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A hollow-cathode discharge cw multicolour He–Cd^+ laser module

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Abstract. We report on the design and performance of a hollow-cathode discharge continuous wave He–Cd^+ laser module, which is capable of simultaneously delivering stable, milliwatt power output at the three primary spectral lines blue, green and red. A mixture of these lines can result in a wide band of colours, including white light. The laser can be formed from one or more laser modules. A module consists of two anodes with a hollow cathode located between them. Two long, narrow cylinders (50 mm long, 4 mm in diameter) separated by a wider cylinder (10 mm long, 10 mm in diameter) are made in the hollow cathode . The narrow cylinders serve as hollow cathodes, while the wider cylinder efficiently stabilizes the discharges in the narrow cathode cylinders, making them spatially similar. Owing to this particular cathode design the laser module, with a 10 cm active length, stably and effectively lased at seven wavelengths in blue (λ = 441.6 nm, 3 mW), green (λ = 533.7 nm, 0.3 mW; λ = 537.8 nm, 0.4 mW), red (λ = 635.5 and 636.0 nm, total 0.2 mW), and infrared (λ = 723.8 and 728.4 nm, total 0.1 mW). The optimum He pressure, Cd vapour pressure and cathode current were 8 mbar, 0.01 mbar (corresponding to a cathode temperature of 533 K), and 260 mA, respectively. The short- and long-term laser output power variations were less than 1% (peak-to-peak). The laser has exhibited stable operation for 300 h without discharge deterioration. The above allows us to claim that the presented hollow-cathode discharge continuous wave He–Cd^+ laser module should be useful as a simple, short, long-lived, multicolour laser source, operating at milliwatt output power levels. However, for higher output power level demands (tens of milliwatts) three or four laser modules must be used.

1. Introduction

Today, in the fourth decade of intense development of laser technology, there is still a permanent demand for simple, reliable and inexpensive laser systems that simultaneously generate the three primary spectral lines blue, green and red, a mixture of which can result in a wide band of colours. This demand is mainly due to the fast introduction of lasers for information processing, including full-colour printing, film-to-video conversion and vice versa, film recording and reproduction, image simulation, displays, holographic recording and storage and optical date storage. Among other possible applications are surface inspection (such as medical endoscopy and laser colour microscopy), inspection of photosensitive materials and multicolour measurements.

Since its first introduction (Karabut *et al* 1969, Sugawara and Tokiwa 1970, Sugawara *et al* 1970, Schuebel 1970a, b) the hollow-cathode discharge (HCD) He–Cd^+ laser has been one of the most promising candidates for such a multicolour laser system. The HCD He–Cd^+ laser oscillation wavelengths in red (636.0 and 635.5 nm), green (537.8 and 533.7 nm), and blue (441.6 nm) are close to those of the ideal three primary spectral lines 610, 540 and 450 nm (Thornton 1971), thus offering a chance for a very wide range of colour reproduction. This was demonstrated when Fujii *et al* (1975) obtained simultaneous, well-colour-balanced oscillations in red, green and blue with their flute-type HCD He–Cd^+ laser. The beam emitted by this laser appeared white, therefore, following the inventors, a HCD He–Cd^+ laser emitting such a beam is commonly called a white-light laser. The high ability of the HCD white-light He–Cd^+ laser to reproduce full-colour pictures has been shown practically by Takashima *et al* (1986, 1991). Moreover, the demonstration

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