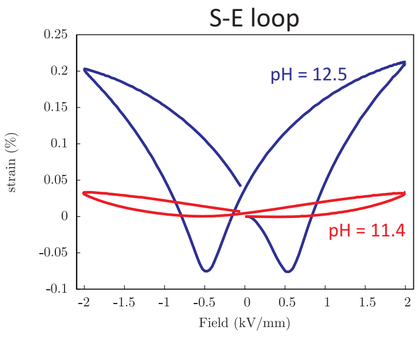
95 % of theoretical density

Comparison of Ferroelectric and Piezoelectric properties of the 0.65PMN-0.35PT system prepared at pH = 11.4 and pH = 12.5

P-E loop

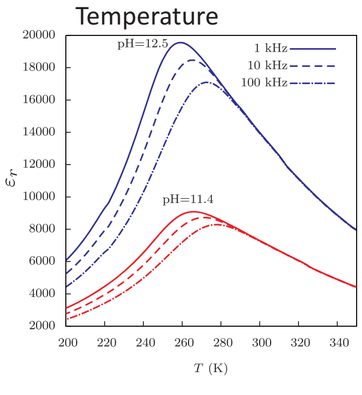


S-E loop

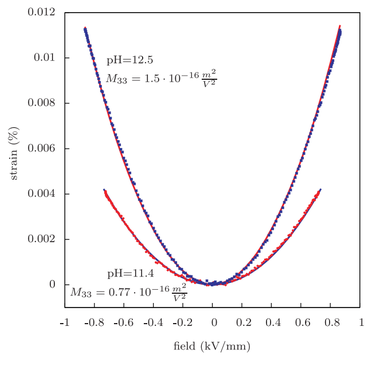


Comparison of Dielectric and Electrostrictive properties of the PMN system prepared at pH = 11.4 and pH = 12.5

Dielectric constant vs. Temperature



Electrostrictive Behavior



Application of $Pb(Mg_{1/3}Nb_{2/3})O_3$ Based Materials - Relaxor Ferroelectrics

$Pb(Mg_{1/3}Nb_{2/3})O_3$ (PMN), $(1-x)Pb(Mg_{1/3}Nb_{2/3})O_3$-$xPbTiO_3$ (PMN-PT)

Interesting Properties

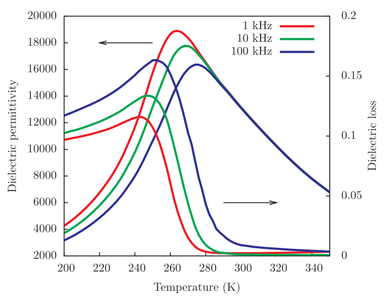
- high dielectric constant (ε_r = 5000 @RT)
- high electrostriction coefficient (PMN)
- excellent piezoelectric properties (PMN-PT: ceramics d_{33} = 700 pC/N, crystal d_{33} = 2000 pC/N)
- good ferroelectric properties (PMN-PT)

Interesting for applications

- capacitors
- actuators
- sensors
- „energy harvesting“
- ultrasonic transducers

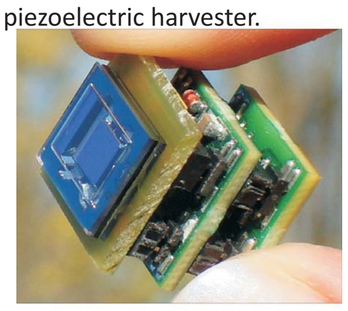
Important for Basic Research

- PMN is a Model Relaxor System



Energy harvesting

Autonomous temperature sensor based on piezoelectric harvester.



http://www.energyharvestingjournal.com

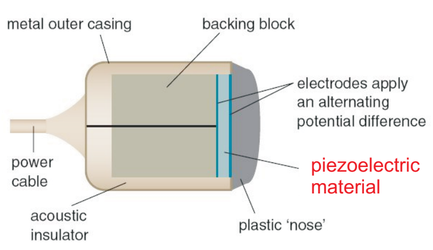
Precesion movement

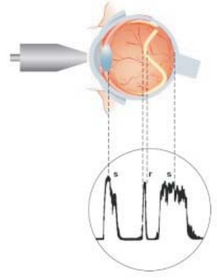
Piezostage for precision movements

http://www.piezostage.net

Ultrasonic Transducers

Ultrasonic trasducers for medical imaging

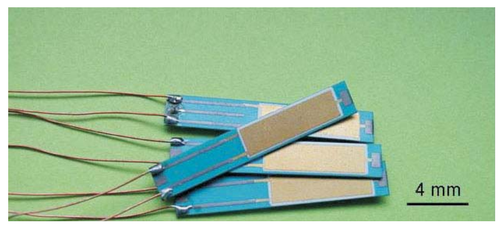


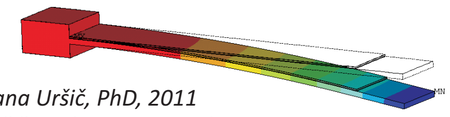


http://www.genesis.net.au

Actuators

Large displacement actuators based on PMN-PT thick films





Hana Uršič, PhD, 2011
Uršič et al., Sensors and Actuators, 2008

Acknowledgments

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