Novel resonantly-enhanced nonlinear frequency conversion scheme for cladding-pumped fiber lasers

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High power continuous-wave (CW) laser sources emitting in the visible spectral region have a diverse range of applications in areas such as laser processing of materials, projection displays, medicine and sensing. The standard method of accessing the visible wavelength region is via nonlinear frequency conversion of near-infrared solid-state and fiber lasers. In the CW regime, the most popular method for generating visible output is via intracavity second harmonic generation in a diode-pumped 'bulk' solid-state laser. This approach exploits the relatively low resonator losses and hence high intracavity powers that can be achieved in these lasers to achieve high second harmonic conversion efficiency and output powers in multi ten-watt regime. Further power scaling of such sources, however, is rather challenging due to the effects of heat generation in the laser medium, which lead to beam distortion and increased resonator loss. Cladding-pumped fiber lasers benefit from a geometry that is relatively immune to the effects of thermal loading and hence offer the prospect of much higher power levels in the visible regime via nonlinear frequency conversion. Unfortunately, the technique of intracavity second harmonic generation is not well-suited to cladding-pumped fiber lasers, since they have rather high resonator losses. One solution to this problem is to employ the technique of external resonant cavity second harmonic generation. This approach has been successfully applied to CW fiber sources, but suffers from the drawback of added complexity since a single-frequency fiber master-oscillator power-amplifier is required and the master-oscillator and resonant cavity lengths must be actively stabilized to ensure that the resonance condition is maintained at all times.

Here we present an alternative approach for efficient second harmonic generation in cladding-pumped CW fiber lasers. Our approach makes use of a simple fiber laser resonator containing an internal resonant enhancement cavity with a nonlinear crystal for second harmonic generation (see Fig.1). The fiber laser automatically lases on axial modes which are simultaneously resonant in the enhancement cavity and the main fiber laser resonator. As

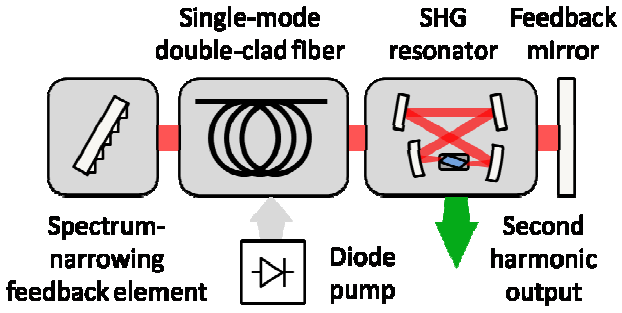

Fig.1: Internal resonantly-enhanced frequency doubling in a fiber laser.

a result, the intracavity power in the enhancement cavity is increased to many times the CW power that can be extracted from the fiber laser alone, leading to high second harmonic conversion efficiency. This approach does not require a single-frequency fiber source and there is no need for active cavity length stabilization since the fiber laser can only lase on axial modes which are resonant in the enhancement cavity. Using this scheme we have generated ~19W of stable green output at 540 nm from an Yb doped fiber laser cladding-pumped with ~90 W of diode power at ~975 nm. These preliminary results were obtained with a non-optimal set-up due to limited availability of components. The prospects for further improvement in performance in terms of output power, conversion efficiency and range of operating wavelengths will be discussed.