

§8. Output Couplers for Optically Pumped 57- μm CH_3OD and 119- μm CH_3OH Lasers

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Optically pumped FIR gas lasers have been utilized as optical sources for various measurements. In the LHD, the plasma electron density profile has been measured by a beat-modulated interferometer using a 119- μm CH_3OH laser pumped by a 9P(36) CO_2 laser, routinely. For high density operation of the LHD and future plasma devices such as ITER, we assume the optimum probe wavelength is about 50 μm from points of view of plasma refraction effect, mechanical vibration effect, and so on. We have developed interferometer and polarimeter using 57- μm CH_3OD laser pumped by a 9R(8) CO_2 laser. A powerful laser is required for these applications. An output coupler is one of the components of the laser system for taking out the FIR laser beam. An output coupler requires high transparency and low absorption for FIR lasers, and it needs high reflectivity and no leakage for pump lasers. Although an FIR output coupler (Laser Optics, a PPGI company) have been used, this type of output coupler is hard to obtain at present. Therefore, we have undertaken the development of output couplers which replace the FIR output coupler. Capacitive metal meshes were made by a vacuum evaporator, and FIR laser oscillations were tested. An IR long pass filter (Lake Shore Cryotronics, Inc.) was also tested.

The FIR output coupler has Au coating of ring on a silicon substrate with a CO_2 laser reflection coating. The coupling hole is 10 mm diameter. It has been designed in order to maximize the transmission of 119- μm laser. Transmittances of the 57- and 119- μm lasers are $T_{57}=24\%$ and $T_{119}=73\%$, respectively. The reflectance of CO_2 laser is $R_{\text{CO}_2}=96\%$. Figure 1 shows the photograph of the capacitive Al mesh on the crystal quartz substrate. Inductive metal meshes (Precision Eforming, LLC) of the different grid were used as an evaporation mask. For example, the optical properties of the capacitive mesh with $g=16.9\mu\text{m}$ and $2a=6.9\mu\text{m}$ are $T_{57}=19\%$, $T_{119}=85\%$, and $R_{\text{CO}_2}=55\%$. As shown in figure 2, capacitive Al meshes make possible oscillations of the 57- and 119- μm lasers. The IR long pass filter is random macroporous silicon by electrochemical etching. This filter scatters the short wavelength. The rejection edge wavelength is 35.8 μm . The optical properties are $T_{57}=47\%$, and $T_{119}=81\%$, and $R_{\text{CO}_2}=30\%$. The capacitive metal mesh and the IR long pass filter were combined with a NiCu mirror, and it was set in the laser device. The NiCu mirror has a circular hole of 10 mm diameter. Table I shows FIR laser powers got by the different types of output coupler. The pump CO_2 laser power was about 21 W. These output couplers have comparable output powers. It was confirmed that the capacitive metal mesh and the IR long pass filter are usable instead of the FIR output coupler. However, the FIR output

coupler is superior to other output coupler, when the pump power is over 30 W. This is because it has high reflectivity for the pump laser. It is desirable to design output couplers so as to enhance the reflection of the pump laser.

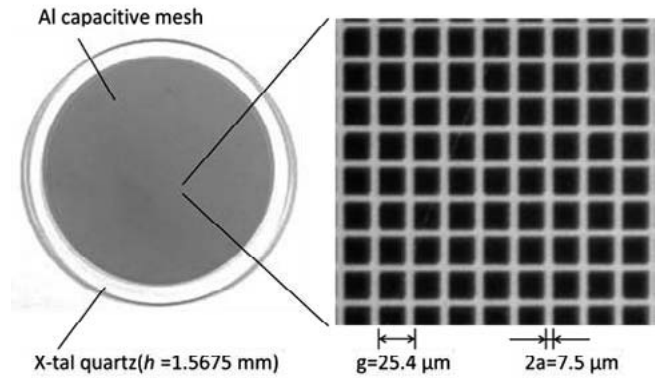


Fig. 1. Capacitive Al mesh deposited on the crystal quartz.

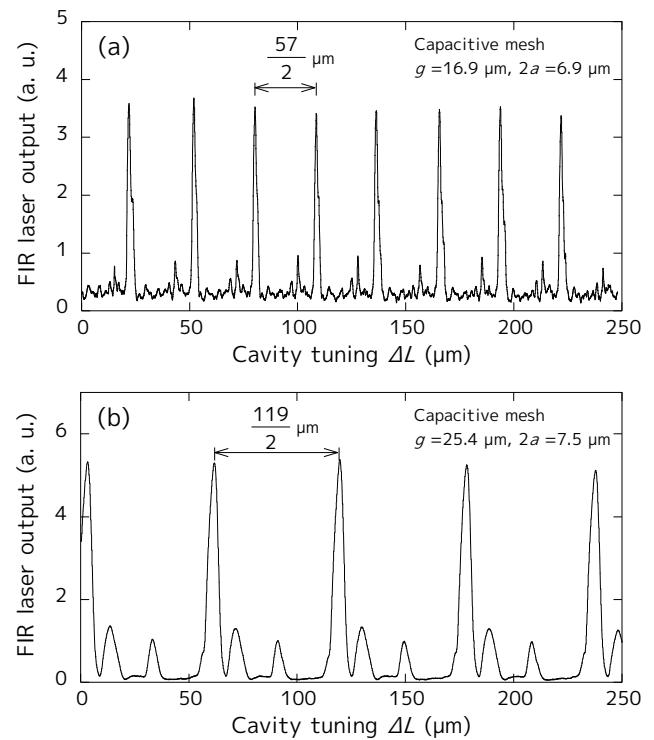


Fig. 2. Detuning curves of (a) the 57- μm and (b) the 119- μm lasers using the capacitive Al mesh output coupler.

Table I FIR laser powers for each output coupler

Output couplers	FIR output power (mW)	
	57- μm laser	119- μm laser
FIR output coupler	35.4	42.0
IR long pass filter	48.7	45.2
Capacitive metal mesh	30.0	40.7