Progress of large-aperture plasma Pockels cell for high power laser in CAEP

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Abstract: Large-aperture plasma Pockels cell (PPC) is one of important components for inertial confinement fusion (ICF) laser facility. We have demonstrated a single-pulse driven 4×1 PPC with 400mm×400mm aperture for SGII laser facility. And four 2×1 PPCs modules with 350mm×350mm aperture have been operated in SGII update laser facility. It is different to the PPC of NIF and LMJ for its simple operation to perform Pockels effect. With optimized operation parameters, the PPCs meet the SGII-U laser requirement of four-pass amplification control. Only driven by one high voltage pulser, the simplified PPC system would be provided with less associated diagnostics, and higher reliability. To farther reduce the insert loss of the PPC, research on the large-aperture PPC based on DKDP crystal driven by one pulse is developed. And several single-pulse driven PPCs with 80mm×80mm DKDP crystal have been manufactured and operated in laser facilities.

Keywords: Plasma Pockels cell; optical switch; single-pulse driven; inertial confinement fusion

Large-aperture plasma Pockels cell (PPC) [1] is one of important components for inertial confinement fusion (ICF) laser facility. To achieve high power output and low cost, the laser driver for ICF is designed to be large aperture and arrays configuration. In the basic PPC concept of NIF, optically transparent, low-density helium plasmas are initiated by two pulser serve as electrodes for the KDP crystals mounted in the Pockels cell. Between the resulting highly conductive electrodes, a high-voltage pulse is applied to produce a uniform electric field in the crystal, which then undergoes the Pockel's effect. In the LMJ, operation of PPC is “one-pulse process” that one positive high-voltage pulse and one negative high-voltage pulse are synchronously applied on two gas cells to perform Pockels effect without prior ionization of the gas [2]. DR. Zhou present a one-dimensional simplified model for the processes of gaseous discharge and charging on the surfaces of KDP crystal for one pulse process in PPC [3]. Recently, we demonstrate a PPC regime only driven by one high-voltage pulser. It is different to the PPC of national ignition facility (NIF) and laser megajoules (LMJ) for its simple operation to perform Pockels effect.

The experimental setup photo of 4×1 PPC with 400mm×400mm aperture is shown in Fig. 1. The switch-pulse generator provides a nominally rectangular pulse of 20kV, 250ns. Its pulse form net (PFN) is based on the double Blumlein line regime with separate inductors and capacitors. Only through one high-voltage pulse generator, the gas in Pockels cell is rapidly broken down and uniform plasma across the full aperture is achieved. The optical performance of the PPC was diagnosed. The rising time of the switch is about 98.5 ns, the static transmission of the PPC is about 92%, and the average switching efficiency across the entire aperture is greater than 99%.

With optimized operation parameters, four 2×1 PPC modules with 350mm×350mm aperture have been manufactured and operated in the SGII update laser facility, as shown in Fig. 2. The simplified PPC system would be provided with less associated diagnostics, less the maintenance, and higher reliability for large-scale ICF laser facility.

To farther reduce the insert loss of the PPC, research on the large-aperture PPC based on DKDP crystal driven by one pulse is developed [4]. By reformative design and employing a capacity to share the gas discharge voltage, the DKDP PPC driven by one pulse is realized. And several single-pulse driven PPCs with 80mm×80mm DKDP crystal have been manufactured and operated in laser facilities.

REFERENCES