Recent Development of Tellurite-based Glasses for Photonic Applications

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Recently, tellurite(TeO_2)-based glasses have attracted interest because of their wide optical window, high refractive index and third-order nonlinear optical properties.[1,2]Binary- and ternary-component tellurite systems, such as TeO_2-Ag_2O, TeO_2-TiO_2-ZnO and TeO_2-Nb_2O_5-ZnO are more intriguing for the purpose of enhanced third order nonlinear susceptibilities. Here, color-changed $20Ag_2O$-$80TeO_2$glasses (See Fig.1) are picked up as our recent results onnonlinear optical glasses [2]. Curiously, when the melting time was short (<90 min.), the glasses synthesized with a alumina cruciblecolored red, which was then changed to orangish-yellow withthe melting time longer.The measurement of third nonlinear opticalsusceptibility$Re\chi^{(3)}$was conducted by a Z-scan method for the homogeneous glasses,melted in alumina crucible for 90-240 min. (the orangish-yellow glasses).The highest$Re\chi^{(3)}$, 6.15×10^{-13} (esu),was obtained forthe sample synthesized with the 180 min. melting time, which was approximately 23 times of that of silica glass.On the other hand, the glassessynthesized with a Ptcruciblewereeasily crystallized and opaque. However, transparent $20Ag_2O$-$80TeO_2$glasses wereobtained when Al_2O_3 was added. The resultant glasses showed yellowish color regardless of the melting time. The Al_2O_3-added Ag_2O-TeO_2 glass synthesized with Pt crucible was also subjected in Z-scan and Raman. Raman spectroscopy revealed the glass possessed more TeO_4 unit structure in comparison with the glasses synthesizedin alumina crucible. The evaluation of $Re\chi^{(3)}$was 1.19×10^{-12} esu, which was quite high and comparative to that of α-TeO_2 single crystal.

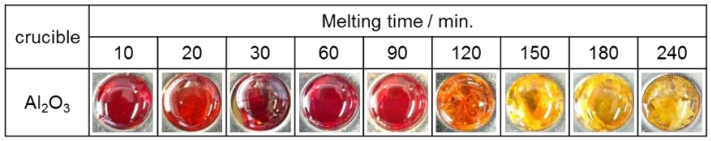

Fig.1 Photographs of $20Ag_2O$-$80TeO_2$ glasses synthesized with an alumina crucible for the varied melting time.[2]

The other topic of the development of photonic tellurite-based glasses is up-conversion (UC) phosphor. It is well-known that Tm^{3+} ions exhibit blue up-conversion photoluminescence (UCPL) via three steps energy transfer from Yb^{3+} ions as a sensitizer. However, the low probability of energy transfer related with the blue UCPL remains an unsolved issue. TeO_2 based glasses are suitable materials for UCPL phosphor matrix because of their low-phonon energy, large solubility of rare-earth ions. Recently, Tm^{3+}, Yb^{3+} co-doped TeO_2-$TlO_{0.5}$-ZnO glass system was developed for optical applications in our group [3]. UCPL spectra of $60TeO_2$-$30TlO_{0.5}$-$(9-x)$ZnO-$x$$Tm_2O_3$-$1Yb_2O_3$ glass comprised three luminescence peaks centered at 480, 650, and 800 nm, assigned to $^1G_4 \rightarrow {}^3H_6$, $^1G_4 \rightarrow {}^3F_4$, $^3H_4 \rightarrow {}^3H_6$ transition of Tm^{3+} ion, respectively. From spectral data, the energy transfer rate $\gamma_{d5}$from Tm^{3+} to Yb^{3+} ions was analyzed as a function of Tm_2O_3 concentration. The optimized rate was quite high to be 2.07×10^{-17} cm^3/s for $0.2Tm_2O_3$ doping, which was comparative with the literature data [3].

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[2] K.Kato, T.Hayakawa, Y.Kasuya, P.Thomas,*J.Non-Cryst. Solids,* **431**(2016) 97.
[3] M.Uchida, T.Hayakawa, T.Suhara, J.-R.Duclère, P.Thomas, *Int. J. Appl. Glass Sci.***6** (2015) 83.