

## Technical Note – No. 4

### Classification of Antireflection Coatings for Diode Lasers

Antireflection coated diode lasers can be classified according to their performance within external cavity laser systems. There are four different regions where the lasers show a different types of behavior.

- a) Reflectivity Range of 30% .. 0.5%: These reflectivity values are used for increasing the output power of diode lasers in connection with extending the length of the laser chip. The influence of the output power is given in formula (1) of <http://data.sacher-laser.com/publications/ao2003.pdf>. There is some minor effect on the threshold current as described in formula (6) whereas the actual value depends on the cavity length. With these values, there are only small ranges in the order of 2 .. 4GHz where the diode laser is properly coupled to the external cavity. Theoretically, the width of the coupling range can be estimated by linewidth calculations which are published by Agraval, IEEE JQE-20 468-471, 1984.
- b) Reflectivity Range of 0.5% .. 0.05%: There is a considerable influence on the threshold of the diode laser with these reflectivity values. With decreasing the reflectivity values from 0.5% to 0.05%, the coupling of the laser chip with the external cavity increases until there is a good coupling reached for Littrow cavities around 0.05%. Within this intermediate regime, the benefits of AR-coating start to show up as described in <http://data.sacher-laser.com/techdocs/wavelength.pdf>. For typical chip length of diode lasers, there is a doubling of the threshold current to be found for a reflectivity of 0.05%.
- c) Reflectivity Range of 0.05% .. 0.005%: With reflectivity values of 0.05% or below, an excellent coupling of the laser chip to the external cavity is guaranteed. We suggest our customers only to use diode lasers with 0.05% reflectivity or below within an Littrow external cavity diode laser. For these reflectivity values, the internal cavity of the laser chip typically does not show any threshold within the operation current of the diode laser. This is a necessary condition for a turnkey laser system.
- d) Reflectivity Range of 0.005% or below: These values are needed for external cavity diode lasers in Littman configuration. Due to the high selectivity of the external cavity with double passing of the grating, there are lower reflectivity values for the diode laser necessary.

Document:: <http://data.sacher-laser.com/techdocs/classes.pdf>

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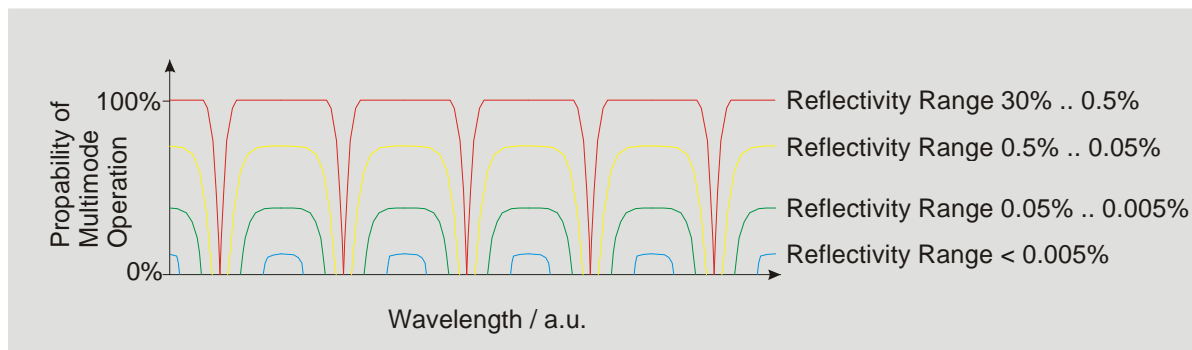
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## Influence of Antireflection Coatings on External Cavity Diode Lasers

Paul Zorabedian proposed the concept of the probability of multimode operation for external cavity diode lasers. This concept allows a visual demonstration of the influence of the antireflection coating of the diode laser on the total performance of external cavity diode lasers.



As one can read from this figure, the range where a non-antireflection coated diode laser can be used within an external cavity laser system is very small and difficult to find. With a successive lowering of the reflectivity of the diode laser, the performance of the external cavity diode laser system drastically increases. For an excellent performance of an external cavity diode laser, it is needed to use diode lasers with a reflectivity according to regime c) or d).

The most effective way of proving the reflectivity of high quality AR-coatings for diode laser is the method of Kaminov et. al, IEEE JQE 19, 493-495, 1983. We always provide these data for the diode lasers which are used within our laser systems, c/f <http://data.sacher-laser.com/techdocs/testdata.pdf>.

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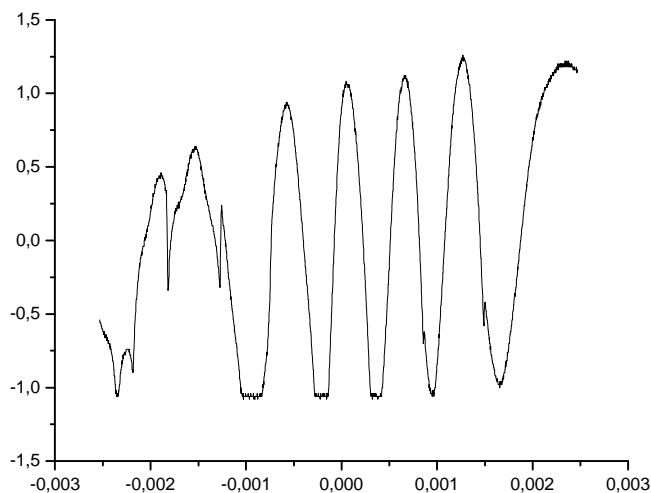
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### Example for non-sufficient antireflection coating

There are suppliers who are offering antireflection coated diode lasers without providing a proof of the quality of the antireflection coating. Such coatings may cause serious problems with the operation of external cavity diode lasers.



The graph shows an example of the tuning curve of an Antireflection Coated Diode Laser with Class C coating within a Littman/Metcalf cavity. The oscilloscope trace shows the piezo voltage of the wavelength scan versus the optical power. The laser switches completely on and off during the wavelength scan and shows a large number of mode-hops. The regions with high light intensity are present as long as the frequency of the external cavity modes matches the modes of the diode laser. The regions where the laser system shows only minor intensity with spontaneous emission occur when the frequency of the modes of the external cavity and the modes of the diode laser do not match. In summary, there is no reasonable mode-hop free tuning possible.

In summary, antireflection Coated Diode Laser with Class C coatings not suitable for operation in Littman/Metcalf type of cavities. With some restrictions, Class C antireflection coated diode lasers are suitable for Littrow type of cavities.

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