defined to be 100%, and thus, the transmittance values in Table 2 are just the ratio of transmitted optical power between doped polymer and undoped polymer. Meanwhile, the crosstalk is remarkably different between the carbon-black-doped and BzMA-powder-doped clad waveguides. In Table 2, the results of 10-ppm carbon-black-doped waveguide are also shown for a comparison. In the case of the 10-ppm carbon-black-doped polymer, the light transmittance at 850-nm wavelength is 80. 1%, which is higher than that of 0.5-wt.% BzMA-doped polymer. However, the crosstalk in the waveguide with 10-ppm carbon-black-doped clad (–45.3 dB) is lower than that (–36.0 dB) in the BzMA doped counterpart. Therefore, it is verified that the low crosstalk values in the waveguides with carbon-black-doped cladding is attributed to the high "absorption" loss, while high scattering loss would not necessarily contribute to the crosstalk reduction effectively.

From the results in Section 5, it is of another concern that high-scattering loss in cladding can increase the crosstalk (due to a multiple scattering effect.) However, it is noteworthy that the crosstalk of –36.0 dB is comparable to the crosstalk in the waveguides with undoped PMMA cladding shown in Fig. 7. In order to carefully investigate the contribution of scattering loss, we should vary the haze of the cladding and evaluate the crosstalk. This result will be described elsewhere.

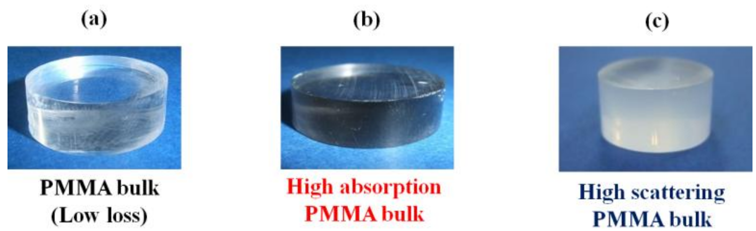

Fig. 10. Appearance of PMMA bulks with (a) no attenuation material (b) high absorption material (c) high scattering material.

Table 2. Characteristics of Waveguides with Carbon Black or BzMA Powder in Claddings

	Carbon black waveguide (10 ppm)	Carbon black waveguide (25 ppm)	BzMA doped waveguide (0.5 wt.%)
Core diameter /pitch (μm/μm)	98/270	90/230	95/250
Propagation loss (dB/cm)	0.029	0.029	0.030
Numerical aperture (NA)	0.170	0.180	0.176
Index exponent value (g value)	2.8	2.5	2.2
Transmittance value of 10 mm bulk @850 nm(%)	80.1	48.4	55.4
Crosstalk after 1m propagation (dB)	–45.3	<-69.3	- 36.0

6. Conclusions

We fabricated novel GI-core polymer parallel optical waveguides with carbon-black-doped cladding to add a high-absorption-loss to the cladding. We demonstrated that the waveguides with high-absorption-cladding could reduce the inter-channel crosstalk dramatically, maintaining the low propagation loss of the cores. At the same time, it was suggested that a concentration higher than 10 ppm of carbon black doping into the cladding is preferable for the crosstalk reduction. In addition, the crosstalk of the waveguides fabricated by means of the lithography method was decreased by carbon-black doping in the cladding despite the high scattering loss of the waveguide (core) material.

We also confirmed that other waveguides with high scattering loss in the cladding were not as effective as high absorption loss did for reducing the crosstalk.

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