Application of high-pressure microwave discharges to compact high-intensity discharge lamps

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The present work is devoted to develop compact microwave discharge lamps with high luminous efficacy, high brightness and long life from a viewpoint of energy saving and earth environment preservation. HID lamps without electrodes are expected as promising lamps which can satisfy these requirements. However, the lamps and their ignition systems uses microwave cavities and/or parabolic antenna as microwave launchers so that it is impossible to apply these lamp systems to automotive headlamps and road lightings because of poor light distribution controls due to their large scales and equipment of suppression from microwave leakage. Moreover, magnetron oscillator as a microwave power supply is not suitable to vehicle lamp systems because of weakness against vibrations and very short life.

At first, the basic experiments were carried out in the present work, using the gas-flow type discharge tube. It was confirmed that the plasma excitation method developed here was best in the application to the discharge lamps without electrodes. Next, the lamp filled with xenon at 40 kPa and small amount of metal iodide was used in the experiment. The lamp efficacy remained at 51 lm/W. In order to clarify the reason of low luminous efficiency, power balance in the discharge tube was numerically calculated. Consequently, thermal radiation loss and the heat conduction loss to the microwave launcher were too large, while the power consumed to visible light is only 18.2 %. Finally, the metal halide HID lamps that are commercially available, filled with xenon at 5 atmosphere, was applied to the present ignition systems. It is found that the lamp could be ignited with the luminous efficacy of 135 lm/W by 50 W microwave power, which is a much higher than that of the automotive HID lamp. It can be explained that the lamp electrodes work as a microwave antenna so that microwave power is directly fed at the center of the lamp, ionizing the high-pressure gases and sustaining the plasma column apart from the lamp wall. Therefore, discharge tube wall heating and heat conduction loss to the microwave launcher can be effectively suppressed to the low level, which leads to high luminous efficacy and long lamp life.