The ytterbium-doped fibre laser (YDFL) has become the forerunner for high-power fibre lasers and amplifiers largely owing to the broad emission of Yb³⁺ ions (λ = 975 to 1200 nm) and their ability to be incorporated in a silica host in relatively high concentrations. Achieving multi-kilowatts of output power from a fibre has been made possible through improved fibre design and fabrication. In this paper we report on a robust polarization-maintaining (PM) YDFL with a unique aluminosilicate pedestal structure.

A Yb-doped aluminosilicate pedestal fibre was fabricated using modified chemical vapour deposition (MCVD) and a novel in-situ solution doping technique [1]. The preform was then drilled and assembled with borosilicate stress rods to form a PANDA structure. A double clad fibre with 120 μm outer diameter was pulled from the preform. The refractive index contrast in the pedestal layer and in the core was achieved by Al and Al-Yb doping, respectively. The pedestal layer has 0.12 NA with respect to silica which is comparable to fibre where the thermal expansion mismatch against the silica cladding was estimated by linear function of weight factor of glass constituent, i.e. \( \Delta p = \sum f_i w_i \) where \( \Delta p \) is change in the thermal expansion coefficient, \( f_i \) is thermal expansion of constituent, \( i \), and \( w_i \) is molar weight of constituent, \( i \). [3] The \( f_i \) of P₂O₅, GeO₂, and Al₂O₃ were obtained as 1.33 \( \times 10^{-7} \), 0.71 \( \times 10^{-7} \), and 0.5 \( \times 10^{-7} \text{°C}^{-1} \text{mol%}^{-1} \), respectively, from [3]. In order to achieve a 0.12 NA, 5.68 mol% of P₂O₅ is required in the pedestal layer which will induce 7.58 \( \times 10^{-7} \text{°C}^{-1} \) of thermal expansion mismatch against the silica cladding. A GeO₂-SiO₂ pedestal layer would produce 2.41\( \times 10^{-7} \text{°C}^{-1} \) of thermal expansion mismatch for the corresponding NA with 3.42 mol% of GeO₂. The same NA can be raised by 2 mol% of Al₂O₃ which causes only 1\( \times 10^{-7} \text{°C}^{-1} \). Thus, the respective thermal expansion mismatch caused by P₂O₅-SiO₂ and GeO₂-SiO₂ is ~ 7.6 and ~ 2.4 times higher than that by Al₂O₃-SiO₂. Note that the stress rods overlap the pedestal layer as shown in Fig. 1, which clearly indicates low stress build-up in the preform with aluminosilicate inner-cladding. The birefringence of the fibre was measured as 2.4\( \times 10^{-4} \).

Laser performance of the PM Yb-doped pedestal fibre was tested in a linear cavity pumped at 975 nm. We utilized a half-wave plate and a polarization beam splitter to align polarization direction of laser oscillation along with a birefringence axis of the fibre. The laser output power vs launched pump power is presented in Fig. 2. The output power linearly increases with the pump power and exhibits 79% of slope efficiency. The maximum output power is 14.7 W which is limited by available pump power. The fibre length used was 2.5 m permitting ~98% of pump absorption. The polarization extinction ratio was higher than 12 dB at maximum power.

In conclusion, we report the first demonstration, to our knowledge, on PM aluminosilicate pedestal fibre which is readily scalable to large mode area design.

References