PEROVSKITE ELECTROCERAMICS

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Some call them smart materials, others a novel ceramic, technically you would call them oxide perovskites based on ferroelectric ceramics. There are numerous studies being done in the field of electroceramics in which chemically doped perovskites give the most efficient results. Figure 1 (A) illustrates an ideal perovskite structure, while figure 1 (B) illustrates a usual perovskite with its‰ large cation displaced from the center. The most common perovskite is Barium Titanate (BaTiO3). In our case we wish to produce large crystalline wafers of mostly Lead Magnesium Niobate (PMN or PbMg1/3Nb2/3O3), which presents large problems discussed later.

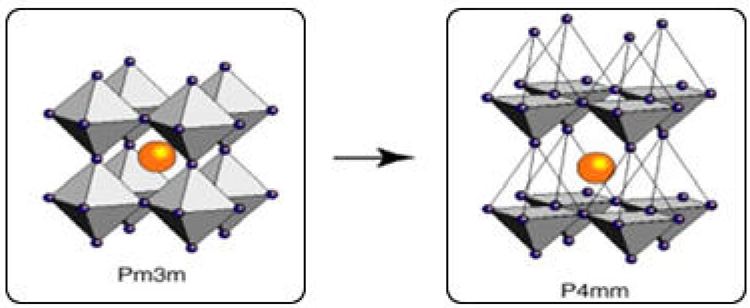

Figure 1(A) **Figure 1(B)**

The main interest in perovskites is due to the displacement of the central cation. This effect causes a net dipole moment throughout. The more interesting feature, however, is observed when a stress or strain is applied to the crystal structure. This results in a polarization and an even larger dipole moment, thus producing a voltage across the crystal. Not only is that the case, but also the reverse is true, apply a voltage and the result is a change in shape due to stress or strain. The location of the stress or strain is purely dependent on the location and manner of the applied voltage as depicted in figure 2. This particular result is what the industry finds most attractive, in fact in excess of 20 applications are under study.1 The most interesting of these studies are: deformable mirrors1 and deformable wing systems. In the first case a glass mirror can be attached directly to several thing layers of crystalline PMN in either a telescope or an optical communication system. The layers of PMN would then allow for control of the phase of light wave1 or the focal length of a telescope while in use. The latter study is of great concern to aircraft industries. With the proper production of layers onto wings and the correct voltage one would have the ability to change the physical shape of the wings while in flight to compensate for rapidly changing atmospheric conditions. This result would actually eliminate the need for mechanical devices along or inside aircraft wings.

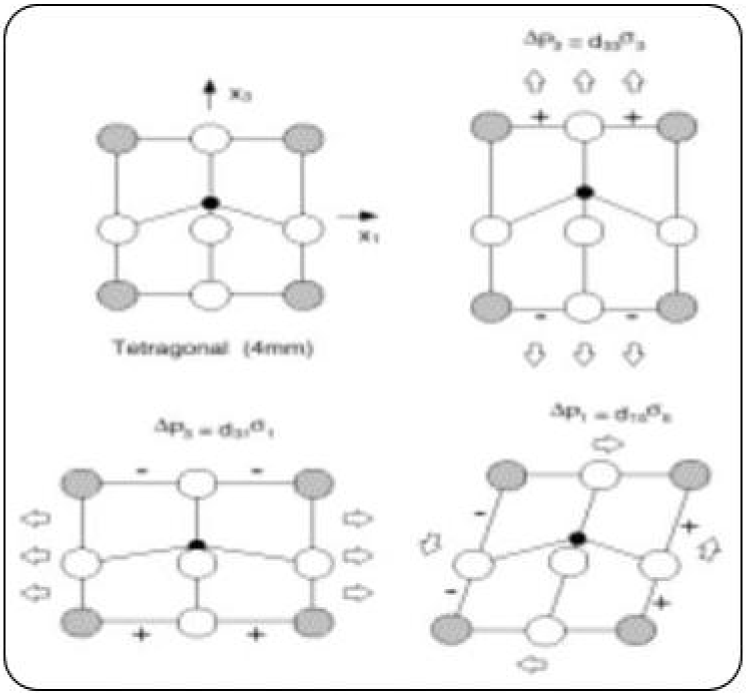

Figure 2

The studies discussed are very practical, but one problem persists more than any, the difficulty in growing large crystals in high quantities. This is necessary in order to carry out the explained functions. Two main problems are present: Lead Oxide (PbO) has a tendency to vaporize at temperatures and pressures near synthesis, and large, defect free crystals are required for applications. The main thrust of our research throughout the week mainly dealt with evaluating the current phase diagram. We were to essentially test compound compatibilities and establish a phase stability diagram. Figure 3 shows a current phase diagram of PMN. Once these tasks are complete the results can then be used towards the large crystal synthesis.

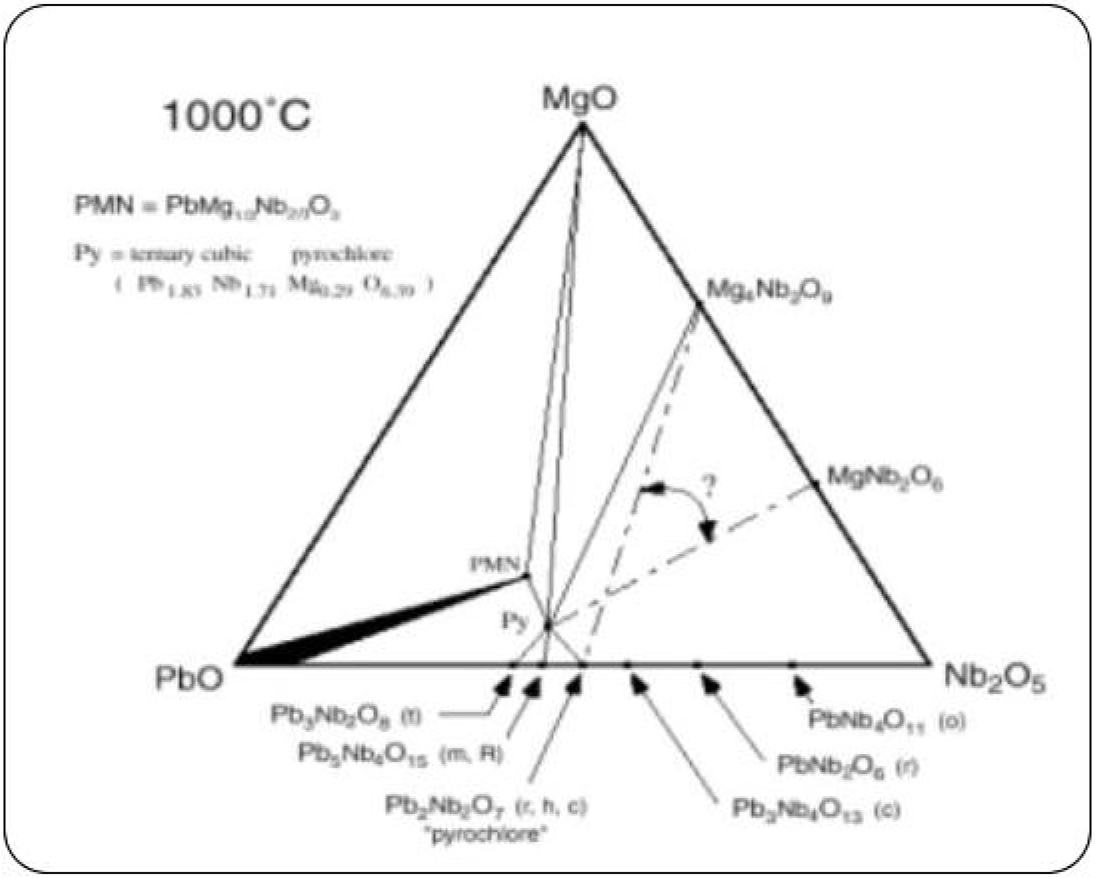

Figure 3

Two experiments were performed during our week of research, both using the Piston-Cylinder. The first experiment dealt with testing compatibility lines in the phase diagram; we mixed equal molar amounts of MgO and Pb2Nb2O7 at 10 kbarr and 1000 degrees Celsius for 1 hour. X-ray diffraction was used to examine the product; the spectrum obtained resembled that of some Lead Magnesium Niobate compound. Further results were not obtained due to time constraints. The final experiment was simply applying a pressure of 10 kbarr at 1000 degrees Celsius for 1.6 hours to Pb2Nb2O7. The purpose of this experiment was to determine if a high-pressure phase existed under those conditions. Results obtained via x-ray diffraction yielded no change in patterns.

The work carried out during one week is just one small part of the necessary research in this area. Further investigation of high-pressure phases and the phase diagram are crucial. Once the diagrams can be firmly established the goal is to grow a wafer, at least 2 inches in diameter, of PMN/PbTiO3 for optimal ferroelectric properties.

Acknowledgements

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References

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