

2377
17-20 Sep

Rank Prize Symposium on Applications of Free Electron Lasers, Grasmere 2001.

The Use of the Free Electron Laser source at JLABS for Near-IR Absorbance Measurements of Ga:La:S Glasses.

Marco Petrovich, Harvey N. Rutt.

*Optoelectronics Research Centre, University of Southampton, Southampton, SO17 1BJ, UK.
(e-mail address: mnp@orc.soton.ac.uk)*

Glasses based on gallium and lanthanum sulphides (GLS) have attracted considerable interest over the past few years as they have potential for a range of practical applications. These glasses are among a few systems in which lanthanide compounds appear as a constituent; by partly substituting lanthanum with any other rare earth, optical materials with excellent fluorescence properties are readily obtained. The low phonon energy of the sulphide host reduces the non-radiative quenching of electronic levels with small energy separation to the lower levels; radiative transition rates are high because of the very large refractive index (~ 2.35 at $1.5 \mu\text{m}$). Thus, optical transitions are available in GLS that are commonly not observed in the conventional oxide glass hosts, enabling new schemes for fibre lasers and optical amplifiers. The high refractive index of GLS also correlates with high third order nonlinearity, which can be exploited for all-optical switching devices. With their transparency window ranging from about 0.5 to $8 \mu\text{m}$, GLS glasses are relevant for applications both in the telecom window, and in the mid-IR.

The most challenging part in realising practical devices is the fabrication of single mode optical fibres. While fiberisability of GLS glasses has been demonstrated, optical attenuation in typical GLS fibres is still of the order of dB per meter. This loss, described as partly absorptive and partly due to light scattering, has until now been assumed to be extrinsic, that is, caused by residual impurities, crystals and other defects introduced during the fabrication. However, the bulk loss of GLS has never been adequately measured and even the loss mechanisms are not yet fully understood. Since in other sulphide glass systems the "weak absorption tail" of the electronic absorption edge represents a fundamental limit to the minimum achievable attenuation, the identification and quantification of the loss mechanisms in GLS glass is indispensable.

Measuring the bulk loss in high index optical media is notoriously not an easy task. Thick samples are often not sufficiently homogeneous; on the other hand, the loss over \sim centimetre lengths is only less than one hundredth of the Fresnel reflection loss at the sample surfaces, making transmission measurements very troublesome. Besides, these can only provide the total attenuation. Laser calorimetry, on the contrary, is a highly sensitive method to measure directly optical absorption, where a high power laser is directed on a sample placed in a vacuum chamber, and the temperature rise monitored. Analysing samples cut from the same glass batch with different thickness allows discrimination between surface and bulk absorption. The only constraint of the technique is the availability of suitable laser sources at the wavelength of interest. In this respect the Free Electron Laser at the Thomas Jefferson National Accelerator Facility (JLFEL) represents a unique source; when operated on its third harmonic, JFEL provides an average power of several hundred watts which can be tuned across the whole near-IR region from the 1 to $2.2 \mu\text{m}$.

In this paper we propose the use of JL-FEL for absolute absorption measurements of GLS glasses in the near-IR window, we discuss in detail the design of the calorimeter and present some preliminary results relative to two different glass compositions.

The authors gratefully acknowledge the team of the Free Electron Laser Program at the Jefferson National Laboratories for their valuable contribution to this work. This work was funded by EPSRC through the grant n. GR/R56372/01.