

# Superconducting Properties of Melt-Quenched $\text{Bi}_{1.6}\text{Pb}_{0.4}\text{Sr}_2\text{Ca}_{n-1}\text{Cu}_n\text{O}_y$ Superconductor

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**Abstract** – The effects of varying the copper content and pelletizing pressure on the x-ray diffraction (XRD) patterns of superconducting  $\text{Bi}_{1.6}\text{Pb}_{0.4}\text{Sr}_2\text{Ca}_{n-1}\text{Cu}_n\text{O}_y$  ceramics are examined. The samples were fabricated via the melt quench method. The copper content with  $n=3.5$  revealed to have the highest percentage of high  $T_c$  peaks. The low  $T_c$  phase was predominant in all samples. There is no observable trend on the effect of variation in pelletizing pressure on both high  $T_c$  and low  $T_c$  phases of the samples.

**Index Terms**— melt-quenched, superconductor, pelletizing pressure, copper content, x-ray diffraction, ceramics, high  $T_c$ , low  $T_c$

## 1 INTRODUCTION

A large variety of techniques have been developed and applied for the fabrication of high  $T_c$  Superconductors [1]. Among these are the alkoxide route, citrate gel process, coprecipitation technique, combustion method, freeze drying, floating zone method, solgel, solid state reaction method and the melt quench method. In the melt quench method, the raw materials are melted above the melting point and then rapidly quenched to room temperature.

Of the various potentially useful materials only the bismuth containing ones such as the  $\text{Bi}_2\text{Sr}_2\text{Ca}_3\text{Cu}_3\text{O}_y$ , and related compounds [2,3] can be prepared by quenching from the molten state, which typically requires the melt to be heated to 100 to 200°C above the melting point. One of the benefits of the melt quench technique is that the glass resulting from a high quenching rate is necessarily chemically homogeneous and it is possible to obtain different shapes and forms after melt quenching which may be useful to wire and tape production.

This paper presents the effects of varying the copper content and pelletizing pressure on the superconducting properties of  $\text{Bi}_{1.6}\text{Pb}_{0.4}\text{Sr}_2\text{Ca}_{n-1}\text{Cu}_n\text{O}_y$  ceramics prepared by the melt quench method.

## 2 Procedure

The atomic ratio of Bi:Pb:Sr:Ca:Cu was controlled to 1:6:0.4:2:n-1:n, where n ranges from 2 to 4 with an interval of

0.5. Appropriate amounts of the raw materials of  $\text{Bi}_2\text{O}_3$ ,  $\text{PbO}$ ,  $\text{SrCO}_3$ ,  $\text{CaCO}_3$  and  $\text{CuO}$  were weighed to adjust the final composition. The weighed materials were mixed thoroughly in an agate mortar and pestle for 30 minutes. The mixture was melted in alundum crucibles. The approximate temperature in which melting was expected to occur is 1080°C. The liquefied material was removed from the furnace and was immediately poured on a stainless steel plate. After quenching, the sample was ground with an agate mortar and pestle. From the total quantity of the ground material, amounts of 4 grams were weighed and were pelletized. The pelletizing force was varied from 2 to 8 tons with an interval of 2 tons. Each pellet measured 2 cm in diameter and 0.25 cm in thickness. The pellets were then placed in alundum boats and were sintered for 24 hours at a constant temperature of 840°C. The samples were characterized by XRD.

## 3 RESULTS

Figure 1 shows the XRD patterns of the samples subjected to a pelletizing force of 2 tons. It can be observed that the low  $T_c$  phase is predominant in all the samples. Figure 2 shows the graph of the percentage peaks versus copper content of the samples subjected to a pelletizing force of 2 tons. It can be observed that the sample with copper content  $n=3$  contains the highest low  $T_c$  percentage and the sample with copper content  $n=3.5$  contains the highest high  $T_c$  percentage. The sample with copper content  $n=4$  contains the highest percentage of unidentified peaks.

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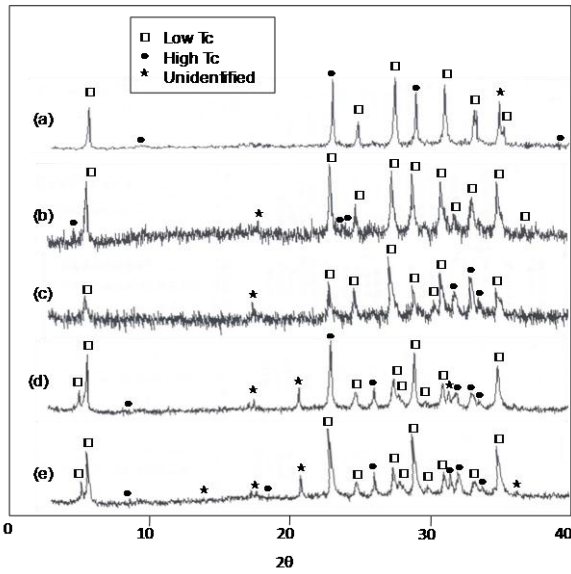


Fig. 1 XRD patterns of samples subjected to pelletizing force of 2 tons and copper content (a) n=2, (b) n=2.5, (c) n=3, (d) n=3.5, and (e) n=4

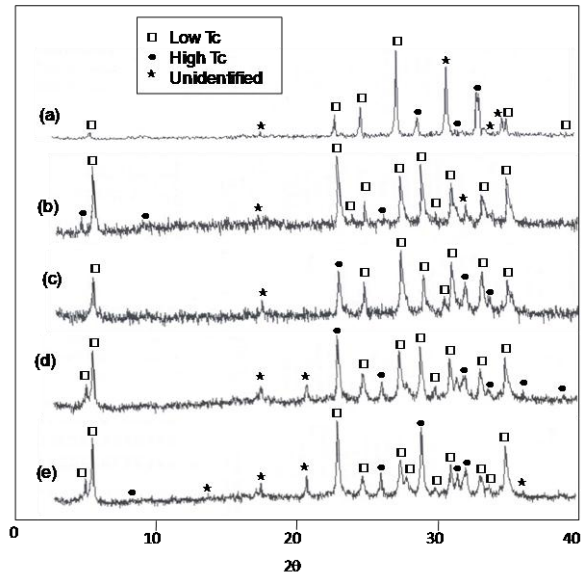


Fig. 3 XRD patterns of samples subjected to pelletizing force of 4 tons and copper content (a) n=2, (b) n=2.5, (c) n=3, (d) n=3.5, and (e) n=4

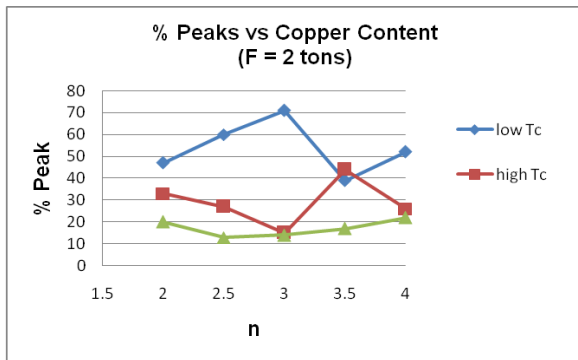


Fig. 2. Graph of percentage peaks vs. copper content of samples subjected to a pelletizing force of 2 tons

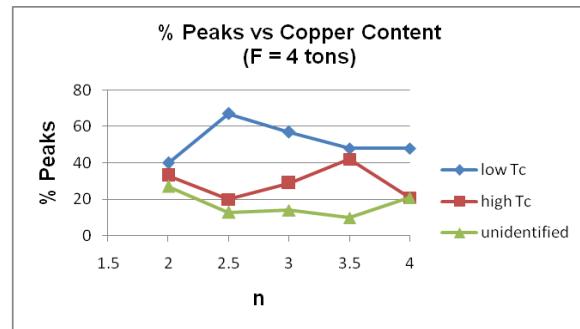


Fig. 4. Graph of percentage peaks vs. copper content of samples subjected to a pelletizing force of 4 tons

Figures 3 and 4 show the XRD patterns and the graph of the percentage peaks versus the copper content, respectively, of the samples subjected to a pelletizing force of 4 tons. It can be seen from the graph that the sample with copper content n=2.5 contains the highest low Tc percentage and the sample with copper content n=3.5 contains the highest high Tc percentage. The samples with copper content n=2 and n=4 contain the highest percentage of unidentified peaks.

Figures 5 and 6 show the xrd patterns and the graph of the percentage peaks versus copper content, respectively, of the samples subjected to a pelletizing force of 6 tons. The sample with copper content n=2.5 contains the highest low Tc percentage and the sample with copper content n=3.5 contains the highest high Tc percentage. The samples with copper content n=2 and n=4 contain the highest percentage of unidentified peaks.

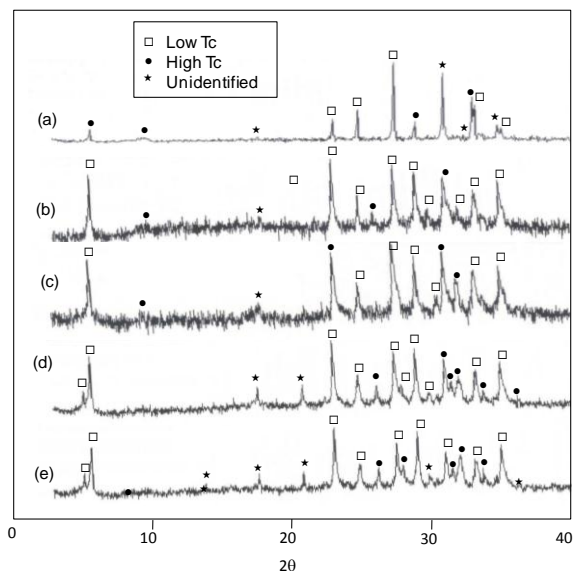


Fig. 5 XRD patterns of samples subjected to pelletizing force of 8 tons and copper content (a) n=2, (b) n=2.5, (c) n=3, (d) n=3.5, and (e) n=4

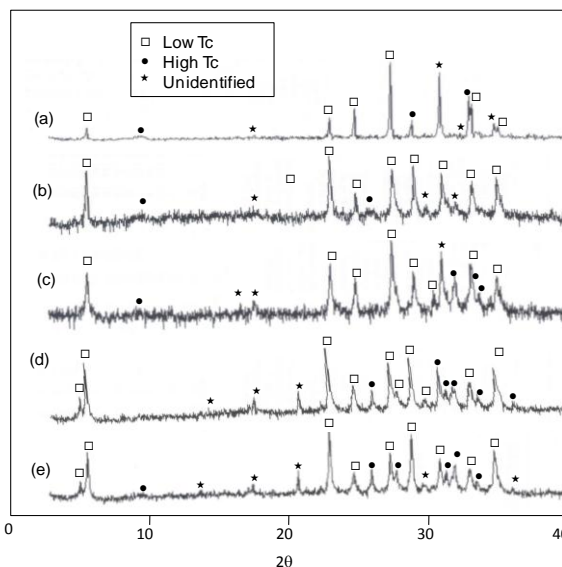


Fig. 7 XRD patterns of samples subjected to pelletizing force of 8 tons and copper content (a) n=2, (b) n=2.5, (c) n=3, (d) n=3.5, and (e) n=4

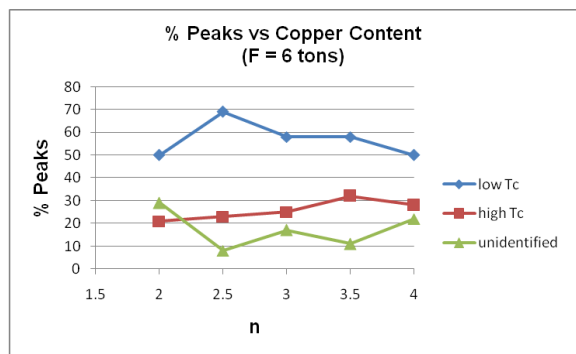


Fig 6. Graph of percentage peaks vs. copper content of samples subjected to a pelletizing force of 6 tons

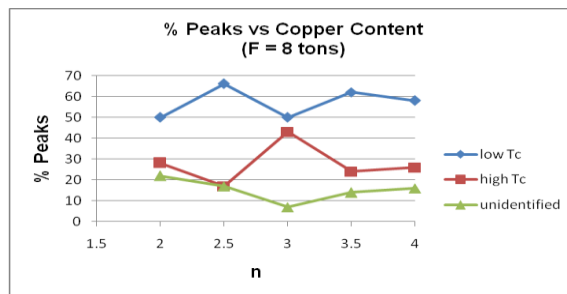


Fig 8. Graph of percentage peaks vs. copper content of samples subjected to a pelletizing force of 8 tons

Figures 7 and 8 show the XRD patterns and the graph of the percentage peaks versus copper content, respectively, of samples subjected to a pelletizing force of 8 tons. The sample with copper content n=2.5 contains the highest low Tc percentage while the sample with copper content n=3 contains the highest high Tc percentage. The sample with copper content n=2 contains the highest percentage of unidentified peaks.

In summary, most of the samples with copper content n=3.5 obtained the highest percentage of high Tc peaks while most of the samples with copper content n=2.5 obtained the highest percentage of low Tc peaks.

The variation of the pelletizing force does not show any particular characteristic trend with regards to the amount of high Tc peaks in the samples. This may be due to the use of the melt quench method which already yields a dense material even without pressing.

#### 4 CONCLUSION

The use of the melt quench method on the fabrication of  $\text{Bi}_{1.6}\text{Pb}_{0.4}\text{Sr}_2\text{Ca}_{n-1}\text{Cu}_n\text{O}_y$  ceramics, yielded samples with both low Tc and high Tc peaks. The XRD patterns of the samples showed that the low Tc phase is predominant in all the samples. Most

of the samples with copper content  $n=2.5$  contain the most number of low  $T_c$  peaks. Most of the sample with copper content  $n=3.5$  contain the highest percentage of high  $T_c$  peaks.

There is no observable trend, however, on the effect of variation in pelletizing pressure on the high  $T_c$  phase and low  $T_c$  phase of the samples.

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