CHARACTERIZATION OF LOCAL STRUCTURE IN METALLIC GLASS SYSTEMS USING HIGH-FIELD NMR

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Introduction

Metallic glasses are usually formed by cooling metallic supercooled liquids with certain composition down to glass transition temperature while avoiding crystallization [1,2]. Metallic glasses are structurally simpler and provide an important model system to study the phenomena and theories related to crystallization and the nature of glass transition. Recently discovered bulk metallic glass (BMG) systems not only make these studies possible, but also offer enormous opportunities in the field of structural materials with huge technological potentials [1].

For metallic glass systems, an important task is to determine the character of chemical short range order and how it is related to glass forming ability [3,4]. The nature of chemical bonding at a given site will be reflected by the Knight shift of the corresponding nucleus, since Knight shift is determined by the local density of state at the nucleus. We used the high field superconducting magnet at NHMFL to explore the field dependence of spectra of ^{27}Al and ^{63}Cu in $Zr_{50}Cu_{50}$, $Zr_{47}Cu_{47}Al_6$ and $Al_{92}Sm_8$ metallic glasses. Since ^{27}Al and ^{63}Cu are both quadrupolar nuclei, high field will have a great advantage in achieving high resolution.

Experimental

The preparation of BMG systems such as $Zr_{50}Cu_{50}$ and $Zr_{43}Cu_{43}Al_6$ is well described in literature. At NHMFL, we used the 833 MHz narrow bore superconducting magnet system to get the spectra of ^{63}Cu in $Zr_{50}Cu_{50}$, $Zr_{43}Cu_{43}Al_6$ and ^{27}Al in $Zr_{47}Cu_{47}Al_6$, $Al_{92}Sm_8$.

Results and Discussion

At 19.6T, the line width in the ^{27}Al and ^{63}Cu spectra of both samples decreases compared to that of the low field ones as expected for quadrupolar nuclei. With the line narrowing, we see some features in ^{27}Al spectrum of $Zr_{47}Cu_{47}Al_6$ and ^{63}Cu spectrum of $Zr_{50}Cu_{50}$ not observable at low field. This observation suggests that there might be different types of local environments in these metallic glasses. X-ray diffraction was not able to resolve such structures, leaving high field NMR the method of choice to characterize such intriguing local structures.

Conclusions

We see some features in ^{27}Al and ^{63}Cu spectra in different metallic glass samples which are not present in low field NMR spectra. We cannot yet say conclusively that there are different types of local chemical environments for Al and Cu nuclei. More detailed high field studies are needed to clarify the issue.

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