Fluorescence of optical filter glass: characterization and measurement results

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Optical filter glasses are for example used in spectroscopy. In order to obtain a good signal-to-noise ratio, the self-fluorescence of optical filter glass should be low. Therefore we present measurement results of the fluorescence for different optical filter glasses at 365 nm excitation as well as the impact of melt-to-melt fluorescence change of the same filter glass type.

1 Introduction

Optical filter glasses are for example used in spectroscopy to separate the incident light from the measurement signal (light). In order to obtain a good signal-to-noise ratio, the self-fluorescence of optical filter glass should be low at application wavelength. Different optical filter glasses are available for such an application from UV to near IR light.

In this article a measurement set-up for (self-) fluorescence measurements is shown. Afterwards we present measurement results of the fluorescence for different optical filter glasses at 365 nm excitation.

Besides other factors, fluorescence depends on impurities of the raw material of the glass. Due to slight fluctuations of the raw material used for the filter production the fluorescence of the same filter glass type will fluctuate for different melts. Although the raw material has slight fluctuations the filter glass fulfills the specification according the datasheet (typically defined transmittance values) but can change the not specified (self-) fluorescence. Thus, results from different melts will be shown.

2 Fluorescence basics

Fluorescence is light absorption of a material at a certain wavelength and almost instantaneously re-radiation of light at longer wavelength due to lower energy, see Fig. 1 [1], [2].

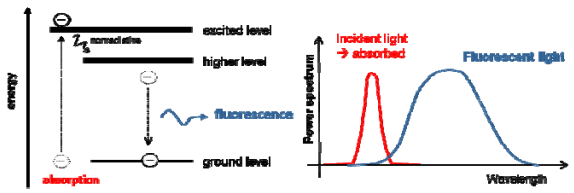

Fig. 1 *Energy scheme illustrating fluorescence (left) and corresponding power spectrum vs. wavelength (right).*

3 Measurement set-up

A Fluorolog-3 measurement system from the company Horiba was used for the measurement. In total 55 different samples were measured for 53 different (SCHOTT) optical filter glasses. Each filter glass is a plano-plano filter with optical polished surfaces. A 450 W high pressure Xenon lamp was used as a source. A monochromator ensures excitation light at 365 nm +/- 2 nm. In 90° direction to the incident light the fluorescence light spectrum was measured using a monochromator, see Fig. 2.

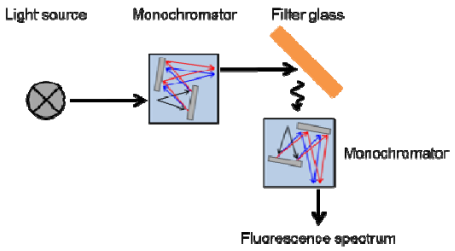

Fig. 2 *Fluorescence measurement set-up (sketch) with 45° tilted filter glass for short optical path of fluorescence light.*

The accuracy of the measurement system is better than 5 % and the re-producebility is better than 2 %. A typical measurement result is shown in Fig. 3 for 365 nm excitation.

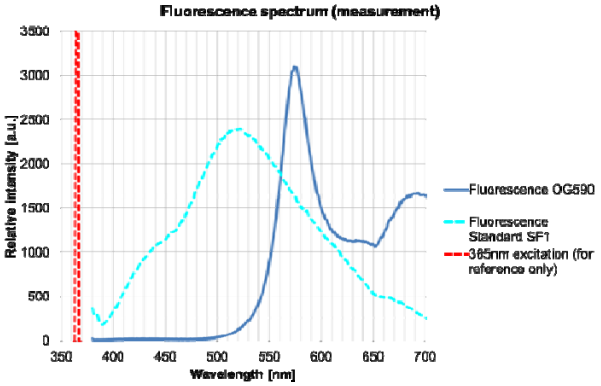

Fig. 3 *Fluorescence spectrum of filter glass OG590 (batch # 0001738096) and optical glass SF1 which serves as fluorescence standard.*

DGaO Proceedings 2015 – http://www.dgao-proceedings.de – ISSN: 1614-8436 – urn:nbn:de:0287-2015-C028-0

submitted: 26.Jun.2015 published: 17.Aug.2015

In Fig. 3 are two fluorescence spectra shown: one of the filter glass OG590 and one of optical glass SF1. Here SF1 serves as a reference (similar to standard JOGIS 04-1994) which allows the representation of fluorescence in a single parameter [3]. Here we call this single parameter relative integral fluorescence (RIF), which is for 365 nm excitation defined by:

———————, (1)

where is the measured fluorescence spectrum (intensity) of the sample (OG590 in Fig. 3) and is the reference fluorescence spectrum of SF1. According Eq. (1) the RIF of SF1 is 1 or 100%. For OG590 RIF was measured to 0.729 which means it has 72.9 % of the integral fluorescence spectrum of optical glass SF1.

4 Fluorescence measurement results of optical filter glasses

With the definition of Eq. (1) a single parameter allows the comparison of (self-) fluorescence for different filter glasses.

4.1 Results of 53 different filter glasses at 365 nm excitation

First all 53 different filter glasses were measured (as well as SF1) in order to find a ranking for (self-) fluorescence, see Fig. 4.

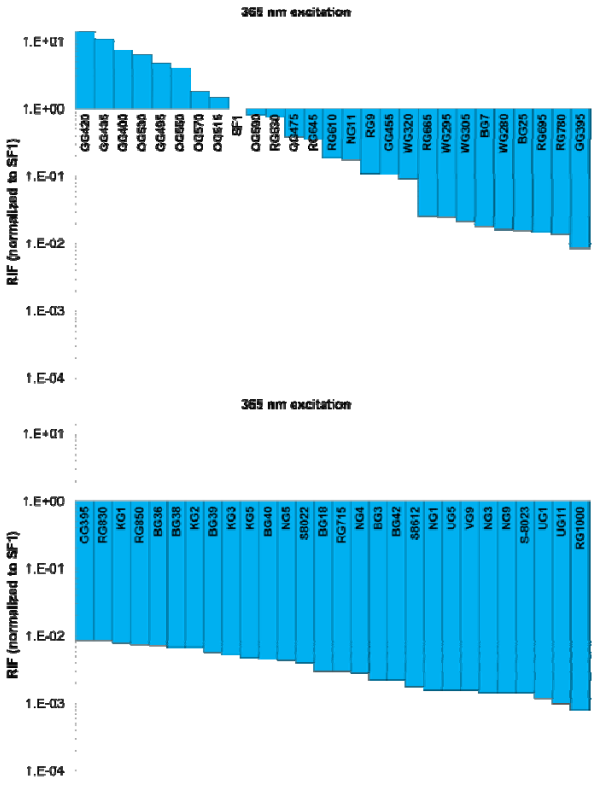

Fig. 4 *Measurement results of (self-) fluorescence of 53 different SCHOTT optical filter glasses displayed as RIF vs. filter glass type. Top and bottom show the same logarithmic y-axis scale for better comparison.*

The values vary from RIF = $8 \cdot 10^{-4}$ for RG1000 (lowest value) to 13.8 for GG420 (largest value).

4.2 Results for melt-to-melt variation

Now the effect of melt-to-melt variation due to slight fluctuations in raw material is analyzed, see Fig. 5. All glass types fulfill the guaranteed specified values according the datasheet.

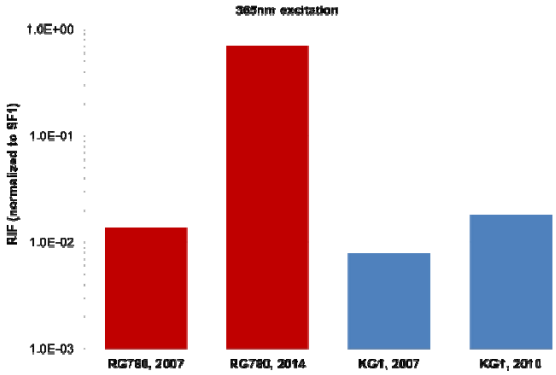

Fig. 5 *Measured RIF (log. scale) for 2 filter glass types but melted at different times (melt-to-melt fluctuation).*

The measured values of RIF can be found in Tab. 1. Fluorescence (RIF) for KG1 varies by a factor of 2.2 whereas for RG780 RIF varies by a factor of 50.7 (for these 2 melts).

Glass type	Melt number	Date of melting	RIF
KG1, 2007	G1014646	29.10.2007	0.008
KG1, 2010	G1015590	26.02.2010	0.018
RG780, 2007	343740	05.04.2007	0.014
RG780, 2014	0001745054	23.04.2014	0.710

Tab. 1 *Results for melt-to-melt fluorescence variation.*

5 Summary and outlook

In this article measured values of fluorescence level for different SCHOTT filter glasses were presented. RIF was measured to vary between $8 \cdot 10^{-4}$ for RG1000 (lowest value) to 13.8 for GG420 (highest value). All filter glasses fulfill the guaranteed values according the datasheet. A melt-to-melt fluctuation of fluorescence was measured and shows strong dependency up to a factor of 50. Fluorescence of filter glass is a “side effect” and typically not specified in a datasheet. But measurements can be performed at SCHOTT enabling a low fluorescence filter glass.

References

[1] B. Saleh, M. Teich: *Fundamentals of Photonics*, (John Wiley & Sons, 1991)

[2] A. Siegman: *Lasers* (University Science Books, 1986)

[3] SCHOTT Technical Information: *TIE-36: Fluorescence of optical glass*, available for download *http://www.schott.com/advanced_optics/english/knowledge-center/index.html* (2009)