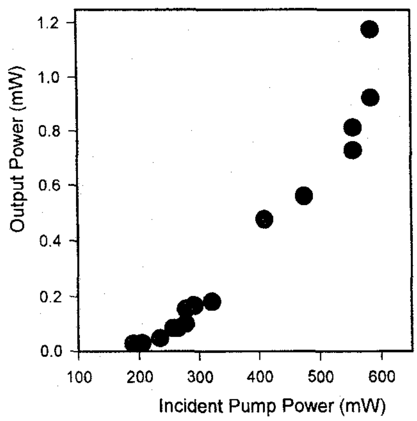
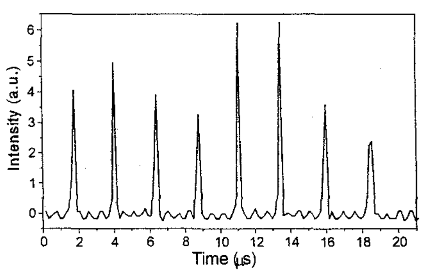


TuP4 Fig. 2. Output power versus incident pump power for a neodymium doped Ga:La:S glass fiber laser operating at 1080 nm.



TuP4 Fig. 3. Temporal behavior of the output power of a neodymium doped Ga:La:S glass fiber laser.

beam operating at 815 nm, was focused into the fiber core with a ×20 microscope objective. As with the bulk laser,[1] room temperature laser action was achieved on the $^4F_{3/2} \rightarrow {^4I_{11/2}}$ transition at a wavelength around 1080 nm and the dependence of the output power on the incident Ti:sapphire pump power is shown in Fig. 2. The threshold is about 200 mW and a maximum output power of 1.2 mW was obtained for this particular output coupler, however, by increasing the output coupler reflectivity to 99.5% the laser threshold could be reduced to around 50 mW.

Although in pumped continuous wave (cw) the fiber laser did not lase cw, but showed a self-pulsing behavior, an effect not observed in the bulk laser which showed stable cw laser action.[1] The fiber laser emitted pulses with about 0.2 μs width and regular pulse spacings with repetition rates between 2 μs and 3.5 μs. A typical train of pulses is shown in Fig. 3. Self-pulsing has been observed in rare-earth doped fiber lasers before, although the explanation for such effects are not fully understood. In this particular case, the fact that the bulk laser operates cw would indicate that the effect is concentration dependent since the neodymium dopant level is much lower in the case of the fiber laser. Finally, the laser was operated for a considerable time without a significant change in the threshold or slope efficiency indicating that pumping close to the intrinsic glass absorption edge is practical in these glasses.

In conclusion, the neodymium doped Ga:La:S glass fiber was fabricated using the rod-in-tube technique and showed laser action at room temperature at a wavelength of about 1080 nm when pumped with a Ti:sapphire laser at 815 nm. This result is a significant step towards the realization of practical devices in this new class of materials, in particular, efficient 1.3 μm amplifiers for telecommunication and new fiber lasers operating at mid-infrared wavelengths.

Chalcogenide starting materials were supplied by Merck Ltd. of Poole, England.

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TuP5 **14:45**

System demonstration of an in-service passive surveillance scheme for optically-amplified branched optical networks

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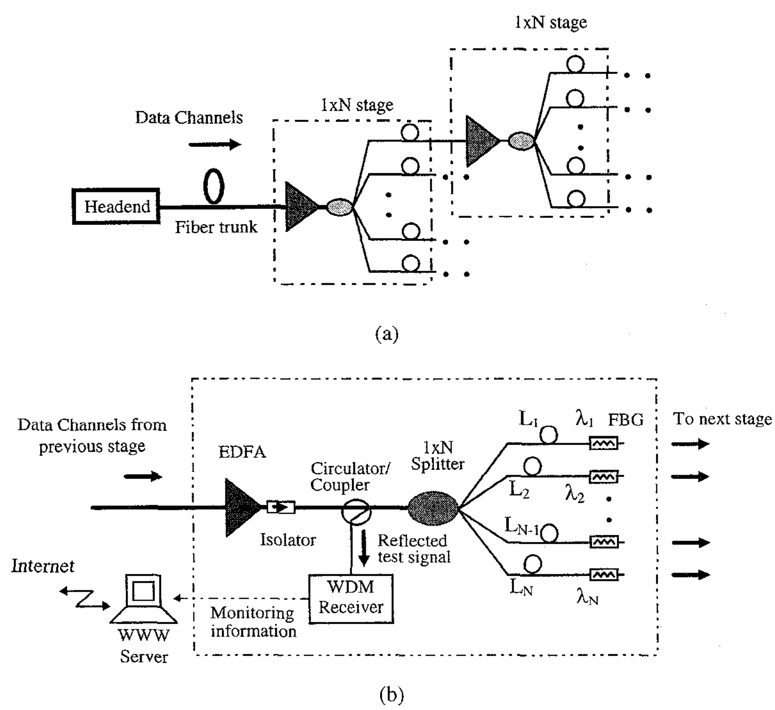
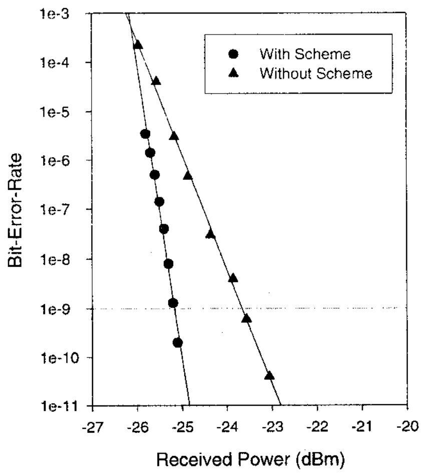
Passive branched optical networks (PBON) are very promising and cost-effective architectures for future subscriber networks such as CATV and fiber-to-the-home systems. Erbium-doped fiber amplifiers (EDFA) are usually placed before each splitter to compensate for the splitting and fiber losses. To ensure a reliable transmission of data channels over the subscriber networks and to maximize the link utilization, it is essential to have a non-intrusive and cost-effective surveillance system to identify the faults along the fiber link timely and continuously while the data channels are still in service.[1,2]

We have proposed a passive surveillance scheme[3] for in-service fault identification of fiber links and optical amplifiers on PBONs using fiber Bragg gratings (FBG) and the residual amplifier's noise as the source. Figure 1(a) shows the overall scheme of an M-ary PBON which consists of multiple 1xN stages, and the proposed surveillance scheme can be employed in every 1xN stage as in Fig. 1(b). The FBG placed on each branch is used to slice and reflect the ASE power at a designated wavelength other than the data signal wave-



TuP5 Fig. 1. (a) An M-ary tree-branched PBON. Our proposed surveillance scheme for (b) a 1xN stage. Note that the optical isolator can be removed when the optical circulator is used instead of the coupler.

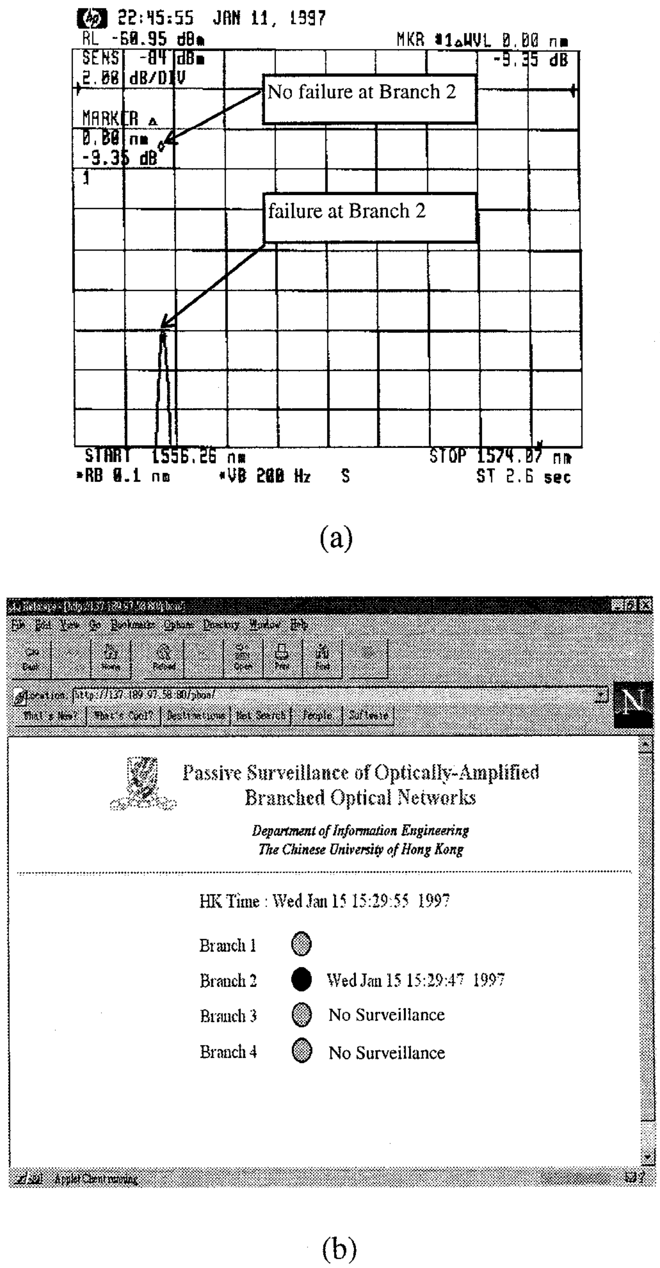


TuP5 Fig. 2. BER performance of 1-Gb/s (2^{10}-1 PRBS) NRZ data channel at 1555 nm, detected at branch 1 with and without the surveillance scheme.

lengths to form a monitoring channel for that branch. All reflected monitoring channels from all branches are extracted using an optical circulator or a fiber coupler, and detected by a WDM receiver which consists of an array-waveguide grating (AWG) and a power sensor array. If any received monitoring channel is below the detection limit, this indicates that there might be a fault at the corresponding fiber branch. The monitoring information at each 1xN stage can then be transmitted back to the network operators via either telephone lines or internet.

Here, we demonstrate the system operation of our surveillance scheme for a 1xN stage shown in Fig. 1(b). We show that our scheme can effectively provide surveillance without interrupting the in-service data channels. Moreover, the reflected monitoring channels are demultiplexed by an AWG (PIRI AWG-16 × 16-100G-1.5-1) and detected by a power sensor (HP81532A). The link status of all branches can be accessed by a remote host via internet. In our demonstration, the 1xN stage has four branches (via a 1 × 4 coupler) with fiber lengths L_1 = 8.8 km, L_2 = 6.6 km, and FBG center wavelengths at λ_1 = 1557.5 nm, λ_2 = 1559.9 nm. Branch 3 and 4 are left unmonitored. The 3-dB bandwidth and the reflectivity of each FBG are 0.9 nm and 90% respectively. The AWG used in the WDM receiver has 4 dB insertion loss and 0.4 nm 3-dB passband. The power sensor has a sensitivity of −110dBm. A 1-Gb/s (2^{10}-1 PRBS) NRZ data channel at 1555 nm with transmitted power 6 dBm is inputted to the fiber trunk before splitting. Figure 2 shows the bit error rate performance of the data channel at the end of branch 1 when a Fabry-Perot optical filter with 1 nm 3-dB passband is used before detection. It is shown that our scheme does not degrade the data channel transmission and thus it can support in-service data transmission. Instead, there is about 1.3 dB improvement in receiver sensitivity at BER = 10^{-9} and this is due to the reduction in ASE noise power by the in-line FBG. To simulate the fault identification process, the fiber of branch 2 is intentionally disconnected, and the reflected spectrum after the AWG is shown in Fig. 3(a). There is about 9 dB drop in the reflected power at λ_2 received at the receiver, indicating a fault in branch 2. The status of each branch is automatically updated to a world-wide-web (WWW) server which can be accessed by a remote host via internet. At the remote host, the network operator can read the status (see Fig. 3(b)) of each fiber branch timely through some WWW browsers such as Netscape.

In summary, we have experimentally demonstrated the system operation of our proposed passive surveillance scheme for optically-amplified branched optical networks. The in-service data channels are not interrupted nor degraded and the link status of all fiber branches can be monitored continuously and simultaneously by remote hosts via internet.



TuP5 Fig. 3. (a) Output spectrum of AWG when branch 2 is failed, (b) webpage of the surveillance scheme with branch 2 detected failed. The time on the right indicates the time of failure.

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