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Implementation of Artificial Neural Network Technique in analyzing the role of Samarium on the Ferroelectric behavior of Barium Titanate

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Abstract—Barium Titanate(BT) ceramics (lead free dielectrics) have been widely used as materials for dynamic random access memory, capacitors for design and fabrication of microphones and even for sensors and transducers which are used in embedded systems. Different dopants have been used so far as well to dope BT in various proportions to achieve optimum performance characteristics in different aspects such as dielectric, ferroelectric, optical, electromagnetic etc. This paper is an attempt to design and simulate a model for prediction of error in BT and its doping with Samarium, which is highly soluble in BT and is hence used to modify various properties of BT, using the feedforward backpropagation(FFBP) algorithm of Artificial Neural Network (ANN).Initially, certain synthetic data sets of all three-layer curveshave been taken for training the network, then the network is validated by the field datasets collected from the experimental work done by M. Ganguly et al and various corresponding work[1,3,4]. With proper training of back propagation networks, it tends to give the actual predictive values of dopant ratio and corresponding results without carrying out the experiments physically[2].

Keywords— Barium Titanate, Samarium, doping, ANN, FFBP algorithm etc.

I. INTRODUCTION

Artificial Neural Networks (ANN) are based on the working of biological neuron structure and can be used as an efficient tool in handling computations of material engineering[26]. Very similar to actual biological systems, the central processing element in an artificial neural network is known as a neuron (or node)[27]. The output signal of a neuron or node is calculated as the weighted sum of input signals from the coming neuron, changed by the transfer function. The learning capacity of a neuron is carried out by adjusting the weights in consent to the chosen learning algorithm. The process is repetitive.

The basic ANN architecture consists of three types of layers input, hidden & output layers. Number of neurons in input and output layer depends upon the number of input & output parameters respectively. The selection of the number of neuron in a hidden layer is an important decision however there is no definite formula.

There are several types of architecture of ANN. However Multilayer Perceptron (MLP) observed to be effective in modeling of chemical processes. MLP trained by the back propagation algorithm is based on a system capable of modeling complex relationship between the variables. ANN is the powerful tool for modeling, especially when the data relationship is unknown. ANN can identify and learn correlated patterns between input data set and corresponding output data set. After training ANN can be used to predict the output of the new independent input data [1, 2].

There are number of applications of ANN, that include, standardization of digital colorimeter [5], estimation concentration heavy metals from aqueous solution[6,29], estimation of composition of a ternary liquid mixture [7], mass transfer predictions in a fast fluidized bed of fine solids [8], compressive strength predictions using FFBP[30], development of substitutionally doped amorphous semiconductors and its possible application of amorphous silicon in photovoltaic devices [20], fault detection [21, 22], load forecasting[28], modeling for estimation of hydrodynamics of packed column [9], fault diagnosis in complex chemical plants [10], adsorption studies [10, 11, 12, 13], modeling combined VLE of four quaternary mixtures [114] and similar others [15, 16, 17, 23] are also reported.

The prediction in error helps to realize the most effective and suitable material composition to achieve a predefined level of accuracy for one or more parameters without actually carrying out the experimentation [24, 25]. In this paper we have referred data from the experimental works carried out by researchers and put them as inputs to a predictive ANN model incorporating FFBP algorithm. Thereafter a comparative study of the results of both the real time experimental work and the predicted output of the model has been carried out.

II. DESIGN OF ANN MODEL

There are three layers of the model a) input layer b) hidden layer and c) output layer as shown in Fig. 1. The input layer takes input in terms of real time experimental data as referred from [1], no. of hidden layers has been calculated based on

requirement of achieving best prediction and the output layer finally shows the result which can be compared with the real time analog data referred as input. n number of inputs are there in the single layer input data set which are provided to ten hidden layers and finally the corresponding n no. of output data set is generated in a single layer after training the model.

M. Ganguly et al [1] have done work on doping of Barium Titanate with Samarium. In the present paper we have referred this work to predict error with the help of the ANN model considering two design parameters a) relative permittivity vs temperature and b) loss tangent vs temperature.

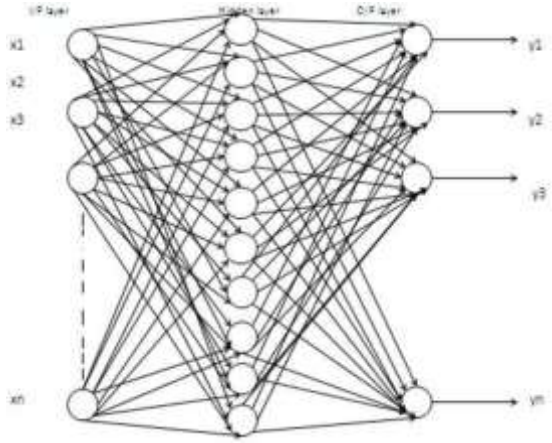

Fig. 1 ANN model incorporating FFBP algorithm

III. RESULT AND ANALYSIS

The ANN model has been trained with two data sets here (i) Dielectric Constant vs temperature (ii) Dielectric Loss vs Temperature referring the data sets generated from the work of M. Ganguly et al[1]. Two types of data have been generated with respect to frequency 100 Hz and 10,000 Hz for undopedBarium Titanateand Barium Titanate doped with Sm and used for this purpose.

The prediction accuracy R achieved in each case is minimum 99.811% and maximum 99.897%.

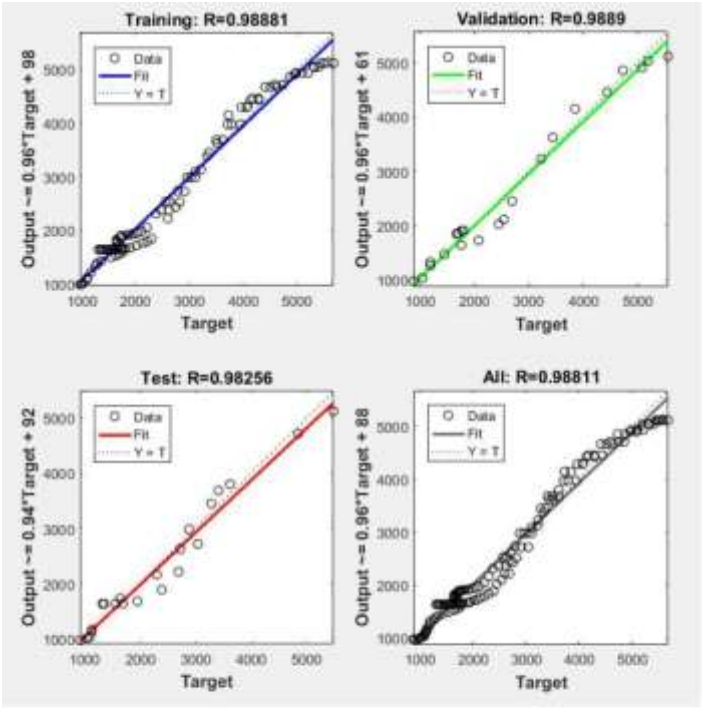

Fig. 2. Training of FFBP model with R=0.99454

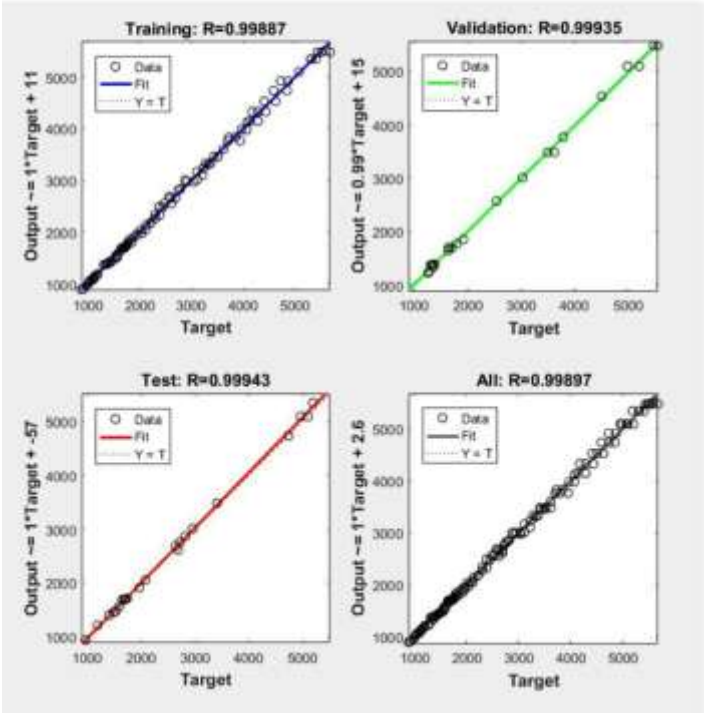

Fig.3. Training of FFBP model with R=0.99887

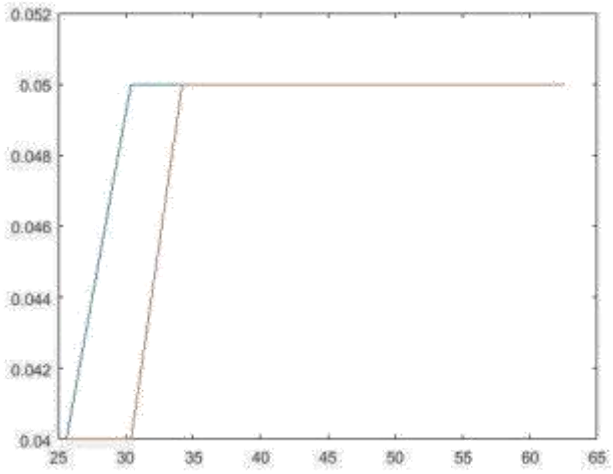

Fig.4 Test accuracy plot: RED – predicted, BLUE-original/experimental

The first inference lies in the fact that the input layer takes input from real time experimental data & the no. of hidden layers has been calculated depending on requirement of achieving best prediction and the output layer finally shows the result. The algorithm used here was feedforward back propagation (FFBP) algorithm in ANN. The error was predicted with the help of the ANN model considering two design parameters a) relative permittivity vs temperature and loss tangent vs temperature. The ANN model has been fed with two data sets (i) Dielectric Constant vs temperature & (ii) Dielectric Loss vs Temperature, generated with respect to frequency 100 Hz and 10,000 Hz for undoped Barium Titanate and Barium Titanate doped with Sm. The data was fed into the ANN model and the result was obtained. The result for dielectric constant vs temperature, yielded a prediction accuracy of 99.811% and the dielectric loss vs temperature yielded a prediction accuracy of 99.877%. Thus, the error was successfully predicted to be 0.189% and 0.123% respectively. This error prediction would help to comprehend & analyse the most effective, optimum and satisfactory material composition of Barium Titanate (BT) with the dopant, Samarium (Sm) to achieve the maximum level of accuracy for one or more parameters without actually performing the experiment for. The test accuracy can be observed from the above graph.

IV. CONCLUSION

Barium Titanate (BT) has been tested in two different forms here, one undoped and the other doped with Samarium. The data were generated with respect to two different frequencies of 100 Hz and 10,000 Hz. There are two data sets used here, one for dielectric constant vs temperature which has given a prediction accuracy of 99.811% and one for the dielectric loss vs temperature with prediction accuracy of 99.877%. The error was successfully predicted to be 0.189% and 0.123% respectively. This error prediction will help to comprehend the most effective and satisfactory material composition of Barium Titanate (BT) with the dopant, Samarium (Sm) to achieve the given level of accuracy for one or more parameters without executing the experiment for real.

REFERENCES

1) "CharacterizationofA-sitedeficientsamariumdopedbariumtitanate" M. Ganguly,S.K.Rout, W.S.Woob, C.W.Ahn, I.W.Kim

2) "A robust behavior of Feed Forward Back propagation algorithm of Artificial Neural Networks in the application of vertical electrical sounding data inversion" Y. Srinivas, A. Stanley Raj, D. Hudson Oliver, D. Muthuraj, N. Chandrasekar

3) Artificial Neural Network Approach For Modeling Of Adsorption Of Ni (Ii) And Cr (Vi) Ions Simultaneously Present In Aqueous Solution Using Adsorbent Synthesized From AegelMarmelos Fruit Shell AndSyzygiumCumini Seed S. L. Pandharipande1, Aarti R. Deshmukh2

4) Rumelhart D E & McClelland (1986) Back Propagation Training Algorithm Processing, M.I.T Press, Cambridge Massachusetts.

5) R. D. Khonde& S. L. Pandharipande, (2011) "Application of Artificial Neural Network for Standardization of

Digital Colorimeter", International Journal of Computer Applications, ICCIA-5, pp1-4.

6) S.L. Pandharipande, Aarti R. Deshmukh and RohitKalnake, (2013) " Artificial Neural Network modelling for estimation of concentration of Ni (II) and Cr (VI) present in aqueous solution", International Journal of Advances in Engineering & Technology (IJAET), Vol. 5, Issue 2, pp122-131.

7) S. L. Pandharipande, Anish M. Shah &HeenaTabassum, (2012) "Artificial Neural Network Modeling for Estimation of Composition of a Ternary Liquid Mixture with its Physical Properties such as Refractive Index, pH and Conductivity", International Journal of Computer Applications, Vol. 45, No. 9, pp26-29.

8) Zamankhan, P., Malinen, P., Lepomaki, H., (1997) "Application of Neural Networks to Mass Transfer Predictions in a Fast Fluidized Bed of Fine Solids", AIChE, Vol. 43, pp1684-1690.

9) S. L. Pandharipande& Ankit Singh (2012) "Optimizing topology in developing artificial neural network model for estimation of hydrodynamics of packed column", International Journal of Computer Applications, Vol. 58, No. 3, pp49-53.

10) J. C. Hoskins , K. M. Kaliyur& David M. Himmelblau, (1991) "Fault diagnosis in complex chemical plants using artificial neural networks", AIChE, Vol.37, No.1,pp137-141.

11) KaanYetilmezsoy, SevgiDemirel, (2008) "Artificial neural network (ANN) approach for modeling of Pb(II) adsorption from aqueous solution by Antep pistachio (Pistacia Vera L.) shells", Journal of Hazardous Materials,Vol.153, pp1288-1300.

12) R. D. Khonde& S. L. Pandharipande, (2012) "Artificial Neural Network modeling for adsorption of dyes from aqueous solution using rice husk carbon", International Journal of Computer Application, Vol. 41, No.4, pp1-5.

13) S L Pandharipande, Y.D. Urunkar, Ankit Singh,(2012) "Comparative Study of Topology of ANN Models for Adsorption of Colouring Agents from Aqueous Solutions

14) using Adsorbents Synthesized from Agricultural Waste Material". IJAERS, Vol. I, pp214-216

15) N. Gamze Turan, BasacMesci, OkanOzgonenel, (2011) "Artificial neural network (ANN) approach for modeling Zn(II) adsorption from Leachate using a new biosorbent", Chemical Engineering Journal 173, pp98– 105.

16) ShekharPandharipande& Anish M Shah, (2012) "Modeling combined VLE of four quaternary mixtures using artificial neural network", International Journal of Advances in Engineering, Science and Technology (IJAEST), Vol. 2, No. 2, pp169-177.

17) S. L. Pandharipande , Aditya Akheramka, Ankit Singh & Anish Shah, (2012) "Artificial Neural Network Modeling of Properties of Crude Fractions with its TBP and Source of Origin and Time", International Journal of Computer Application, Vol. 52, No.15, pp20-25.

18) S AMandavgane, S L Pandharipande& D Subramanian, (2006) "Modeling of desilication of green liquor using Artificial Neural Network", International journal of chemical technology, Vol. 13, pp168-172.

19) H.R. Godini, M. Ghadrdan, M.R. Omidkhah& S.S. Madaeni, (2011) "Part II: Prediction of the dialysis process performance using Artificial Neural Network (ANN)", Desalination, Vol. 265, pp11-21.

20) R.A Gibson, P.G le Comber &W.E Spear " Doped amorphous silicon and its application in photovoltaic devices",IEE Journal on Solid state and electron devices, Vol 2, issue 3.\

21) Hassan Abniki, Saeed Nateghi &Mohammad Nabavi Razavi " An ANN based fault detection technique in T-connection transmission overhead lines", 11_{th} Environment and Electrical Engineering Internation Conference(2012)

22) Deepak Kumar Gaud, Pratesh Jayaswal " Effects of Artificial Neural Network parameters on rolling element bearing fault diagnosis", International Conference on Futuristic Trends in Engineering, Science, Humanities & Technology 2016, January, Vol1

23) Nurlaila Ismail, Md. Hezri Azarul Rahiman & Md. Nasir Taib "Application of ANN in agarwood oil grade

classification", Signal Processing & its applications(CSPA) 2014 IEEE 10_{th} International Colloquium.

24) Wu Wang, Yuan-min Zang " Application of Recursive Predict Error Neural Networks in Mechanical Properties' Forecasting", Artficial Intelligence 2009 JCAI.

25) L Lahousine Abaih, A van Bennekom & M. Fathi "Development of an ANN for the prediction of heat treatment temperatures for Martensitic Stainless Steels", Industrial Electronics 2007, ISIE 2007, IEE International Symposium.

26) Internal Journal of Materials Engineering Innovation, Inderscience Publishers

27) Parveen Kumar & Pooja Sharma" Artificial Neural Networks- A study", IJEERT, International of Emerging Engineering Research and Technology, Volume 2, Issue 2, May 2014.

28) Axay J Mehta, Hema A Mehta, T.C Manjunath & C. Ardil " A Multilayer ANN Archtecture Design for Load Forecasting in Power Systems", World Academy of Science, Engineering & Technology, vol 5, Issue 2, 2011.

29) Pimolpun Kampalanonwat & Pitt Supaphol " The study of Competetive Adsorption of Heavy Metal Ions from Aqueous Solution", Energy Procedia, 2014.

30) Razavi SV, Jumaat MZ, Ahmad H El-Shafle "Using FFBP Neural Networks for Compressive Strength Prediction of lightweight concrete made with different percentage of scoria instead of sand", International Journal of the Physical Sciences, vol 6, 2011.