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REJUVENATION OF HELIUM-NEON LASERS*

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We have recently had cause to consider the origin of the characteristic loss of power output from helium-neon lasers as a result of aging. This deterioration is observed to occur independently of whether or not the laser is actually operated; typically, we find, a laser tube will suffer a loss of power by a factor of around two in a period of order 1 to 2 years. It is reasonable to assume that at least a part of the power degradation is due to irreversible effects such as contamination from electrode and wall sputtering, but in our case, the operating time was small, and we felt this effect was unlikely to be dominant. It is known that thin walled vessels of glass or quartz are particularly permeable to helium,[1] and a diminution of lasing efficiency of a helium-neon laser is to be expected as the helium escapes and the gas mixture departs from optimum. This gas loss is reversible, and refilling may be accomplished in a very simple manner. We have immersed the complete laser, without any dismantling, in a helium atmosphere, at atmospheric pressure, inside a suitable container of thick Pyrex or metal. The laser is left there for one to several days. Upon removal, we have measured increases in output power of up to a factor of <u>six times</u> that of the prefilling value, powers which are as great as or greater than the manufacturer's specification. We have in this manner renewed three of our helium-neon lasers: (a) A Spectra Physics Model 115, $\approx$ 6 years old, whose power output had fallen from 2 to 3 mW to 0.55 mW; after 3 days in the helium bath its power had risen to 3.0 mW. (b) An Optics Technology Model 195, $\approx$ 1 year old, whose output had fallen to 1.5 mW; after about 18 hours in helium, the power was 5 mW. The manufacturer's specification is $\geq$ 2 mW. (c) A Spectra Physics Model 130B, of uncertain history, whose power had fallen from the rated 1 mW to 0.4 mW. The power rose by nearly a factor of two in $\approx$ 20 hours, then suffered a slow decrease, from 20 to 40 hours, falling to around 0.5 mW; in this case the optimum helium pressure was exceeded.

These observations are consistent with calculations based on the known diffusion rates of helium through quartz and through Pyrex.[1] The filling pressure of normal laser tubes is $\approx$ 1 Torr helium to $\approx$ 0.1 Torr neon, and the tube is either quartz or Pyrex, usually having quartz laser beam exit faces. The diffusion rate of helium through Pyrex is about an order of magnitude slower than through quartz, and the resultant loss rate is dependent on the precise tube structure. However, for typical tube dimensions, the helium pressure falls by one half in a time of order 1 to several years, the observed time scale of power falloff. On the other hand, when the helium pressure difference across the tube is 1 atmosphere, the diffusion rate is 760 times as fast. Thus the refilling operation takes a time only 1/760 of the prefilling lifetime. For maximum improvement, the laser output power should be measured as a function of time in the helium bath; the tube should not be significantly overfilled so as to exceed the optimum helium-neon gas mixture of around 7:1.[2] We have found a bath duration roughly 1/760 of the known lifetime to be adequate.

Finally, we remark that the diffusion of neon is negligible, being less than that of helium by about four orders of magnitude, and that it is possible to obtain output powers 30% or more greater with the use of He^3 and Ne^{20} in a 9:1 mix.

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1. S. Dushman, Scientific Foundations of Vacuum Technique (John Wiley and Sons, New York, 1958).

2. E. I. Gordon and A. D. White, Appl. Phys. Letters 3, 199 (1963).