Long-reach 100 Gbit/s Ethernet could be on the horizon with a new avalanche photodiode receiver

NTT researchers in Japan have demonstrated 25 Gbit/s transmission over 40 km without the need for power-hungry optical preamplifiers. The team designed an avalanche photodiode receiver optical subassembly module (APD-ROSA) that allowed them to smash the previous best transmission performances of 10 Gbit/s using APDs.

“The power consumption of semiconductor optical amplifiers will be a big issue for small transceivers in the near future,” said Masahiro Nada from NTT Photonics Laboratories. “Our APD-ROSA has the potential to realise low-power-consumption and low-cost, middle-reach 100 or 400 Gbit/s Ethernet systems. I believe that our results will open the door to using APDs for 100 Gbit/s systems.”

Reaching out

Over the last couple of years, long-reach 100 Gbit/s Ethernet systems have started to appear. However, with the transmission distance limited by fibre losses, employing a receiver with a high sensitivity is critical to extend to distances over 10 km.

Up until now, semiconductor amplifiers (SOAs) have been the only candidate with sufficient performance at the required channel bit rates of 25.8 Gbit/s, and optical transceivers using SOAs were demonstrated in 2011 in a practical realisation of a 103 Gbit/s transmission system over 40 km.

While SOAs present a simple solution to extending the transmission distance, the problem is that they consume a lot of power, and are also rather bulky. This has led the NTT researchers to investigate the APD as an alternative which, with their superior multiplication gain, are widely used in 10 Gbit/s systems to extend the transmission distance over that achievable using conventional photodiodes.

Coming up ROSAs

It is only recently that APD technology has matured enough to offer a sufficient gain-bandwidth product (GBP) at higher channel bit rates. Researchers have employed various different materials with a larger GBP for the avalanche layer including InP, InAlAs and even Si, although high-speed operation is still difficult with Si.

Making the avalanche layer thinner has also shown some promising results. NTT’s approach has been to make a low-high-low electric field profile and, by replacing the InP avalanche layer with a thinner layer of InAlAs, they were able to improve the GBP from 100 to 235 GHz.

The NTT team assembled their 25 Gbit/s APD together with a commercially available transimpedance amplifier in a CAN-type ROSA that is widely used in 10 Gbit/s systems. They used a glass feed-through and flexible printed circuits as an electrical interface. Using their APD-ROSA as a receiver at 1310 nm they were able to demonstrate 40 km error-free transmission with a comparable power penalty to that previously reported using SOAs.

Avalanche control

Nada and his colleagues think that increasing the multiplied-responsivity bandwidth product at the operation conditions is important for further development of their APD, and they will be trying to achieve this by optimising the absorption layer structure. They will also be trying to improve the GBP by optimising the avalanche layer.

“Using such improved APDs, I want to build optical receivers with higher sensitivities and higher speeds for 400 Gbit/s or 1 Tbit/s systems,” said Nada, who is working with his colleagues to develop optical receivers, front-end modules and photo-mixers based on customised high-speed and high-output photodetector technologies.

Looking ahead to the challenges of achieving even higher APD operation speeds while maintaining a high gain and responsivity, Nada comments: “The Si avalanche layer is well known for achieving a high GBP of 300 GHz. For 400 Gbit/s or Tbit/s operation, an even higher GBP will be required. GaN and SiC are attractive materials for meeting this requirement. However, they are not lattice matched to an InGaAs absorption layer. So, how do we fabricate an APD with them? And are there any other attractive available materials? These are fundamental questions, but are worthy to pursue.”