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Local structure of Bi ions in Bi doped silica glasses analyzed by XAFS

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Introduction

Recently, the significances of optical fiber are becoming all the higher in advanced information society. Optical fibers normally laid down show zero-dispersion in 1.3 μm band; therefore optical fiber amplifiers in 1.3 μm band enable optical fiber communications with little distorted waveform. We newly discovered Bi doped silica glass (BiSG) that are expected to be applied as optical fiber amplifiers in 1.3μm region, but the luminescent mechanism is still unclear.

In this work, we aim to reveal the local structure around Bi in BiSG by XAFS and then this will lead to make clear the luminescent mechanisms.

Exprimental

Chemical compositions of BiSG are listed in Table 1. Bismuth L_{III} XAFS spectra were measured in transmission mode at BL-12C,7C in the Photon Factory (PF). X-ray absorption data in the neighborhood of the Bi L_{III} edge (13426.5 eV) were collected at 481 energy points ranging from 12926 to 14526 eV. Absorption spectrum of crystalline α-Bi_2O_3 was also measured. Data analysis was carried out using UWXAFS. The backscattering amplitude and the phase shift were theoretically calculated by the FEFF8.2 code. The Debye-Waller factor was estimated on the basis of results of raman spectroscopy [1] by an Debye code implemented in FEFF8.2.

Table 1: Chemical composition of BiSG samples

Sample	Composition [mol%]		
	Bi_2O_3	Al_2O_3	SiO_2
Bi1	0.5	0.5	99.0
Bi2	0.5	2.5	97.0
Bi3	0.5	5.0	94.5
Bi4	1.0	1.0	98.0
Bi5	1.0	5.0	94.0

Results & Discussion

Figure 1 shows the radial structure function | F(r) | of α-Bi_2O_3 and BiSG samples. The peaks shown in 1.0 Å are the oscillations in XANES region. The large peaks in 1.5 Å (the first peaks) correspond to the first neighbor Bi-O bonds. The first peaks of BiSG were by about 0.15 Å shorter than that of α-Bi_2O_3.

The | F(r) | curves of BiSG were curve-fitted over range 1.2-2.0 Å in r, the first peaks, and that of α-Bi_2O_3 was also fitted over range 1.35-2.15 Å using FEFF8.2. The first coordination spheres of BiSG were calculated to be 2.10 Å, the second to be 2.35 Å for BiSG.

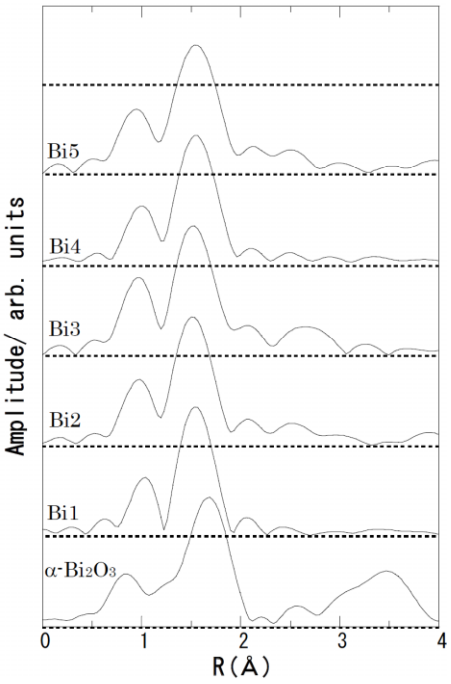

Fig.1: The radial structure function | F(r) |of α-Bi_2O_3 and BiSG samples

The Bi-O bond distances in $LiBiO_3$(Bi^{5+}) [2] are reported to be 2.1Å for Bi^{5+}-O. On the other hand, 2.3Å of Bi-O distance corresponds to the Bi^{3+}-O. Therefore, the first and second coordination spheres in BiSG approximately corresponded to Bi-O bond distances of Bi^{5+} and those of Bi^{3+} respectively.

Conclusion

Local structure around a bismuth ion in Bi doped silica glasses (BiSG) were investigated by Bi L_{III} XAFS. Bi ions exist as both Bi^{3+} and Bi^{5+} states in BiSG. Bi^{5+} have an important role of constructing a peculiar luminescent center.

References

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