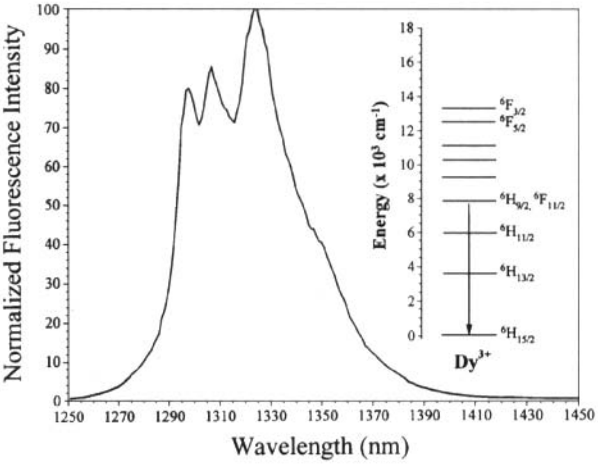


**Ballato Figure 1.** Normalized fluorescence spectra for solution-derived $Dy^{3+}$:$LaCl_3$.

efficiencies of 66% and 72% are measured, respectively, for these samples. $Dy^{3+}$:$LaCl_3$ (500 ppm) samples exhibited relatively narrow 3-dB emission bandwidths of 50 nm (1295 → 1345 nm) (See Fig. 1). Measured lifetimes of 1.11 ms (200°C) and 1.31 ms (400°C) correspond to measured efficiencies of 66% and 78%, respectively.

The spectroscopic properties of these hosts are comparable, if not better, than melt-grown, ultra-pure single-crystal analogs verifying the ability of inexpensive and low-temperature solution-based methodologies to produce low phonon-energy materials. The versatility, ease, and low cost of this solution process represents a significant advance in 1.3 µm fluorescent materials for both optical fiber and thin-film amplifiers for planar integrated photonics.

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## High-speed Multi-wavelength Photonic Switch

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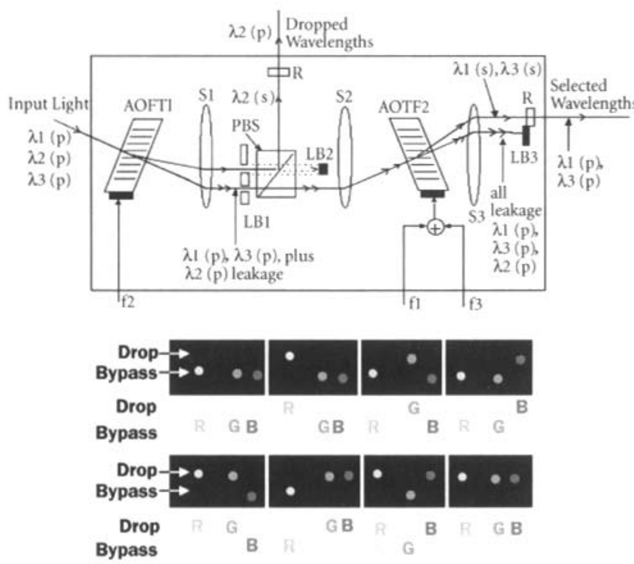
The ability to rapidly and independently switch multiple wavelengths in a light beam is useful for both WDM fiber-optic communications and for hardware compressed photonic signal processing. Key features for such a multi-wavelength switch include microsecond domain wavelength switching and excellent –50 dB optical switching isolation, leading to rapidly reconfigured high signal-to-noise ratio photonic systems. Previously, the bulk acousto-optic tunable filter (AOTF) was found to be attractive for this multi-wavelength switch application as the bulk AOTF can operate over wide optical bandwidths with high speeds and at high optical power levels. Recent improvements in AOTF device designs have lowered the high drive power requirements commonly associated with bulk AOTFs.[1] In addition, these new devices show spectral resolutions in the 1-nm level range, indicating possible use for high (> 32) channel count WDM fiber communications. Nevertheless, one debilitating problem associated with the inherent operation of the AOTF is its finite (*e.g.*, 95%) diffraction efficiency that leads to its low and undesirable –20 dB level type optical crosstalk numbers.

Recently, we proposed a dual-AOTF based multi-wavelength switch structure that solves this inherent AOTF caused low crosstalk problem, hence making it possible to use bulk-AOTF devices for a broad range of multi-wavelength photonic signal processing applications. Specifically, a new high-speed and ultra-high crosstalk suppression multi-wavelength add-drop optical filter structure (see Fig. 1) is demonstrated using two bulk AOTFs.[2] Using simple spatial blocks, polarization optics, and orthogonal set drive conditions for the AOTFs, an average –47 dB optical suppression is measured for the unwanted wavelengths at the filter output ports. The filter is tested for the three standard red, green, and blue visible wavelengths, and demonstrates a switching time of 0.65 µs and an average optical loss of 5 dB. Polarization diversity techniques can be applied to make the switch in Figure 1 insensitive to the input polarization, such as required in fiber-based applications. Applications for this switch can range over a wide optical spectrum, with optimized designs possible for both




**Riza Figure 1.** The proposed suppressed crosstalk multi-wavelength filter/switch architecture shown as a drop filter in a 1 × 2 switch configuration for polarized inputs. R = 90° polarization rotator. Figure also shows the drop and bypass port images captured using a video camera. The images show the three independent R, G, B colors as they are switched to the two ports in our experimental filter.

the visible and near-IR fiber communications bands. Further improvements are required in packaging to implement a compact, robust unit. Wavelength capacity for such a switch is AOTF device design limited, and 32-wavelength processing is achieveable.

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## Optical Means of Generating Time-aligned Picosecond Data Pulses[2] and Producing Enhanced Pulse Compression[3] on WDM Beams in a Nonlinear Fiber

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In spite of the intrinsically small value of the nonlinearity coefficient in fused silica, due to low loss and long interaction length, the nonlinear effects in optical fibers made with fused silica cannot be ignored even at relatively low power levels. This nonlinear phenomenon[1] in fibers has been used successfully to generate optical solitons, compress optical pulses, transfer energy from a pump wave to a Stokes wave through the Raman gain effect, transfer energy from a pump wave to a counter-propagating Stokes wave through the Brillouin gain effect, produce four-wave mixing, and dynamically shepherd pulses. We have found a fundamentally new way to optically generate time-aligned picosecond data pulses on WDM beams in a single-mode fiber[2] and a new method to enhance or generate pulse compression of co-propagating pulses on different WDM beams in a single fiber.[3]

Time-aligned picosecond optical pulses are the backbone for the future ultra-high-speed bit-parallel WDM fiber communication system. A high-power, picosecond pulse, called the shepherd pulse, is launched on a given beam. A number of low-power beams selected based on the WDM format are launched without any signal pulses into a single-mode nonlinear fiber. These beams copropagate with the beam carrying the shepherd pulse in this fiber. Time-aligned pulses will appear on these low-power WDM beams. The nonlinear cross phase modulation (CPM) effect in a single-mode fiber is instrumental in the generation of these time-aligned pulses. Using external modulators, these time-aligned pulses on WDM beams can be used directly as sources for the bit-parallel WDM communication system.[4]

A way to optically compress pulses on WDM beams has also been found. The usual soliton-effect compressor,[1] which makes use of higher-order (or higher amplitude) solitons supported by fiber as a result of interplay between self-phase modulation and anomalous group-velocity dispersion (GVD), is well known. One notes here that the interplay between CPM and GVD may also provide similar pulse compression effect. The significant difference is that pulse compression can take place for pulses on a different wavelength beam. The high-power pulse on one wavelength beam may be used to provide high compression to a low-power pulse on another wavelength beam.[3] One shepherd pulse can cause the compression of all the other wavelength pulses, thereby improving their pulse widths as well as the separation of different pulses. Furthermore, since the longer wavelength pulses are compressed at a rate different from the shorter wavelength pulses, one can conceivably make all pulses have the same time width, which may make detection and discrimination easier to accomplish.

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# DIFFRACTIVE OPTICS

## Wavelength Compensation of Broadband Light Diffraction

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Propagation of electromagnetic waves in free space is a physical phenomenon that explicitly depends on the wavelength of the light radiation. This fact results in the chromatic dispersion of the optical field diffracted by an aperture illuminated with a broadband source. The above situation severely restricts the spectral bandwidth of the illumating source that can be used in a diffraction-based optical system. If our interest is that all the spectral components produce the same effect, broadband-dipersion compensation is then required. The milestone of the compensation procedure lies in achieving the incoherent superposition of the monochromatic versions of a selected diffraction pattern in a single plane, with the same scale for all the wavelengths of the incident light. Achromatic diffraction systems meet the above requirement in a first-order approximation.

The chromatic compensation procedure we developed takes advantage of the chromatic aberrations associated with diffractive lenses. In particular, we demonstrated the achromatic Fourier-transforming capability of an air-separated diffractive lens doublet.[1] Figure 1a (page 20) shows this easy-to-implement optical setup. $DL_1$ and $DL_2$ are diffractive lenses and the input transparency is illuminated with a broadband spherical wavefront beam converging toward the point source S, placed at the optical center of $DL_2$. The achromatic