The group is not only working on a version of MIIPS that can characterize sub-15-fs pulses but is also evaluating different phase functions to improve the determination of arbitrary higher-order phase modulation. Applications include telecom and biomedical studies. — Phillip Espinasse

**hat-shaped hollow improves 3-D waveguide performance**

Less is more, especially when it comes to waveguides, it appears. Fumio Koyama at the Microsystem Research Center of the Tokyo Institute of Technology (Titech; Tokyo, Japan) recently developed a 3-D waveguide with a hat-shaped hollow, showing that the design reduces the thermal sensitivity and propagation loss of the device.

“Dielectric waveguides have been used to guide light waves in passive optical devices, but their temperature sensitivity is a problem,” says Toru Miura, spokesperson for the Titech team. “Also, square metallic 3-D waveguides exhibit a large absorption loss at certain frequencies. While hollow waveguides of various types have been tried in the past, ours presents a novel structure and fabrication process.”

Titech’s method for fabricating a 3-D hollow waveguide is simple. The group cuts grooves in two slabs of substrate material that has a low coefficient of thermal expansion; one groove is wide and shallow, the other is narrow and relatively deep. The faces of both slabs are then coated with multiple layers of thin-film gold or dielectric reflectors. For this study, the team concentrated on thin-film gold. They then assemble the slabs face to face, forming a hat-shaped, gold-coated tunnel through the substrate.

“We calculated propagation loss per unit length for the TE01 mode in a gold-coated 20 × 20 µm square hollow waveguide to be 78 dB/cm,” says Miura. In contrast, the loss of the Titech waveguide was 1 to 2 dB/cm in TE mode. Moreover, insertion loss decreased as substrate gap width increased.

Miura says the hat-shaped structure of Titech’s hollow waveguide avoids high propagation loss. “In the lateral direction, the light is confined by the difference in effective refractive index,” he says. Analysis shows that the refractive index of the region with the deeper waveguide thickness (the top of the hat) is larger than that of the shallower region. The difference in equivalent refractive index in the lateral direction confines the beam to approximately the width of the narrower, deeper groove.

The Titech team used 1550-nm incident light to measure differences in insertion loss at various substrate gap widths. “We found that not coating the sidewall of the waveguide with gold further reduced propagation loss,” says Miura. “We also found that altering substrate gap distances affected propagation loss.” Insertion loss decreased as substrate gap width increased, Miura notes, observing that a 15-µm gap in a gold-coated waveguide resulted in the lowest propagation loss.

Although the gold coating proved the viability of the Titech 3-D hollow waveguide hypothesis of reduced propagation loss, the large absorption due to the coating still pushed propagation loss above target. “We are now working on a waveguide that uses multilayer mirrors instead of gold. We are confident that we can create temperature-insensitive optical filters and grating multiplexers with our hollow waveguide,” Miura says.

Still, the team has to make significant progress to make the technology competitive. “I think the device is very large compared to a photonic crystal,” says Susumu Noda, professor at Kyoto University (Kyoto, Japan). “We can achieve very small channel add/drop devices by simply putting point defects at the vicinity of the line-defect waveguide in a photonic bandgap structure. It is very difficult for other waveguides to achieve such functionality.” — Charles Whipple